(A)RCHITECTURE AT THE HARDWARE STORE

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Abstract

In this paper, I explore do-it-yourself approaches in installation art and building projects. Although DIY products and systems were developed to help non-professionals, they can also enable professionals to experiment with different methods of creating buildings and spaces. DIY approaches allow people to change spaces while they occupy them, because do not require specialized construction tools, knowledge and insurance. This has practical implications for design and its practice. I show how DIY approaches create evolving, germinant spaces by looking at examples of site-specific installations and experimental residential projects. The blurring of designing, making and occupation in these projects reveals how everyday materials can act upon and transform design practice.

Keywords: DIY, site-specific installation art, experimental making, germinant practice.

1 DIY space

I want to broadly define an under-acknowledged area of do-it-yourself practice: how DIY thinking, materials and products help artists and architects to develop a more experimental, germinant, process-driven practice. With this in mind, I am not concerned with the aesthetic products of DIY approaches, nor the differentiation between professional and amateur practice per se, but rather how DIY can foster evolutionary design processes. DIY is largely associated with non-professional designers and amateurs. Using DIY products and materials enables relatively unskilled laypeople to create and make things with minimal or no help from professional consultants. DIY makers can circumvent the normal hierarchies associated with professional practice, particularly in terms of the commissioning and sequencing of projects. The DIY maker can act as client, designer and builder simultaneously, developing projects by blurring these normally independent roles. The non-hierarchical nature of DIY also enables professionals to work outside of their normal areas of expertise and working methods. I refer to site-specific installation and experimental residential building projects as examples of this form of DIY practice. Standard materials and DIY products enable occupants of these projects to design and develop projects through the processes of on-site construction and experimentation.

2 DIY literature

We have been making things for ourselves since the beginning of human history. Nevertheless, making is now a specialized, often poorly remunerated activity. How does DIY sit within contemporary space-making practices? There is a plethora of DIY information and products in the media, particularly on the internet, including: online zines and magazines like http://makezine.com/magazine/ and *The Family Handyman*; community and self-help chat rooms like http://au.groups.yahoo.com/group/DIYrenovations/ : and information websites like http://www.homesite.com.au and http://www.doityourself.com/. Hardware retailer *Bunnings* (2007) conducts regular weekend workshops for home renovators, with specialized activities for children and women. Product catalogues such as *IKEA2007: Sort Your Life Out* and *Howards Storage World: a place for everything* (2006) show how items can be used in residential spaces. Similarly, popular television shows like *Backyard Blitz* (2000-2007) present laypeople with both design ideas and practical construction advice.

Theorists attribute DIY popularity to different economic, social, technological and cultural influences. In post-war, 1950s America, DIY advertisements encouraged families to alter their homes, as part of togetherness, domesticity and post-war leisure (Sparke 1995, p. 171: Goldstein 1998, p. 37: Gelber 1999, p. 275). Paul Atkinson (2006) believes there are many motivations for DIY. For example, he refers to the DIY toy-making activities of the Victorian and Edwardian eras that developed out of economic necessity (p. 4). DIY popularity has also been affected by the increasingly array of fittings and products that can be assembled with relatively simple skills, knowledge and tools.

DIY empowers people to act without commissioning professionals. Several theorists have therefore associated DIY with democracy and democratizing processes (Lupton 2006: Atkinson 2006). In her manual for DIY graphic design, Lupton and her students encourage laypeople to appropriate design knowledge and standard technologies found in many households, such as computer graphic and printing software. Lupton believes that people are empowered when they are both designer and maker, because design products become accessible and affordable. She equates design and labor with issues of power, status and ownership (Lupton 2006, pp. 24-26: Lupton and Miller 2006).

DIY is hard to find in architectural literature, although it is often implicit in other topics related to how things are made and who makes them: these topics include self-build construction and design-by-making, as design decisions are made during the construction process. The relationship between design and making is also discussed in writings about drawing and designing. This is because drawings are often representations of how things might be constructed. Advances in drawing techniques in the fifteenth century allowed architects to design projects away from sites (Robbins 1994). Prior to this time, architects acted like a builder or contractor on site. As a consequence of the split between design and construction, architecture was associated with building ideas that were represented in drawings made in the design studio. This split also increased the social standing of the architect because construction and making were seen as inferior activities to intellectual endeavour (Robbins 1994, p. 15: Forty 2000, p. 30: Hill 2005, p. 14).

2.1 Implications for practice

Many contemporary theorists are interested in issues related to designing and making, due to technological changes affecting the way buildings are visualized and manufactured. This can be seen in a recent issue of the Architectural Design journal *Design Through Making*, in which architects look at the design implications of digitized manufacturing techniques (Calicott 2005: Ayres 2005). Exploring issues of design production reinforces the processes of architecture rather than its products alone. Some theorists use this emphasis on process to advocate a broader conception of architecture and its materials, mediums and methods (Mitchell 1993, p. 89: Hill 1998, p. 148: Hill 2005, p. 20: Willis1999, p. 107: Schulz-Dornburg 2000, p. 15).

Other theorists look at how design-by-making affects the creation of actual buildings. In the 1960s and 1970s, architect Walter Segal developed a method of self-build housing to enable occupants to design and develop their own houses to some degree. His building projects were based on a modular plan and common buildings materials that are easily manipulated on site by future building inhabitants (Hughes 2000, p. 180: McKean 1989, p. 148). The self-build housing approach has been recently described as flexible housing, which ‘can adapt to the changing needs of users’ (Till, Wigglesworth and Schneider 2006). Building occupants can, in theory, incorporate spatial and technological changes into their buildings over time. Similar ideas appear in the notion of unfinished buildings, Herman Hertzberger (1971) and Stewart Brand (1994) advocate for unfinished buildings, whereby building inhabitants can complete components or spaces themselves (Hertzberger 1971: Brand 1994). This approach often presumes occupants will use and / or accessible building technologies. Project home kits, including those designed by architects, can also be put together by or involve future residents (Arieff and Burkhart 2002, p. 51).

2.2 The germinancy of DIY

Regardless of the positioning of DIY in historical, social, cultural and theoretical contexts, it has practical implications for building procurement. DIY allows occupants to be involved in both making and design, often simultaneously. These activities happen as part of everyday life and building use, often resulting in evolutionary, germinant spaces. I use the term germinant because it is an adjective that means ‘gradually developing’ (Kellerman 1980, p. 408), and germinant buildings are always changing. I believe germinant thinking is implicitly reflected in design theories and practices that open up designing to other influences, particularly the creative input of non-designers during the construction phases.

DIY approaches are normally associated with home renovation and hobby projects rather than design through making approaches. I want to address this deficit by fist speculating on examples of DIY thinking in site-specific installation art, an area not normally associated with the DIY tradition. The more poetic term, *bricolage*, has appeared in art and cultural discourse. *Bricolage* is the French term for do-it-yourself, often used in a derogatory sense to differentiate between amateurs and professionals.

3 Bricolage in site-specific installation art

Bricolage stems from the French verb *bricoleuer* which means to fiddle and tinker (Wikipedia 2007). A *bricoleur* assembles things or ideas and ‘then puts them together in a way that they were not originally designed to do’ (Wikipedia 2007). *Bricolage* has also been used in art and cultural theory, associated in particular with Claude Lévi-Strauss (Roberts 1994, p. 14). For example, Attfield (2000) uses it to understand the social and cultural issues of DIY (p. 206), while Armstrong (2002) uses it to develop his new media art research.

I think the term *bricolage* helps us see how DIY thinking infiltrates art projects that encourage active audience spectatorship rather than passive contemplation. Site-specific installation is a practice that has been associated with creative assemblage. This is for two reasons. First, many artists create their works from ordinary and familiar materials, to encourage the audience to interact with the works. Second, the works themselves often contain elements that can be adjusted and moved. When the audience manipulates these elements, they become like the artists who initiated the works. That is, they become *bricoleurs* or creative assemblers.

Theorists such as Reiss (1999) believe installation art began as a genre in the 1960s and 1970s, when artists wanted to make their artworks more accessible to the audience (p. 16). Artists also opposed what they saw as the increasing commercialization of art galleries. Many believed this commercialization oppressed the critical role of art practice. The American artist Allan Kaprow made installations of everyday and junk materials as part of his critical view of art practice (Haywood 1999, p. 37). His works were assembled from materials like rolls of paper, pens, record players, and old car tires. Kaprow made works occupy entire spaces, in the hope that they were harder to buy and consume (Reiss 1999). The audience also engaged in acts of assemblage inside Kaprow’s installations, altering and reassembling the constituent materials and elements.

Two issues of *bricolage* implicit in site-specific installation – the artwork as everyday material assemblage and the audient as *bricoleur* - can be seen in several works in the recent kids’ APT, part of The 5th Asia-Pacific Triennial of Contemporary Art, in Brisbane (December2006-May 2007). Many of these works in this exhibition require the audience to do something to or in the space. In several artworks, children (and adults) assemble and reassemble parts of the artwork made of the kinds of materials used to manufacture toys. In Kwon Ki-Soo’s installation *Run, run, run*, children create people from foam-cutouts and place them on display.

Other artworks require participants to make their own art inside the installation space. In Sutee Kunavichayanont’s *Classroom Upside Down*, children create their own artworks by making crayon rubbings of the etched desks in the space. In another installation, Yang Zhenzhong’s *Light and Easy (Brisbane),* the audience can take and email a trick photo of them holding a council bus in. In Tuyoshi Ozawa’s *Everyone Likes Someone as You Like Someone*, children deliver their drawings into a mailbox atop a mountain of standard domestic futon cushions. It is refreshing to see white galleries filled with jumping and lively children, even if their exertions are limited by concerned gallery attendants and parents.

The everyday, familiar materials used in the above installations – building blocks, foam dolls, pens and paper, computers - invite touch and appropriation because they have been taken from everyday life. The physical installations are also set up like classrooms and playgroups rather than a conventional pictorial gallery. The gallery inhabitants, the children (and their adult supervisors), make decisions about how parts of the spaces are arranged and made, therefore contributing to their aesthetic qualities. In many artworks, the children make only minimal changes to the physical spaces. For example, they take their drawings with them, or their work is displayed temporarily. Nevertheless, both the artists and audience can act as *bricoleurs*, creating works from materials otherwise destined for very different contexts.

3.1 Difference in DIY intent

I would argue there is a significant difference between placing DIY objects like readymades in an art context, using DIY materials to create a design and deploying DIY as a method of audience interaction. For example, artist Allan Wexler makes installations from standardized elements, materials and off-the-shelf products like garden sheds, and has therefore been associated with the DIY movement (Schultz 1998, p. 6). He often develops projects through a design-by-making approach. Other than manipulating some moveable elements, Wexler's projects are arguably physically finished when experienced by the audience. This is different to other installations, where it is not only the artist but the audience who can physically touch and change the works once installed on site. I would describe the latter use of DIY *germinant*. This reinforces that there are significant differences in the basic philosophical thinking underpinning DIY practices.

4 The bricoleur at home

Although DIY approaches are traditionally associated with home renovators, some DIY environments are so unique that theorists consider them seminal artworks or buildings: for example, Watts Tower in Los Angeles or *The Owl House* in South Africa. Their makers are usually untrained, driven by a desire to create spaces rather than to make a public artwork per se. They often work with limited means, experimenting with recycled and junk materials. Experimental making can also be seen in projects initiated by professionals in non-professional contexts. The houses of practicing artists and architects often act as experimental studios for testing ideas and living arrangements. Even if these artists and architects involved in these projects are professionally trained, the way they make their home projects may be very different to professional practice because of the blurring of designing, making and use on site.

Selvalegre is the Australian home of an artist and architect who work in a germinant manner. They have spent years collecting interesting objects and salvaging discarded items from construction bins around the world, which are incorporated into the fabric of their current home. Other items sit on custom-built plinths and shelves incorporated into internal walls. These quirky installations create a unique home in an otherwise standard timber-framed Queensland house. Yet I would argue it is not the physical building per se that makes it unique but rather *the method of its evolution*. Many changes and additions occur within the existing building footprint. This allows the occupants to construct the work themselves and work spontaneously without violating local planning and building regulations.

4.1 Hotrod house

DIY advocates believe that standard, readily available materials and approaches can be used in inventive and thought-provoking ways (McKean 1989, p. 148: Lupton 2006, p. 25). Although Steven Gelber (1999) differentiates between the creative and utilitarian aspects of DIY, he still acknowledges its overall creative benefits (pp. 269-270). Adapting standardized houses helps residents to personalize and transform houses into homes (Attfield 2000, p. 188). *Selvalegre*'s resident architect believes personalization is a key issue of DIY approaches, pointing to a similar culture in the creation of hot rod vehicles. He argues that drivers create unique cars for themselves using accessible technologies from the local auto shop in the same way that home owners develop homes by using standard hardware products and details in inventive ways: for example, by customizing mass-produced IKEA kitchen fittings are customized with purpose-built doors, fittings and finishes. Many if not all houses are, to some degree, *hotted up*. Some transform this DIY practice into a way of life due to necessity, lifestyle choice or a combination of factors (Atkinson 2006, p. 3).

The approach used at *Selvealegre* resonates with aspects of a seminal architectural project, the Eames House, by Charles and Ray Eames in California. The project was officially known as the

Case Study #8, because it was part of a programme of experimental, postwar housing. The Eames' treated the house itself as an experimental laboratory, an ongoing project of experimental living and working, and in this sense the project embodies germinant qualities. Charles and Ray were also notable for their investigation and exploitation of new manufacturing technology and materials: showing how modern, mass-produced technologies are readily appropriated in uniquely crafted projects. However, the Eames house also evolved slightly differently to *Selvalegre*, because of changes to built-in elements. Even if furnishing, interior partitions and object display changed regularly, the basic spatial configuration as defined by the structure was worked out in advance to construction (Colomina 1997, p. 133): this can be seen in the 1949 plan published in *Arts & Architecture*. In contrast, *Selvalgre*'s floor plan changes - such an outdoor bathroom, a garage reconstruction and a new kitchen – developed individually and somewhat spontaneously over time rather than according to an overarching vision for a set plan area.

I believe the Eames' germinant, DIY thinking is more obvious in their approach to interior design and decoration, and furniture and object design. They used the term "functioning decoration" (Kirkham 1998, p. 192) to describe the changing display of personal and inspirational objects, and they designed changeable interior fittings to encourage other people to engage in this activity. Their pegboard wall system for screenwriter's Philip Dunne's 1952 office fitout accommodated changing display elements (Kirkham 1998, p. 193). They also designed toys, such as *The Toy* (1951) and *House of Cards* (1952) that could be assembled and reassembled into different configurations. These latter projects embody the do-it-yourself attitude to creating form seen in contemporary installation projects, particularly those tapping into the energies of children! Toys encourage an uninhibited approach to life, which, according to the Eames', was perfect for exploring design problems (Colomina 1997, p. 139).

5 DIY as germinant practice

DIY does raise issues related to safety and wellbeing. While in some cases, DIY can increase personal safety issues related to poor workmanship (Gelber 1999, p. 275), it can also be self-actualizing (McKean 1989, p. 174: Cross 1996, p. 83: Gelber 1999, p. 292: Lupton 2006, p. 21: Atkinson 2006, p. 7). However, many regulatory bodies remain unconvinced, particularly when poor workmanship leads to injury. In a 2000 case in Brisbane, a deck collapsed, injuring fifteen people. This case and similar incidents prompted the Queensland State Government to issue warnings against DIY activity during the 2004 Easter period in a Brisbane weekend newspaper (Giles and Robson 2004). In the 1950s, authorities encountered the same safety concerns during the DIY boom. Rather than discourage DIY altogether, they highlighted the dangers of undertaking structural repairs. Instead, they encouraged home renovators to tackle only 'small repairs, cosmetic improvements, and light construction projects' (Gelber 1999, p. 275).

DIY projects can involve a degree of on-site material experimentation that may increase maintenance issues. I witnessed this when the domestic futons used in Ozawa's APT installation required replacement in March 2007. Nevertheless, devoting time and energy to DIY projects can be personally, socially or culturally empowering. In this context, DIY approaches contribute to alternative design practices. DIY enables artists, designers and audiences without professional construction skills to design by making, even if their projects are limited in scope. Projects develop in unpredictable and exciting directions that could not be imagined in design drawings alone. Spaces develop in and through their materials, transforming an apparently quotidian visit to the local hardware store into an inventive, creative act.

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THE SILENT HISTORY OF VERNACULAR: EMERGENT PROPERTIES AS BACKGROUND FOR STUDYING TECHNOLOGICAL EVOLUTION IN THE BUILT ENVIRONMENT

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Abstract

All complex systems, which includes buildings and the built environment, possess emergent properties. Complex systems are systems that are composed of numerous interacting parts. Emergent properties are high-level behaviours that arise spontaneously as a result of the structural organisation of, and the interactions between, the individual parts and properties of the system. Thermal performance is an emergent property of buildings and of the built environment. It is the result of the way in which the physical components of a built environment and their thermal properties interact.

Understanding the emergent thermal properties of the built environment is important because there has been an empirically verifiable long term trend in the way classes of buildings have altered over time. Vernacular buildings that have persisted for long spans of time possessed technologies that 'managed' the emergent thermal properties, and their inherent thermal contradictions, whether their builders or occupants have been aware of this or not: they are silent technologies. Classes of buildings that did not possess these silent technologies have, over time, fallen out of use and have not reappeared. As buildings have become ever more complex, these silent technologies have become ever more sophisticated overall in their 'management' of the emergent thermal properties. This has allowed the overall level of thermal choices and control available to building occupants to increase over time, regardless of their contradictory natures.

Keywords: Emergent properties, complex systems, vernacular, thermal choices; thermal control.

1 Introduction

The application of technologies in buildings and the built environment has not always been overt and obvious. Buildings and the built environment, as complex systems, possess emergent properties and technologies that 'manage' emergent properties have existed in vernacular buildings dating back to the time of the earliest built structures, whether their participants were aware of their presence or not. Understanding these silent technologies is important because complex systems have often shown long term trends in the way they have changed over time (cf. climate, the economy), regardless of whether the participants are aware of the presence of these trends or not. For example, animals need not be aware of the processes operating within biological evolution for it to be an empirically demonstrable phenomenon.

Thermal performance is an emergent property of buildings and of the built environment. Understanding thermal emergent properties is important because there has been an empirically verifiable long term trend in the way classes of buildings have altered over time. The people involved need not have been aware of the presence of this underlying trend for it to be empirically verifiable. The very essence of vernacular is quantifiable change within ordinary, non-monumental and non-architecturally-designed buildings that occurs over spans of time that potentially exceed the awareness of the people involved.

This paper outlines an analysis of the emergent thermal properties of a wide sample of vernacular buildings over an extended period of time. It demonstrates that, as buildings became more complex (with more rooms, more levels, more variation in room size and shape) the technologies for 'managing' emergent thermal properties became ever more sophisticated (incorporating more closeable-openings, more transitional spaces, more courtyards, more environmentally-altering devices such as windcatchers, evaporative coolers, braziers). More importantly, however, the most successful and longest surviving forms of vernacular buildings have been those in which the silent technologies were able to enhance the thermal choices and control available to the building occupants, regardless of the contradictory nature of thermal choices and control.

2 Emergent Properties

Emergent properties arise spontaneously within complex systems, systems that are composed of numerous interacting parts, such as the environment, the economy, the internet, buildings and the built environment. They are high-level behaviours that arise spontaneously as a result of the structural organisation of, and the interactions between, the individual parts and properties of the system. The ability of a car to move is an emergent property of cars and the mind is an emergent property of the brain (Cohen & Stewart 2000: 169). A car's capacity to move and a brain to think cannot be studied directly in terms of the individual components, or extrapolated from them. The 'drivability' of a car and the mental capacity of a brain have, however, been studied extensively and intensively, not so much as the *raison d'etre* of cars and brains, but as a consequence of their structure and workings (Eldredge 1989; Conway Morris 1998: 9).

Emergent properties are empirically measurable when observed at the scale of the whole system and, whilst they cannot be extrapolated from a quantitative analysis of only individual parts, some features will have a greater influence on the nature of the emergent properties than others. Additionally, the nature of emergent properties is often the result of contradictions that are inherent within complex systems (Kauffman 1995). These include contradictory processes operating within the system and the way in which the contradictions are resolved (Gould & Lewontin 1984; Kauffman 1995: 171-178). For example, an aeroplane's capacity to fly is an emergent property that arises from the finding of an appropriate compromise between the contradictory requirements of structural strength, flexibility and weight. Finding better and better compromises, however, becomes exponentially more difficult as better compromises are found (Kauffman 1995: 203-205).

3 Buildings as Thermal Machines

Buildings are no different in their operation to brains and cars in that they are complex systems and possess emergent properties. Buildings might be 'machines that people live in' (Le Corbusier 1923) but, in terms of 'technologies', which are by definition properties or processes that are quantitatively tangible and measurable, buildings are (amongst other things) *thermal machines.* Emergent thermal properties cannot be precisely ascertained from a knowledge of only single built features. They are the temporally and spatially holistic result of the interaction between the physical components in a built system and their thermal properties operating in conjunction with the natural elements (sun, water, wind etc.) (Fig. 1), although some thermal features will generally have a greater influence over the outcome than others. For example, the characteristics of the material of a building's wall or roof will have a greater influence on the overall thermal performance than the colour of its furnishings.

Thermal environments are highly sensitive to small changes, such as changes to the buildings themselves, changes to the fixtures and fittings, the occupants and the outside environment. The number of individual thermal states that can potentially be achieved within a space is infinite and it is not possible to know precisely what thermal states will result from effecting a change to a built system. This is because small changes can have large-scale, long-term effects (Szokolay 1987: 21; Clarke 2001ix). In other words, emergent thermal properties must be studied at the scale of the whole thermal system, at the scale of interrelated assemblages of built parts and thermal features.

The main factors upon which emergent thermal properties are predicated are:

1. the characteristics and properties of the building envelope,
2. the way the building sits in the landscape (the characteristics and properties of its surroundings and climate),
3. the arrangement, characteristics and properties of individual rooms, and
4. the presence or absence of active heating and/or cooling systems (fires etc.).

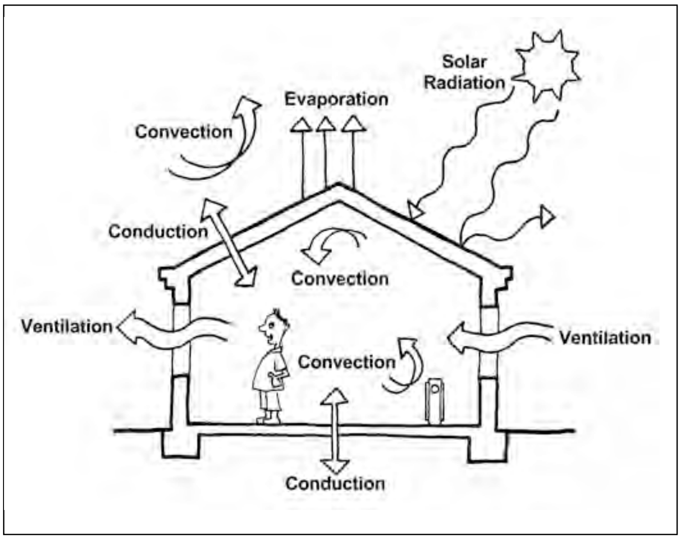

Figure 1**: Thermal Exchange Between Buildings and their Environment**

4 Emergent Properties as Functional Capacity

Emergent properties can be equated to the functional capacity of a system, to the *potential* of a system to achieve a range of individual states. A car possesses the capacity to achieve a range of states, from stationary to full-speed, and it retains this capacity whether the engine is running or not (as long as no other fundamental changes are made), because it possesses the property 'capacity to move'. The nature of the emergent properties will vary, however, from class to class (from make or model to make or model). Mazeratis, for example, constitute a separate class of car to Mini Minors or Bentleys. A building's emergent thermal properties can also be equated to the its thermal capacity. A building's thermal capacity is defined by the range of thermal states and microclimates the building can achieve and the degree to which these can be selectively altered. A building's thermal capacity can, therefore, be used to define its thermal class. Windbreaks, for example, constitute a different thermal class to enclosed huts.

It is, however, possible to redefine a building's thermal capacity in humanistic terms. The range of thermal states and microclimates that a building is capable of capable of providing to its occupants can be redefined in terms of the occupants' *thermal choices* and the degree to which these can be selectively altered can be redefined in terms of the occupants' degree of *thermal control*.

Thermal choices and thermal control are often contradictory. This is because thermal choices are a factor of microclimatic variability: the range of different microclimates available to a person that they can choose to move between and/or occupy. Thermal control, conversely, is a factor of ambient homogeneity: it is easier to selectively control and/or alter something that is already homogenous than if it is variable. For example, a room that is environmentally homogenous and static would offer little thermal choice, but it would be relatively easy to raise the ambient temperature by an even 1°C. Conversely, a room in which there is a wide and diverse range of microclimates would offer a lot of thermal choices, but raising the temperature of each microclimatic zone by an even 1°C would be very difficult. Providing maximum thermal choices and maximum thermal control within a single structure is, therefore, inherently difficult, because as one is enhanced by accentuating certain thermal traits the other is often degraded, and vice versa. For example, the thermal properties of a brick wall, which conducts heat very slowly, is potentially contradicted by the presence of a large single-glazed window inset into it, which conducts heat rapidly.

5 The Long Term Trend

The emergent properties of 158 pre-industrial vernacular buildings (assemblages of interconnected rooms) were examined over a period of time that dated back to the earliest built structures within each of the three study regions: Pakistan (late 4th Mill. B.C. – early 20th C. A.D.), Egypt (early 4th Mill. B.C. – early 20th C. A.D.) and Palestine (7th Mill. B.C. – early 10th C. A.D.). The buildings (entities), from twenty-seven different sites, were allocated into seventeen groups according to region and period. The buildings were treated as composites of forty interrelated built and thermal properties (variables), which represent the main factors upon which emergent thermal properties are predicated (Table 1). The variables were given numerical values equivalent to their capacity to provide thermal choices or thermal control, or both (Table 1 and Fig. 2). The numerical values were derived from the results of an engineering-analysis (ref. Wilkins 2007; Wilkins 2006), an analytical methodology developed within the sciences to investigate the contradictory processes operating within complex systems and thus ideal for investigating the contradictory nature of thermal choices and thermal control (Carlson & Doyle 1999; Jen 2005a & b).

Feature (Variable) No.	Built and/or Thermal Features (Variables)	Reference Illustration in Figure 2	
1-9	Building exposure (n, ne, nw, s, se, sw, e, w & vertical)	A	Features where thermal choices and thermal control are contradictory
10-11	Roof flatness/peakiness and range	B	
12-13	Floor level relative to ground level and range	C	
14-16	Wall and roof material (thermal mass) and roof material range	D	
17-18	Presence of wall & roof insulation	E	
19-20	No. internal angles and range	F	
21-22	Ratio length/width and range	G	
23-24	No. posts and range	H	
25	No. niches	I	
26	No. fixed benches	J	
27	Compactness/longevity	K	
28	No. rooms	L	
29-30	Internal floor/ceiling thermal conductivity	M	
31	No. roofs at different levels	N	Features where thermal choices and thermal control are not contradictory
32	Degree of opening in each direction	O	
33-37	Solar penetration (from s, se, sw, e, w)	P	
38	Cross ventilation	Q	
39	Heating	R	
40	Degree of transitional space	S	

Table 1**: The Built and Thermal Features**

This data was then analysed via a type of statistical multivariate analysis (MVA) known as discriminant analysis. There are three reasons why MVA is ideally suited to analysing emergent thermal properties. First, it can quantitatively analyse large numbers of entities (buildings) that are composed of large arrays of interacting variables (built features and thermal properties). Secondly, it can illuminate trends and patterns within large arrays of complex interrelated data that are impossible to discern by simple means. Multivariate data, data composed of numerous variables, requires a graph of numerous dimensions upon which to plot them. This becomes visually and cognitively impossible to comprehend. MVA, however, reduces the variables to a smaller number, two or three, which still retain the underlying structure of the original data. These are known as Functions and the first two functions capture the most information about the original data. The smaller number of variables can then be easily interpreted, either numerically in table form, or graphically on a two-dimensional plot or scattergram that contains the first two functions (Shennan 1988: 241). Thirdly, MVA can specifically model the thermal behaviour of buildings because it equates the entities (the buildings) with their composite strings of conjoined and interrelated variables (built features and traits), including feedback between the operations (Plog, 1974: 150). A discriminant therefore shows the sum of the variables of each building relative to the sum of the variables of each other building: the emergent thermal properties of each building relative to each other building.

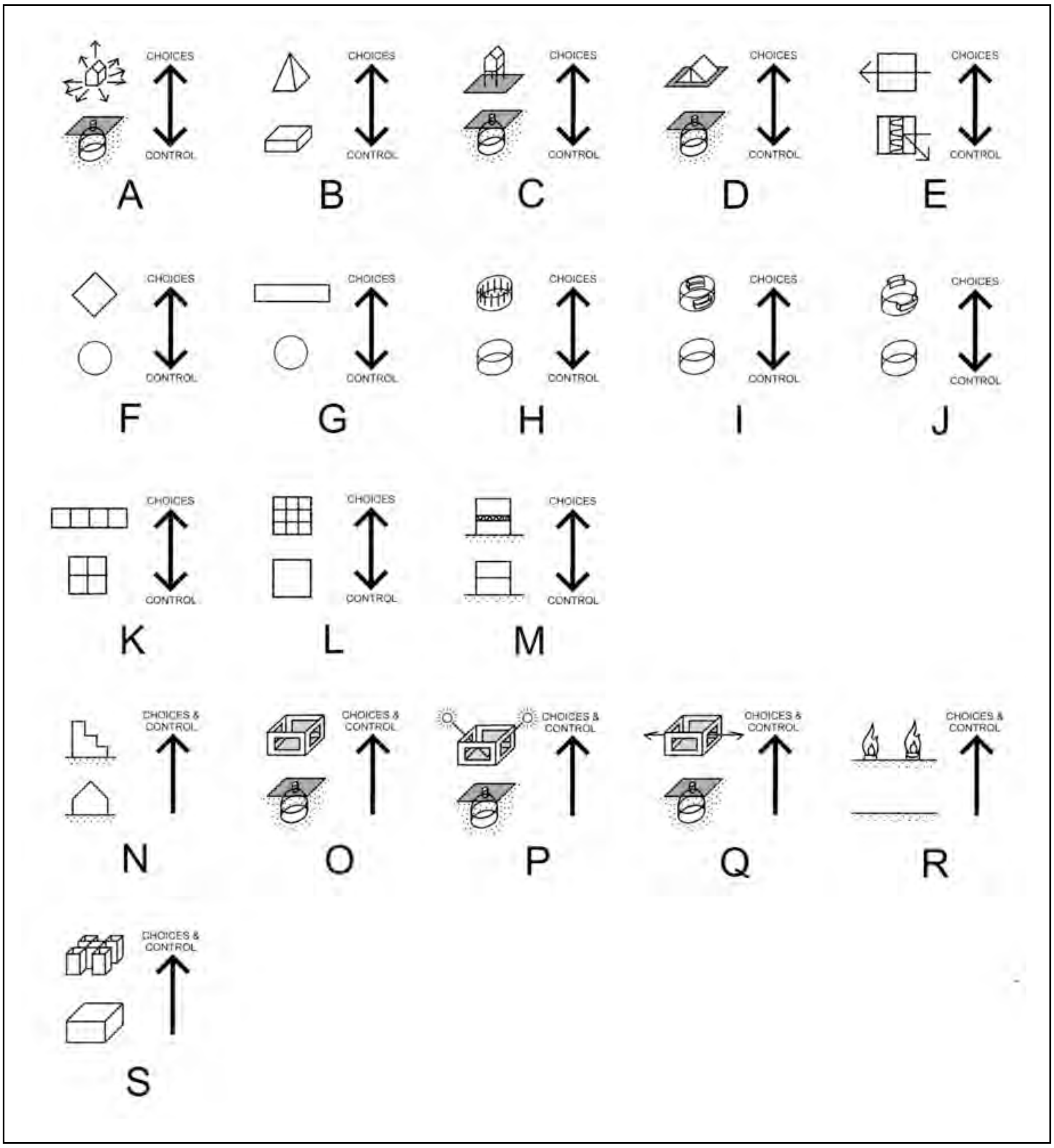

Figure 2**: The Built and Thermal Features according to Thermal Choices and Control**

The resultant discriminant scatterplot (Fig. 3) shows that the emergent thermal properties (thermal capacities) altered discernibly and gradually over time, a trend that was statistically meaningful ($r = 0.818$; $p = 0.000$). The trend is characterised by minimal inter-building thermal variability, as indicated by the relative sizes of the scattergram clusters, up until the pre-industrial era when inter-building thermal variability increased. More importantly, however, the trend is characterised by a general overall increase in building complexity and thermal sophistication. This has allowed the overall level of thermal choices and control available to building occupants to increase over time, regardless of their contradictory natures. The later vernacular buildings of Egypt and Pakistan (there are no vernacular examples for the Palestinian highlands) were highly complex, with more rooms, more levels, more transitional spaces, more courtyards, and more variation in room size and shape, than their predecessors. That is, they possessed a wide range of potentially different thermal environments: high thermal choices. They were also highly thermally sophisticated, with more environmentally-altering devices, such as windcatchers, evaporative coolers, fire braziers and closeable-openings with diverse types of shutters and screens, than their predecessors. That is, they possessed the capacity to be selectively thermally altered: high thermal control (Wilkins 2005). These buildings represent a class of building that is long lasting and which has only recently begun to be replaced in an age when mechanical heating and cooling are readily available.

The scatterplot, however, shows two exceptions to the overall trend towards increasing thermal choices and control. The first is the very early Naqada 1 buildings in Egypt which appear as an outlier group. The second is the Harappan buildings of Pakistan. These buildings, c. 2600-1900 B.C., were characteristically of massive, load-bearing brick construction, were highly thermally homogenous and static and were inherently difficult to alter, both physically and thermally (Wilkins 2005). These buildings, however, represent a class of building that fell out of use and which has not reappeared.

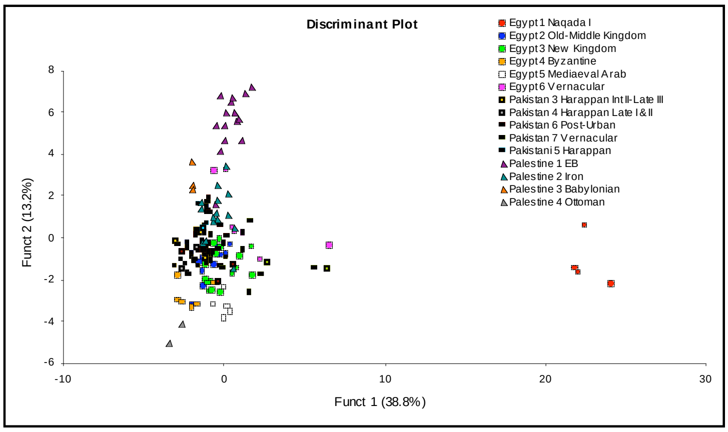

Figure 3**: Discriminant Plot of Emergent Thermal Properties (Thermal Capacities)**

6 Conclusions: Thermal Innovations Over Time

Buildings possess emergent thermal properties. These are empirically measurable, high-level behaviours that arise spontaneously as a result of the structural organisation of, and the interactions between, the physical parts and thermal properties of buildings and the built environment. The earliest buildings possessed emergent thermal properties that differed only in degree, not in kind, from later, vastly more complex buildings. However, later buildings developed ever more sophisticated technologies for ‘managing’ the emergent thermal properties, and their inherent contradictions, whether the people involved were aware of this or not. “Perhaps they did not know technically what they were doing or why, but the results were effective, comfortable and practical” (Stead 1980: 41). More importantly, this development occurred in a way that enhanced the built environment’s capacity to provide thermal choices and control, even though their contradictory natures makes finding technologies that concurrently enhance both exponentially more difficult (Kauffman 1995: 203-205). That is, over time silent technologies developed within the built environment such that ever more people possessed the potential be more thermally satisfied for more of the time.

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8 Acknowledgements

This work was funded by the Australian Government APA program and the Sydney University PRSS.

VIRTUAL EVOLUTION – A MEMETIC CRITIQUE OF GENETIC ALGORITHMS IN DESIGN

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Abstract

This paper discusses some issues in design theory arising from the use of genetic algorithms in architecture. The rationale for such programs derives from the iterative process of Darwinian natural selection, which has been likened to an algorithm, or 'foolproof recipe'. However, while the products of these programs are often visually seductive, researchers rarely question the biological model underpinning them. Approaching the subject from a memetic perspective, the author argues that there are fundamental differences as well as similarities between memes, as cultural replicators, and genes, as biological replicators. Evolutionary design models based on the latter, especially those operating exclusively within laboratory or artificial environments, may therefore be misconceived. A number of problematic issues are identified, involving questions of definition, transmission, embodiment, selection and autonomy. As an alternative strategy, it is suggested that embedding design algorithms in real-life projects offers more promising results. The author concludes that, given the complexity of cultural evolution, the proper subjects for design research are memetic algorithms, rather than the genetic models.

Keywords: Design theory; biological models; virtual evolution; genetic algorithms; memetics

1 Biological models

In my paper I shall try to resolve some questions concerning the current use and misuse of biological models in design, and genetic algorithms in particular, as exemplified in a presentation given by Greg Lynn a few years ago in Sydney. The presentation was one of several offered here in conjunction with the Houses of the Future exhibition in 2004, which focussed, as such exhibitions do, on the impact of new technologies on the shape of residential architecture (Stace). Lynn's contribution consisted of the Embryologic House, a series of computer-generated variations of the now familiar blob-like forms associated with such experiments, the identity and differences between which he clearly struggled to explain.

To his credit, Lynn made no attempt to conceal his dilemma, and recounted an exchange with Peter Eisenman following a similar presentation, in which Eisenman accused Lynn of having "lost all powers of discrimination". Lynn responded that: "They are like my children. I love them all equally". Earlier in his talk, Lynn had also recounted how new technologies of production were being devoted to manufacturing meaningless variations of the same basic product designs, common examples of which, he noted, were the countless numbers of barely distinguishable toothbrushes now available to consumers. Yet, despite all the self-conscious and good-humoured acknowledgement of the problem, when it came to explaining the logic behind his house designs, Lynn had not a single word to offer at any point in his exposition regarding either the purpose or the material properties of the curved shapes his program was producing. I concluded that the Embryologic House, like so many similar experiments, was a perfect example of what I now call 'toothbrush architecture'.

Underlying Lynn's difficulties, and the use of similar design programs based on genetic algorithms (DeLanda; O'Reilly, Hemberg and Menges), is *the problem of selection*. If such programs, which are supposedly modelled on Darwinian theories of evolution, are to be effective, then the criteria of selection and related factors involved have to approximate in some meaningful way to real-life processes, which in this case means *cultural* rather than natural selection. While such anecdotal evidence as I described above might not be taken too seriously, it seems that I am not alone in wondering about the direction and theoretical foundations of such work. In an aptly titled paper, "Drunk in an orgy of technology", Professor Chris Wise, who, amongst other distinguished roles, advises the Emergent Technologies and Design programme at the Architectural Association, pinpoints the same problem:

> "….even with today's 'fab' computers we are utopia-bytes short of enough computing power to study what we really want to study, so the computer goes along a very narrow path. It only stops when its told to. Mimicking Darwin, computerized mutations jump the process into another groove in the hope that somehow the fittest will survive. But the definition of 'fitness' is usually arbitrary, so the tools stunt their own creativity" (56).

Wise's cautionary note, however, is rare in a field where researchers and admiring critics alike are generally so enamoured with the glossy products of these machinations, that they rarely question the underlying assumptions of evolutionary validity. It may be useful at this juncture, therefore, to take another look at the Darwinian model, which, as Wise implies, is the main source of inspiration for much, if not all of this kind of work.

2 Memetic Perspective

I shall approach my subject from a memetic perspective, a relatively new body of knowledge and research kick-started by Richard Dawkins with his seminal book, *The Selfish Gene*. In that book, Dawkins proclaimed that Darwin's theory of evolution is too rich to be confined to natural selection alone, and should be broadened to include human culture. This in itself is not new. Neo-Darwinian analogies of one kind or another have been popular in most fields, including architecture and planning (Alexander; Collins; Abel, "Evolutionary"), ever since Charles Darwin completed *On the Origin of Species*. However, Dawkins went well beyond metaphorical allusions to identify distinct or particulate units of culture, which he called memes, after the Greek root for mimic, which replicate themselves in similar ways to genes:

> "If I had to bet, I would put all my money on one fundamental principle. This is the law that all life evolves by the differential survival of replicating entities" (191-192).

Following Dawkins' lead, the philosopher Paul Dennett has drawn attention to the abstract features of Darwin's theory, which can be generalised beyond its original range of application. According to Dennett, natural selection boils down to a simple but highly effective process familiar to any computer programmer:

> "The theoretical power of Darwin's abstract scheme was due to several features that Darwin firmly identified, and appreciated better than many of his supporters, but lacked the terminology to describe explicitly. Today we would capture these features under a single term. Darwin had discovered the power of *algorithm*" (50).

As Dennett points out, algorithms were already familiar in Darwin's day as mathematical and logical procedures, but it was Alan Turing's work in the 1930s and the great strides in computer science made since then, that confirmed the universal power of the logical structure. Algorithms, Dennett explains, like fool-proof recipes, are nothing more nor less than step by step procedures for achieving a specific, guaranteed result: do this, then this, followed by that, and you will get this result. Natural selection works according to the same simple rules of logic. Susan Blackmore, another leading light in memetics, neatly sums up the whole process:

> "As Darwin realized, *a simple reiterative process can create the most intricate and functional designs apparently out of nowhere* (author's emphasis). It works like this –

start with something; make lots of copies of it with slight variations; select just one of these; and then repeat the process. That's all.

The power lies with the effect of selection….in a world with insufficient food, space, light, and air to go round, inevitably some creatures will do better than others, and whatever it was that helped them in the competition for survival will be passed on to their offspring, and so the process continues. As it does, characteristics such as eyes, wings, hair, and teeth all appear and evolve. These are the adaptations that helped the animals to survive, and will be passed on if they breed" ("Consciousness" 124).

3 Theoretical Problems

So far; so good. There is nothing in any of the above to cast doubt on the wisdom of using genetic algorithms in design, or indeed in any other field. On the contrary, quite literally, it would seem to be the logical thing to do for anyone interested in how things evolve and change, whether they are organisms or cultures.

However, as the burgeoning literature in memetics shows (Aunger), not to mention shots from the sidelines from social anthropologists and others critical of the new discipline (Bloch), Universal Darwinism, as it is called, and comparisons between genes and memes in particular, are fraught with theoretical and empirical problems. To begin with, definitions of what memes, as cultural replicators, actually consist of, are notoriously vague, and include anything from catchy tunes and fashions to major culture-forms like religion - a favourite topic, or rather, target of Dawkins. Moreover, unlike the chemically precise replication of genes from generation to generation, it is difficult if not impossible to trace any equally precise process of reproduction, or imitation, as Dawkins describes it, that applies to all human cultures. According to some sceptical writers, like Dan Sperber, this alone threatens the legitimacy of the whole memetics enterprise.

In addition to the problem of selection referred to at the beginning of this paper, we therefore have two further issues to contend with. Following Blackmore ("Meme"), I shall call these *the problem of definition*, and *the problem of transmission*. However, there are still other reasons to question any close likeness between genes and memes. A clear distinction is made in genetic evolution between the *genotype*, which is the total make-up of genes in each organism, and the sum-total of the various hereditary characteristics of the organism, known as the *phenotype*, which is the *product* of the information carried by the genes. Natural selection favours those genes whose *phenotypic effects* give the organism some kind of advantage over organisms lacking those same attributes, i.e., whose genes produce less robust effects. Although it is the genes, as efficient replicators, which are actually transmitted through the generations, it is the effects or characteristics they produce in the organism that determine their survival.

Natural selection therefore works only *indirectly* on genes, through their phenotypic effects. If the analogy between genes and memes is to hold, then a similar distinction must also hold between memes and their own effects. This requires not only a particulate meme as a distinct unit of culture, but also a selection process that acts indirectly on the meme through its effects. I shall call this *the problem of embodiment*.

Last but not least, there is *the problem of autonomy*. According to Dawkins, bodily organisms are merely convenient vehicles, or 'survival machines', as he calls them, assembled by genes for their own benefit and procreation through their phenotypic effects. Accordingly, the primary targets of natural selection are neither the species nor the group, as evolutionary biologists generally assume, but the genes themselves. Furthermore, genes will always behave selfishly, so to speak, and choose that form or configuration in nature that most favours their own procreation.

Throughout these arguments, Dawkins stresses that, while memes, like genes, might appear – at least from the explanatory language used – to exhibit some kind of purposeful behaviour, this is no more than a useful metaphor, and should not be taken literally to imply any kind of conscious direction. Selection simply acts upon both genes and memes in such a manner that those replicators having the most favourable effects on their chances for survival will inevitably proliferate, and thus behave 'as if' they were active agents in their own fate. Yet it is equally clear from Dawkins' treatment of other aspects of the meme-gene analogy that he regards the comparison with genetic evolution as more than a metaphor, and that memes, like genes, are literally subject to many, if not all of the same harsh laws of Darwinian selection.

4 Key Issues

At the core of these debates are more fundamental questions of the validity of Universal Darwinism itself, and how far Darwinian models of evolution can be fruitfully applied to such diverse phenomena as organisms and human culture-forms, including buildings and other artefacts. I believe that they are applicable, so long as we respect the differences as well as the similarities between genes and memes. Taking each of the five main problems identified above, the key issues can be set out as follows.

4.1 The Problem of Definition

Memeticists are generally agreed that the evolution of humankind differs radically from that of other species, primarily by the nature of their diverse culture-forms and the dominant use of symbolic systems in the organization of knowledge and customary behaviours. Beyond this, however, they are divided over how memes, as cultural entities, should be defined or how they function. Those with a background in psychology, like Blackmore, believe that memes are mental entities and will eventually be located within the workings of the brain by advances in the neurosciences. Others from different disciplines, like Dennett, believe that memes can only be identified through their external cultural manifestations, whether they are forms of behaviour, symbolic systems or artefacts, and have no separate existence. Once these die, so does the meme. In either case, it seems unlikely that memes will ever be defined with the same precision as genes.

Like Kate Distin, I take the position that memes are special kinds of ideas, involving generally applicable concepts, like types, such as tools, clothes; games; dances; disciplines, and, of course, building types and styles (I interpret styles as a different kind of type from the building variety). However, types, as symbolic systems, only have meaning within broader systems of related ideas. The concept of memes as types therefore challenges the notion of memes as particulate or isolable units of culture, comparable with genes as particulate units. In this respect, therefore, memes differ significantly from genes.

4.2 The Problem of Transmission

Amongst the conditions that memes have to meet in order to fulfil their function and transmit their information effectively from person to person and generation to generation, Dawkins stipulated that memes, like genes, should be capable of being copied with a high degree of fidelity. Hence the popularity amongst some memeticists for examples based on the use of modern techniques of reproduction, like printing, photography, photo-copying and computer programs. However, a general theory of cultural evolution cannot be restricted to memes that can only be transmitted or disseminated with modern technologies.

As with the problem of definition, the requirement for absolute fidelity of replication needs to be relaxed in order to accommodate the complexities and diverse methods of cultural transmission. Here I am in agreement with Sperber, who argues that memes are not so much simply copied, as reconstructed by inference, a complex psychological process involving the attribution of intentionality, as well as learning skills. However, while this might seem to weaken Dawkins' original theory of memetic transmission, unlike Sperber, I do not believe that it threatens the basic idea of memes as replicators, albeit the process of replication may be far more complex than Dawkins conceived it to be. The creative process of inference and reconstruction also allows ample room for variations and mutations - an essential ingredient in the Darwinian model - whilst transmitting essential features of the type accurately enough for it to be easily identified, despite the variations.

4.3 The Problem of Embodiment

Reconstruction by inference implies the existence of some kind of publicly accessible evidence indicating what a meme consists of, so that it can be reproduced. Likewise, inferring the intentions of the person or persons who created the form that is being replicated, or reconstructed, also requires some kind of external evidence of those intentions, normally obtained by observation, i.e., listening to the music or seeing the artefact itself. I maintain, with George Kubler, that artefacts, like other culture-forms, owe their identity primarily as one of a series of similar artefacts, or what Kubler calls 'linked problem solutions'. Accordingly, being able to infer the defining attributes of a meme requires the evidence of several exemplars, rather than any single case, so that the essential characteristics of the type can be sifted out from its variations. This of course is precisely what we do as teachers or critics when we explain a particular building type or style to students and designers, who may wish to reproduce that specific form, or at least understand it.

A distinction can therefore be made between memes and their vehicles, comparable with that made between genes and their vehicles, though, as with other comparisons, it should not be taken too literally. In this case, since a type cannot be identified with a single exemplar, it clearly exists in some sense beyond that specific vehicle. However, a gene has a tangible physical existence distinct from its vehicles, whereas a meme only exists as a separate entity when it is inferred and reconstructed from several of its own vehicles. Compared to genes, memes are rather ghost-like entities, only appearing briefly in the act of reconstruction.

4.4 The Problem of Selection

In the closing passage of his chapter on memes in The Selfish Gene, Dawkins breaks with the generally passive picture of Darwinian selection:

> "We are built as gene machines and cultured as meme machines, but we have the power to turn against our creators. We, alone on earth, can rebel against the tyranny of the selfish replicators" (201).

However, in rightly rejecting a too-passive view of human evolution, Dawkins may have veered too far in the opposite direction. As with similarly optimistic statements, Dawkins' declaration of faith in the power of human choice is little more than that – a declaration of faith – rather than a concept or theory supported by evidence (it's a bit ironic, to say the least, that such a statement should come from an avowed enemy of faith-based beliefs). Unfortunately, the historical evidence on the fate of many past civilizations presented by Jared Diamond, suggests a far less rosy future than that held out by Dawkins.

A more balanced and realistic view of how Darwinian selection works, in both the natural and human worlds is offered by Kevin Laland and John Odling-Smee in their theory of 'niche-construction'. Taking up Dawkins' suggestion that an organism's phenotypic effects extend beyond the body of an organism to include all its effects on the world ("Phenotype"), Laland and Odling-Smee point out that, by building dams or shelters or otherwise modifying their environments, beavers and countless other creatures significantly affect the selection pressures acting on their development. Evolution is therefore a two-way process, rather than the one-way process portrayed in the conventional passive picture.

In the same way, by modifying their environments, whether through agriculture, communication systems, or building cities, humans also affect their own selection pressures. However, for better or worse, the same modified environments create new selection pressures of their own, which may actually restrict freedom of action, rather than create more choices.

4.5 The Problem of Autonomy

Just as Dawkins argued that we can only understand the way biological evolution works by reversing the usual focus on the organism and adopting the 'gene's eye view', so he also argues that we can only understand the way cultures evolve by adopting the 'meme's eye view'. What this means in practice is accepting the difficult notion that memes and meme-complexes may have autonomous or semi-autonomous lives of their own. As Dawkins puts it: "A cultural trait may have evolved in the way it has simply because it is advantageous to itself" ("Gene" 214).

Similar notions of autonomous behaviour drive the growing interest in theories of emergence and self-organizing systems (Fraser; Hensel, Menges and Weinstock), as well as the interest in genetic algorithms, to which they are sometimes related. I maintain that the apparently autonomous emergence and development of cultural traits and types is an outcome of the same recurring cycle of positive feedback described above: of modified environments affecting selection pressures, leading to new traits and types, which in turn lead to further modifications of the cultural environment, affecting selection pressures again, and so on, ad infinitum.

Innovations may also be better understood from the same perspective. Rather than being the sole province of creative individuals, as it is normally portrayed, I hold that the process of innovation is a spontaneous outcome of new selection pressures, in which new ideas and technologies are generated in response to a changing social and cultural environment, which in turn leads to new selection pressures, etc. Amongst other factors, I believe that the simultaneous discovery of the same idea or invention by different persons working separately, of which there are some famous instances in the development of evolutionary biology itself, as well as in many other fields, offers ample evidence for my theory. In short, if an idea's time has come, if you don't come out with it, somebody else will!

5 Embedded algorithms

Given all these problematic issues, it must be asked, are evolutionary models of design based on genetic algorithms simply abstract versions of real-world processes, as their protagonists claim them to be, or are the differences between cultural and genetic evolution so great as to suggest that such models are fundamentally misconceived, or, at least misleading?

I hasten to add that, personally speaking, I have no problem with the evident preoccupation in these exercises with baroque form as such. There have always been designers who put formal and aesthetic issues before everything else, consciously or unconsciously. Lynn's interest in the ornamental aspects of design is also well documented ("Ornament"). However, I suspect that much of the attraction of genetic algorithms - for students as well as for their teachers - lies in the illusion of authority accruing to the design from the algorithm, which the genetic model, as I have explained, may not merit.

An alternative strategy would be to embed design algorithms in real-life projects, as Chris Williams did with the design for the roof over the Great Court in the British Museum, so exposing the selection process to a wider range of environmental issues, both cultural and material. Wise also suggests something of the kind when he calls for more project-related experiments:

> "So far, the emerging technologist has usually had to limit the output of the process to an object rather than a project. A project has a definite purpose. A project has a site. A project interacts with people. It interacts with climate. It interacts with time. And unlike a computer process it is made of imperfect things and materials that change according to this interaction. In short, the project lives" (57).

Parametric modelling, as used by cutting edge practices like those of Norman Foster and Frank Gehry, already does much of the job (Abel, "Technology"; Abel, "Ecologies"; Burry; Glymph; Whitehead). While it automates many complex and time-consuming design processes, unlike genetic algorithms, it has the built-in virtue of permeability. That is to say, it facilitates and encourages external human and environmental inputs of virtually any kind at any stage of the development process, adjusting design parameters along the way.

6 Conclusions

Beyond such ad hoc developments, however, I am doubtful there will be any significant progress in understanding how architecture, or indeed any other culture-form evolves, so long as researchers remain fixated solely on the genetic model. While the clarity and precision characteristic of computer algorithms might accurately simulate the precision of genetic replication, they hardly reflect the far less exact and ambiguous processes that characterize the evolution of cultures. In sum, the proper subjects of study for design research are *memetic algorithms* rather than the genetic variety (Abel "Cultural Evolution"). Though they might lack the mystique of the latter, with all their pretensions to precision engineering, as models of cultural evolution they are more likely to be relevant to our real needs.

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BUILDING ON TRANSIENCE: TOLERANCE AND THE SUBJECTIVE DIMENSIONS OF TECHNOLOGY

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Abstract

Technology acquires a provocative charge in different ways, one arising from observations of 'transience' in the built environment, particularly of the life and performance of buildings over time, their conception and construction, use and performance, inevitable failure or decay. Technological systems can be particularly thought provoking when human expectations and actions are implicated in the performance of buildings - which, of course, is always. This paper discusses how building technology (its conception, operation and valuation) is mediated by an ethical imperative aimed at managing change and the uncertainties it poses and from which an understanding of identity, character and values may be derived.

The concept of operational 'tolerance' draws our attention to the capacity of building technologies to articulate change and perform according to varied physical and aesthetic expectations. Expectations might be said to include those for a certain kind of structural soundness and integrity or visual clarity. A failure to fulfil these serves to draw our attention yet further to particular environmental and even social circumstances which characterise, inhibit or enhance the operation of architectural medium – like unstable soils, pervious or defective building materials, poor workmanship or even extremes of weather and neglect. The concept of tolerance is related to the governance and normalisation of habitable space in modern times though has precursors in other times and varied modes of construction. Here it is cast as a useful analytical tool for understanding transience and the built environment in terms of technology and for describing the patterns of sensibility and self-awareness arising from an experience of technological systems.

Keywords: transience, tolerance or operational tolerance, technological transfer, identity, character, values.

1 Introduction

This paper forms part of a broader research project on transience and the built environment. The thesis underlying this project is that transience, understood alternatively as i) a state of change characterising one thing or another (phenomenal transience) or ii) an apprehension of the impermanence of all things – their inevitable changefulness, fallibility or passing away (existential transience) - has been and remains a key feature of human experience. Relations between these two understandings of transience are neither accidental nor simply metaphorical; there are additional conceptual as well as technological circumstances relating the one to the other. Serving as a register of everyday expectations and anxieties associated with science and related practical and industrial arts, for instance, technology is regularly called upon to ameliorate the consequences of time's passage in multiple spheres of human experience. However, the prospect of better science and more technology does little to allay apprehension that our tools, machines and buildings invariably break down or fail to perform the way they should or that other circumstances may arise in the future to complicate the tasks they were meant to perform. At one extreme of a scale of conceivable malfunctions, the phrase 'catastrophic failure' has been coined to describe circumstances in which technological systems, particularly and most spectacularly structural systems, undergo a complete, typically sudden failure from which their recovery is unlikely. Compared to expectations likely to characterise a pre-industrial age, the fallibility of human tools and industry (and humans themselves) has become as much a 'fact' of life today as the finitude of life itself.

Among the possible ways that building technology and its performance might be seen to engage change and lead to an understanding of human subjectivity, this paper is counterpoised by, and largely rejects one particular perspective as narrow and untenable. It is a perspective which takes technology to comprise a broad category of human means and intentions (sciences, industrial and practical arts) that threaten to alienate human beings from some other, supposedly 'natural' or truly meaningful state of existence and belonging. This figure that comes most clearly to mind who espouses such a view is Alberto Perez-Gomez, though others like Dalibor Vesely and Karsten Harries share it in some measure. Perez-Gomez implicates patterns of sensibility, self-awareness and mutual understanding in a hypothetical 'poetic' dimension of building; a claim which is metaphysical and grounded in the transcendental phenomenology of Edmund Husserl. Perez-Gomez writes ("Built", 3-4) in the introduction to his most recent book:

> "This book argues that the materialistic and technological alternatives for architecture – however sophisticated and justifiable they may be, in view of our historical failures – do not answer satisfactorily to the complex desire that defines humanity. As humans, our greatest gift is love, and we are invariably called to respond to it. Despite our suspicions, architecture has been and must continue to be built upon love. I will endeavour to show how this foundation possesses it owns rationality, one that the built environment will not follow if it is based on premises drawn from normative disciplines or abstract logical systems. While recognizing the dangers of traditional religions, moral dogmas, and ideologies, true architecture is concerned with far more than fashionable form, affordable homes, and sustainable development; it responds to a desire for an eloquent place to dwell, one that lovingly provides a sense of order resonant with our dreams, a gift contributing to our self-understanding as humans inhabiting a mortal world."

The passage calls upon a universal and timeless (by and large essentialist) view of human identity; references to basic desires and the need for dwelling animate the book and call to mind popular concepts of place and concerns for Heidegger's conceptual couplet of building and dwelling. With an emphasis on placefulness and being and by downplaying change, contingency and risk (except to diagnose the latter as ills), these concerns are inadequate to describe the multiple impacts of transience on human character and values. In the passage, changefulness and the multiple forms of change conceivably manifest, impeded or enhanced by buildings are largely downplayed. Instead, the author seeks a static condition in which the forms and functions buildings and building technology are reconciled by the dutiful and poetically-minded designer in pursuit of 'true architecture' (Perez-Gomez). The view of identity acquired by such a perspective is largely eschatological and basically fundamentalist. To the contrary, this paper evinces a view that is more multi-faceted and historically-grounded and less in need of metaphysical support. It does not cast material concerns and technological systems as one category of means and intentions amongst a number of 'alternatives' for architecture. Unlike Perez-Gomez's book it is not a discourse on 'love' or any perversion of the term, Greek or otherwise ("logical", "affordable" or "sustainable"); it does not engage archaic ideas and practices to support its claims. Rather, the paper aims to show that materials and technology, particularly when part of 'normative' disciplines can be productive of self-awareness and understanding in positive, ethical ways. Though dismissed by Perez-Gomez and his disciples, technology can be one means of finding our place in this "mortal world."

In view of the broad scope of this research project and a potentially large source of illustrative material available from the history of science and technology, this paper narrows its themes by describing one key concept and a number of historical references to illustrate it. It focuses on the performance of technological systems and their operation and human reaction to their reliability (or otherwise), by way of describing the concept of ‘tolerance’ as a potentially useful analytical tool. It is a tool whereby both understandings of transience are drawn together and from which forms of awareness (environmental and ethical) constitutive of identity may be derived. Qualified by adjectives like ‘operational’, ‘technical’ or ‘mechanical’ or, most commonly in architectural practice, ‘building’ (or ‘builder’s’), the term ‘tolerance’ denotes the margins of error or workmanship determining whether or not a device, machine or manufactured material, building product or practice fulfils its intended purpose or achieves a desired result, structurally or aesthetically or in some other way. The paper aims to show that by acknowledging these margins a person may also be admitting something about themselves - their own limitations, perhaps, or prospects for further creative and practical endeavour.

2 Operational Tolerance

The concept of ‘tolerance’ offers one way to think about the interaction of both phenomenal and existential transience given the mediation, design and human experience of technological systems. Common to everyday language, but also reflecting the particular concerns of moral philosophy and theology, medicine and biology, the term ‘tolerance’ has long denoted the ‘performative constitution’ (OED) of a thing – most commonly, of a person with a capacity to endure pain or hardship or someone able to withstand particular doses of medicines, poisons or drink. Each of these manifestations of tolerance (or conceivably, intolerance) draws on a temporal framework and likewise implicates the perceptions of change – in oneself, one’s companions or one’s surroundings. For instance, a person is praised for enduring a life of hardship or for acquiring the related values of patience and forbearance as these become apparent only over time. A capacity for withstanding the effects of one or the other consumed substances may be inherited or acquired and so, implicates life experiences (genetically-attuned or habitual) of varying duration. In either case, consequently, it may be claimed that one comes to exhibit a tough or relatively feeble constitution for resisting or exacerbating those agents, persons or things which inevitably impact upon someone. From observations of innumerable instances of resistance or acquiescence one might draw broader lessons of the meaning of existence itself – that life is hard, for instance, unpredictable and risky.

Of more recent derivation and owing to the history of industrialisation and empirical science, the growth and differentiation of technological systems, operational (encompassing technical, mechanical or building forms as well) tolerance transposes what was once an attribute of living things onto machines or objects of human and industrial manufacture. Machines ‘normally’ tolerate or perform as expected if margins of error in workmanship are followed or certain physical, geometrical or environmental conditions satisfied. This is, in fact, partly what makes technology normalising in ways described by Georges Canguilhem (370-378): instrumentally and systematically, behaviourally, cognitively and ethically. The ‘performative constitution’ of a manufactured object connects the thing to yet other objects and machines - those which first produced it or which, in turn, may be used by it – as part of a system within which devices are used and through which they acquire operative as well as other kinds of non-operative (like semantic and moral) values. In relation to manufacture, the term ‘tolerance’ first appears in English usage, according to the Oxford English Dictionary, in relation to minting and the standardisation of coinage. The “small margin within which coins, when minted, are allowed to deviate from the standard fineness and weight” (OED) contributed to the stabilization of worldwide currency exchange in the nineteenth century and contributed to an economic order governed by monetary agencies and international agreements. This first, internationally-sanctioned tolerance was, plus or minus, one-sixteenth of a carat or 15 grains (approximately 972mg) for the fineness or quality of the metal and 12 grains (777.586mg) for weight for each troy pound (5760 grains or approximately 373.24 grams) of coin. The principle can be seen at work with many of the first objects of standardised manufacture, particularly those which were widely valued and commonly traded, their parts readily replaced or interchanged. The manufacture of rifles is one case in point. The margin for error in workmanship and performance required to produce and use rifles and other military hardware can be related to such phenomena as the codification of ballistics, the re-incorporation of infantry and its disciplines into modes of modern warfare and even calculations of strategic advantage between rival states with large (now industrialised) armies.

Such relations not only underscore the systemic character of most technology (not only military hardware) generally, they also identify structures or avenues of a kind – comprising discourses and disciplines, calculative and governmental regimes – that facilitate the process commonly called ‘technological transfer’. Commonly cited instances of this phenomenon include the transfer of aluminium technology from military to civilian aviation industries following the Second World War. It begins to explain how plastics, developed in part to remedy the shortages of naturally-occurring raw materials during wartime, found innumerable uses (many, newly created) in a range of industries afterwards (Philips). More recently, an instance of technological or material transfer is the movement of large stocks of titanium, reserved for weapons production during the Cold War, onto the open market for building supplies. While not exactly the turning of a sword into a ploughshare, the metal has been transformed into a Guggenheim museum or two (so far) and countless executive toys. When accounting for why these transfers were successful, it is perhaps less significant that one or the other person had the idea that aluminium, plastic or titanium might have a novel use. Rather, it is important is that there were means available (scientific and industrial, corporate and governmental) for allowing such ideas to be acted upon – to effect the transfer of material or manufactured goods, in other words, from one use to another. Change of this phenomenal kind, facilitated by these overlapping conceptual, practical and institutional contexts, contributes to apprehension of a world of further possibility, creative and practical endeavour.

Meanings of ‘tolerance’ have come to include the performative dimensions of manufactured objects as well as to denote a character trait of human beings. At the same time the concept of operational tolerance has served to further heighten a domain of human sensibility (one might call this a focus for self-awareness) where technology raises questions of identity, character and values - humankind being the principle devisor, user and ultimately, the beneficiary (as well as a chief victim) of the tools they devise. Among other things, a person may now be obliged to be tolerant of their tools. Chief among the forms of self-awareness engendered by the use of technology are those accompanying what Ian Hacking calls the taming of chance. This is where, in view of the many tasks technological systems might perform, more or less adequately, there arises apprehension of those circumstances in which technology does or most likely will fail. These occasions are a challenge to normal expectations for the predictability and reliability of technology brought into play as people attempt manipulate nature for human benefit. They lead on to questions of whether one is able to or should do so – questions of the limits of scientific expertise, technological prowess and ultimately, human agency and of the tolerability of overstepping certain limits (as in the case of accidents).

3 Tolerance and Environmental Awareness

One form of self-awareness is the kind of prescience that comes from being conscious of one’s surroundings. An experience of technology has a bearing on this too. This seems a particularly important issue to highlight by way of drawing this paper to a close and in view of current environmental problems, their likely cause in unrestrained industrialisation and their hopeful solution in yet more human industry, better science and sustainable technologies. Environmental concerns are broadly implicated by the first understanding of tolerance (a constituent part of selfhood) described earlier in the paper. Historically, though most clearly since the time of Francis Galton, human character – including potential character traits like tolerance, patience and forbearance – have come to be seen as dependant upon a person’s unique constitution and a history of adaptations, more or less effectively, to specific environs. These environs include both natural and social circumstances determining human vitality - whether a person strives or withers.

Equally, the normality, behavioural and self-reflective aspects of technological systems implicate natural and social contexts brought into focus by the concept of operational tolerance. Instances of catastrophic failure are often a consequence of either the unforseen physical behaviour of materials or cataclysmic, environmental circumstances in which their performative limits have been exceeded. Investigations of material fatigue, being an instance of the former, have come about largely in response to the long-term use of devices like steel ships or aluminium aircraft or, more humbly, the repeated unbending and bending of paperclips by anxious office workers. The kind of progressive damage done to materials due to minimal, cyclic or fluctuating loads which are oftentimes much less than their static yield strength is evident in the famous collapse of the Tacoma (Washington, USA) Narrows Bridge in 1940, a consequence, it was subsequently determined, of wind-induced vibrations. This episode prefigures others, most notably, the unexpected swaying of London’s Millennium Bridge designed and engineered by Arup, Foster and Partners and sculptor Anthony Caro, a phenomenon more disquieting than potentially catastrophic due to the synchronous lateral excitation of the bridge caused by the footfalls of pedestrians.

Of cataclysmic environmental events which have led structural systems to undergo a complete and sudden failure, the collapse of concrete freeways during the 1989 Loma Prieta earthquake in the San Francisco Bay area was attributed to a seismic-related phenomenon called soil liquefaction. Another, the widespread shattering of curtain-wall glazing on high-rises across downtown Houston in 1983, was due to an unprecedented differential in air pressure caused by the passing of hurricane Alicia. Whether due to material failure or environmental circumstances, instances of catastrophic failure gives one cause to doubt the potential for human understanding to fully comprehend how nature, its elements or 'departments' truly works (Taylor). This kind of insight into the human condition can lead to the acceptance or rejection of certain values. It can lead one to acquiesce to the 'laws' or pre-eminence of nature or to reject, wholly or partly, positive claims made on behalf of technological systems by their engineers, manufacturers and salespeople or other self-interested parties with a stake in the buildings they give rise to (like the developers of high-risers in cities like Houston). Environmental and self-awareness can also arise from and contribute to apprehension of the novelty value, not so much of life-threatening cataclysms perhaps, but of less-threatening, technical malfunctions. Having reason to doubt ourselves when confronting nature with dubious technological fixes, their failure can nonetheless be a prompt for yet further invention – encouraging further hope that things can be made all right.

4 Conclusion

Operational tolerance is a useful analytical tool, to be placed alongside others leading to understanding of the physical and philosophical, historical and social dimensions of technological systems. It is particularly suited for more extended study of building technology than has been permitted by this paper as buildings, the ways they are built and the materials that comprise them, impact on most, if not all aspects of life. Consideration of their 'performative constitution' draws our attention to the expectations and anxieties manifest by building systems and materials as well as their physical attributes, structural or aesthetic aspects. It draws out attention to how systems manifest, impede or enhance an experience of change in a phenomenal sense as well as encourage other kinds of thoughts on their (and our own) fallibility and probable failure. Understanding how these sensibilities contribute to forms of awareness challenge other, narrow, metaphysically-grounded theories of architecture. The view of a fixed, universal or timeless character to human identity implicated by the work of Perez-Gomez and others can be challenged with a broader understanding of how human beings devise and experience their tools and technical capabilities and are consequently impacted upon them, both positively and negatively.

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COMPUTER GAMING, BIOTECHNOLOGY AND ARCHITECTURE: EMBEDDING THE INTERSECTION WITHIN AN ARCHITECTURAL CURRICULUM

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Abstract

Today, leading computer games provide real time environments including spaces, objects and characters that range (by manipulating an enormous array of parameters and being subject to simulations of real world physics) from the super realistic to the super delirious. Biotechnology, although apparently unrelated, also requires the manipulation of information in space and time and promises to affect environments in a range of ways that is at least as extreme. The opportunities suggested by an intersection between Architecture, Computer Gaming and Biotechnology were instrumental in the creation of courses and topics for students in first year right through to students studying toward a Masters degree.

This paper reflects on and critically reviews the implementation, strategies and outcomes of embedding the intersection between Computer Gaming and Biotechnology within an Architectural curriculum. It draws from the experience of over 500 students, two Universities and major technological shifts. It develops the notion of the experiment in design.

In contrast with the introduction of computer gaming technology into a core first year course, that had the underlying aim of including these technologies as a part of a general design curriculum, the introduction of issues connecting architecture with biotechnology (through computer gaming technology) reflects the specific research agenda of the author and is not intended for general application across an architectural curriculum. For more general application it could be seen as a strategy to promote cross disciplinary collaboration through the concept of the 'boundary object'.

Keywords: Architecture, Computer gaming, Biotechnology, Design Experiment, Boundary Object.

Figure 1: **Examples of student work – Kelly Cheesman, Michael Gunn, Xiao Tian, Antony Pelosi.**

1 Introduction

A recent article in 3D World drew attention to a trend that computer game "modders" could see coming from some time ago.

"This year's event continued the evolution that began in 2005: architectural visualization now makes up about half of the program, while the video game industry has been somewhat sidelined. And yet, in an interesting twist, video game technologies were to the fore in nearly all of the event's conferences and special presentations."

They go on to say that "the various presentations made it quite obvious that simulations of light, fluids and behaviour have reached such a high level of realism and effectiveness that they are on the verge of supplanting all other traditional approaches" (Imagina 20).

When the authors suggests that the realism and effectiveness of these simulations is on the verge of supplanting traditional methods they are writing with regard to professionals within the animation/visualization industry. In terms of the capacity of the general undergraduate student to create these simulations, computer gaming technologies will allow them to far exceed their capabilities than if they were restricted to traditional CAD approaches. In 2003 the idea of computer gaming technologies supplanting traditional approaches within an architectural curriculum suggested an opportunity to rethink the way those traditional digital technologies contributed to the design process. This paper reflects on the implementation and development of that opportunity from 2003 to the present.

2 DESN104: Introduction to Computers for Designers: Developed for Victoria University of Wellington, New Zealand. 2003-2006

This first year multidisciplinary course formed a part of the core curriculum for students intending to enrol in further studies in Architecture, Interior Architecture, Landscape Architecture, Industrial Design and more recently Digital Media Design. A key requirement for the course was for students to develop strategies for choosing and learning software that would become instrumental in their exploration and experimentation in design. The inclusion of computer gaming technology within the curriculum facilitated this in two ways. It provided an additional category of digital modelling, to add to the traditional two of solid and surface modelling, thereby increasing the depth and richness in terms of comparisons and contrasts that could be made. See Figure 2 below. Secondly, the priority of the software is towards a real time interactive experience of design that shifts dramatically away from the preconceived outcomes that one associates with CAAD software and traditional key frame animation. This priority is absolutely necessary for scientific experimentation.

The inclusion of computer gaming technology within an architecture course is not unique, in fact Lehtinen (2002) claimed that "game engines have been tested in this purpose for at least a decade". He went on to say that the "only limiting factor was ease of use" which resulted in only a "select few" becoming acquainted with the technology (within an architectural visualisation course). Over three years he had a total of 7 students. While these numbers seem low they are actually quite typical. In 1999 Achten held a studio in Eindhoven, Germany, using 6 PC's and in 2002 Moloney held a studio with 26 students. In addition to their small numbers often the students in question were in the final stages of their degrees. In direct contrast to this the enrolments in DESN104 usually fluctuated between 90-120 students with almost all of them being first year students with no prior knowledge of 3d modelling software.

There were three reasons we were able to over come the obstacles that faced the other authors and introduce computer gaming technology so early and with such high numbers of students.

1. In 2002 Lehtinen said that “all game creation tools currently lack any easy way to import from any common CAD-software”. 2003 saw a shift in approach to custom content from the game makers. The Unreal engine 2 with the Ued3, first released with UT2003, was the first major game engine/editor combination that would rely on outsourced models and textures. The developers at Epic Games see their Unreal Editor as a “content creation tool filling the void between 3D Studio Max and Maya, and shippable game content” (Unreal Technology).
2. As recently as 2004 O’Coill and Doughty found that models built using a combination of AutoCAD and 3DSMax with only 400 polygons would have over 100 errors. Repeated failures like this resulted in their PhD students giving up on working with a computer game engine altogether. The inclusion of a solid modelling software in the suite of software DESN104 students used totally eliminated errors due to open meshes and coincident surfaces (the cause of O’Coill and Doughty’s problem). With the ultimate realisation of their design work being a computer gaming environment DESN104 students were instructed to use the surface modeller for modifying, texturing and UVW mapping geometry only, not creating it.
3. Ironically the final reason why we were able to introduce computer gaming technology so early and with such high numbers of students is that the students were at an early stage in their design education and that there were a large number of them. Many authors have found that significant prior knowledge of CAAD software can be an impediment to learning computer game editing software (O’Coill and Doughty, Hoon and Kehoe). In addition to this Zobel has noted that the facilities of 3d visualisation and virtual reality “facilitate an increased understanding for those people who are unused to the traditional design tools” (1995). The large size of the class made it possible to take advantage of some of the opportunities suggested by the culture surrounding computer gaming technology outlined in section 4 below.

Figure 2 (below) shows a list of parameters that define the qualities that facilitate real time architectural experimentation using digital media. This table should not be understood as a description of three particular instruments but rather as a matrix of elements that might be combined to create a Synthetic Instrument (Stratton). Each of the generic instruments on the top row may be replaced by one of the many alternatives that exist in its category.

instrument / parameter	**SolidWorks**	**3DSMax**	**UnrealEd3**
Sculptural priority	solid modelling	surface modelling	spatial modelling
Tutorials	simple	challenging	dispersed
Online community	very small	large	massive
Industry	industrial design	architectural	game design
Materiality	physicality	aesthetically	geometry
Interaction	parametric	key framed	real time
Modding	none	via plug-ins	by design
Sound	none	acting on geometry	environmental
Cost	very expensive	expensive	free
Complexity of Use	medium	high	low

Figure 2: **Matrix of software elements that might combine to create a Synthetic Instrument**

3 The ‘experiment’ in DESN104; Introducing Scientific Method

Following Matta-Clark, design is characterized as an *imaginative disruption of convention*. In each experiment students were expected to find and exploit possible causes of the disruption of convention by first developing a hypothesis that would be based on the observation of a designed object, space, terrain or relationship chosen from a limited pool. Each pool comprised a small group of artists, designers and companies who were well known for the disruptive effect their work has had with respect to the conventions of their creative communities. Artists, designers and companies such as Zaha Hadid, Peter Eisenman, Issy Miaki, Psyop, Patricia Piccinini, Michele Gondry and the Chapman Brothers are a representative sample of those that have supplied projects that have acted as hypothesis generating precedents within these experiments.

The best definition describing the scientific method in this first stage is provided by the Frascati Manual and elaborated under the category “Experimental development”. Experiment development is defined by “systematic work, drawing on existing knowledge gained from research or practical experience, that is directed to … new processes, systems and services; or to improving substantially those already produced…” (Frascati 7)

The first experiment in *DESN104: Introduction to Computers for Designers*, (Lowe) was conducted over a three week period that included six three-hour tutorial sessions. The experiment required students to select one project from the portfolio of Ron Arad, Herzog & de Meuron, Michael Heiser, or Patricia Piccinini and generate a hypothesis from it that would challenge conventional understandings of normalcy and mutantcy. Using the Ued3 world builder they each created two rooms, a normal room and a mutant room, which were to be connected by a corridor. Along with a website that provided an executive summary of the environment they created each student submitted a UT2004 map that would provide the key evidence demonstrating specific qualities within their experimentation. The primary assessment of the work was carried out within the real time environment itself where tutors were looking to *experience* the imaginative disruption of convention the students had created.

Following a tutorial that shipped with a special edition of the UT2004 game DVD the student’s were able to engage with the Ued3 world builder and begin experiencing the spaces they had designed within 15 minutes of the beginning their first class. Frequent ‘play-testing’, where the students ‘compile’ and enter the real time 3d version of their environment generated in Ued3, was emphasized as a strategy for testing and systematizing their work. The required sophistication of the students elaboration of conceptual terms (demanded by the transitional condition of the corridor) and the collateral learning taking place (creating custom textures for their environment in Adobe PhotoShop, capturing screen shots in Fraps for the website they designed in Macromedia DreamWeaver) set up an incredibly challenging experiment that was for many students their introduction to design computing. Even though many students found the learning curve very steep there seemed to be a profound sense of accomplishment as they experienced their architecture coming to life in 3 dimensions in real time. They were, literally as well as metaphorically, immersed in their work. This contrasts with the arms length engagement we’ve experienced when introducing traditional CAAD software. In June 2006 an independently conducted and collated “End-of-Course Evaluation by Students” found that 81% of students either agreed or strongly agreed that their “interest in the subject has been stimulated by the content and presentation of this course”.

The second experiment, called “Making and Modifying”, had students create a *first object* (Treadwell 1996) in SolidWorks, export it to 3DStudio Max and use a limited selection of modifiers to generate 81 additional versions. In addition to its conceptual underpinnings in terms of Originals/Copies/Multiples/Series and reflecting on the work of Rosalind E. Kraus this experiment set students up with the required skills and techniques for creating the outsourced 3d models that they would use to fully reengage with the Ued3 world builder in the final experiment.

The final experiment, called Navigation, utilized these custom models as vehicles (both literally and figuratively) to have students experiment relativisticly; that is, to understand that perspective and point of view play a significant role in experimental observation. In their environment the students had to enable navigation below, on and above a terrain. Please see the link below for examples of student work (Lowe).

Examples of student work from experiment 3 “Navigation”:

1. Oren Oaariki used an investigation of graffiti (inspired by Psyop) to subvert the conventional understanding of an arrow as a symbol for accurate navigation. His

pathways became three dimensional scripts (each writing the word "space") that oscillated between floor, wall, and ceiling surfaces and always terminating with an arrow. While looking anything but, they were surprisingly navigable and demonstrated incredible control in terms of guidance through an open architectural network (a mobius strip is closed and simplistic in comparison). Designing such complex forms that rely on a finely balanced manipulation of the occupant's perception (itself changing over time) would rely on so much assumption and guesswork as to be almost irrelevant without frequent and immersive testing against experience.

2. Rurehe Taylor's intention was to recreate a historical event "Urapatu" (a NZ Maori word that translates to "scorched earth policy") by creating an environment of "fear and pain". His Architecture is created by fragments coming together after being triggered by occupants as they navigate the scorched landscape. His use of atmospheric effects including fog, fire and lightning created a parallel temporality in visual acuity. It seemed initially that a strong narrative might be at odds with a real time interactive environment (and better be expressed in a traditional animation). Rurehe's strategy of inflicting pain and death (in one's avatar) if one strayed from the path, and ultimately death at its conclusion left enough room for occupants to feel engaged but swept along by events that attained an undeniable certainty.

3. Hye Bin Sung created an environment inspired by a chest of drawers by Droog design (Tejo Remy, 1991). She interrogated the very notion of environment by reproducing it as a series of spaces that deal with environmental factors as independent elements. One space reversed the effects of gravity, another was filled entirely with water, a third used "emitters" to fill a space with multiple objects that moved without physical presence or resistance (their collision was disabled). Audio effects occupying specific zones throughout her 'environment' supported and extended the above. Frequent "play-testing" comparing multiple versions of the environment allowed Hye Bin to develop a sophisticated understanding of the subtleties between the experience of falling (in this case upwards) and floating through space.

4 Learning from the Culture of the Computer Gaming Community

In bullet pointing the positive characteristics of their new Unreal Engine Epic games highlights the importance of the "mod community".

"Every Unreal Engine license includes the right to redistribute *UnrealEd* publicly, enabling teams to release the content creation tools along with their game to the mod community. Mod support has been a major factor behind the success of many prominent PC games today, and we anticipate that support for PC-based mod development may be a significant factor in future console games as well" (Unreal Technology).

Modding a PC game can involve anything from changing the look of a character to creating a whole new environment to changing fundamental relationships between every active element within an environment (making gravity work upwards for example). They are produced by a largely volunteer community that is characterized by an open flow of information, free distribution of custom content and collaboration. The community grows and sustains itself through websites and forums dedicated to providing online training and answers for technical questions (3dbuzz.com is a good example). To a much, much, lesser degree they facilitate design critique.

Following this paradigm and paralleling the introduction of computer gaming technology the method of instruction shifted from 'demonstration' to 'collaboration' via small clusters we called research groups. Previously the course had employed the demonstration model where the course instructor, or tutor, would demonstrate a sequence of operations while students would take notes and then attempt to replicate the result themselves. Due to the length of many demonstrations it was inevitable that the student's recollection would be incomplete. The result was that after each demonstration the tutors would move from student to student filling in the gaps in their note taking and, more often than not, answer the same question many times over. With the collaborative research group model students were placed into research groups of approximately six students at the beginning of the course. The students in each research group were told that they were to rely on each other to gather the technical skills to complete each experiment. The tutors were instructed not to answer any technical question directly but were to facilitate the process whereby the students learned how to find the answer for themselves. Following the modding community often this involved collaboration, discovering websites, posting on online forums and learning to read and critique the tutorials available on them. This helped students directly regarding the computer gaming software they were using and indirectly in terms of mining the effective and not so effective help functions of more conventional CAD software (Solidworks and 3dsMax respectively).

Both tutors and students found this approach difficult at first, often it would have been much easier to indicate a certain button to press or certain step that the student was missing. But quite quickly it became apparent that the research group provided a vehicle where every student had something distinct to contribute, even if it were simply the clarity with which they formulated their questions. With this approach the tutors found they could become higher level facilitators focusing on pedagogy rather than micro managing skill acquisition. It followed that students were able to spend more time designing and the tutors more time advising on design development.

An important part of the design development process involved in-game critiques of the students work. At various times students were required to swap environments with each other and complete the same marking schedule that the tutors would later use to grade their work. On other occasions the whole session (30-45 students) would explore one map simultaneously. Where one student navigating a map (without prior coaching) provided interesting anecdotal evidence as to the clarity, or otherwise, of its experiences and “pathways” the presence of a large group within the environment established clear trends that we found were replicated in other tutorial sessions. For many it was a surprise to learn how people actually navigated their spaces. We found that students productively assimilated feedback from these sessions in their subsequent design work.

5 ARCH1501 Investigation Workshop, Experimenting within the Intersection between Architecture and Biotechnology. Developed for UNSW FBE 2007.

Background: ARCH1501 Investigation Workshop (UNSW, FBE, C. Lassen and M. Gusheh course conveners) is taken by final year Architecture students and is the precursor course to their Graduation Project. At the beginning of the session the entire cohort of students is presented with a range of studio group options that reflect the particular research interests of the staff involved and they enter a ballot as to their preferred option. In the studio group option this author presented students would be introduced to workshops held in conjunction with the tenth artificial LIFE conference held in June 2006 and asked to use what they understood to be the intention of one workshop to engage with a series of architectural issues.

In Picon and Ponte’s introduction to Architecture and the Sciences: Exchanging Metaphors they refer to a new type of enterprise “in which the sciences are viewed not from the interior, as is usual, but from the exterior – that is, from sites and places interfacing with other fields of knowledge and culture.”

The attitude to biotechnology developed in this course borrows from the idea of viewing sciences from the exterior but rejects the implication in the books subtitle that viewing a subject from the site of another necessitates a purely metaphorical understanding. The United Nations Convention on Biological Diversity defines biotechnology as "any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use." The latest computer gaming technology (used in this studio) with its real time simulation of many of the physical parameters shared between the architecture of the built world and the architecture of the biological world gave students the opportunity to experiment in the intersection between them in a very direct way, i.e. with a unprecedented amount of realism, interactivity and testability (this incredible new capability in computer games has only been available since 2005, with Valve’s HL2). Using computer gaming technology that has integrated real world physics to engage with some of the ideas within biotechnology extends Frost’s (2002) understanding of the design sketch as a “boundary object”. Frost understands Leigh Star’s (Star 1989) concept of the boundary object in science as a material object that facilitates the coordination of scientific work because they can be simultaneously read by generalists and specialists. Even though the focus of their mutual attention may be quite different the boundary object allows them to come together for some common endeavour. The environments of these new computer games, enabled with real world physics, allowed the “generalist” architectural design students in this course to directly negotiate with ideas within biotechnology from an understanding of architectural space they related to implicitly. It is this capability that distinguishes the design studio task here from Picon and Ponte’s exchanging of metaphors.

6 ARCH1501IW aLIFEx student work

To give a sense of a progression through that series I will describe 3 experiments by one student, Shawn Li, with additional comments as captions to the work of Andrew Lim, Andrew Wallace, Cheung Lok Kan and George Barbas. In addition to the submission of their real time environments the students were required to represent there findings in short video animations. The comments below directly reference those animations. Please find a link to the animations below (Lowe, 2007).

1. **Shawn Li, EXP1: The Workshop.** In the representation of this experiment Shawn develops a narrative that introduces a character grappling with the concept of the 'boundary object'. His character explores the instruments available in the HL2 modification GMod to alter visual and material reality. "Bit by bit he would piece together a contraption that would grant him passage out of the void". Over the period of the animation Shawn's workshop transforms from a place of passive experience to a place of actual fabrication, i.e. the materiality of objects, new relationships between objects, and between the observer and environment, are created and altered within the real time environment.
2. **Shawn Li, EXP2: The Differential.** The premise of this experiment suggested that within extremely complex sequences control becomes an act of shepherding rather than ridged prescription (Lowe 2007). The Architectural challenge was to create a physical system that I called a "Differential". The Differential received inputs and through a sequence of operations produced an output. "The key to differentials is the relationship between two entities with a common stimulus. This relationship is a compensatory one that often includes an action and reaction. The role of this in the artificial life is the understanding that its methods will bring about different effects on its surrounding (during the process) even if the end result is similar." Shawn Li.
3. **Shawn Li, EXP3: The Physical Collaboration.** In the final experiment Shawn's hypothesis was that the architecture of a path through a space could influence the user of that pathways contribution to group collaboration. The collaborative activity involved the manipulation of a 5 story tall marionette so that it would 'walk' down the length of the space. Each participant physically controlled a key joint in the marionettes structure and followed a path that sloped up and down with the intention of promoting their intended contribution. As you can see in the video capture of the actual event the overall control of the marionette becomes less as the number of controlling participants is increased. While Shawn's strategy seemed reasonable at the outset, and was reasonable within a limited range (1-2 participants), the real time collaborative experienced suggested that the architecture would have to be much more sophisticated than it was to make the contribution ultimately intended. That the architecture needed to promote/accommodate more sophisticated communications networks, and possibly a central brain, was another outcome of the experiment.

Andrew Lim: Architecture as avatar, the development of a non anthropomorphic participant.

Andrew Wallace: A rhythm of linear and rotational motion is destabilised as zones of tolerance become so broad as to overlap.

George Barbas: An environment that evolves through responding to the presence and movement of its inhabitants.

Cheung Lok Kan: "The physical impossibility of death in the (artificial) mind of someone living". Damien Hirst (1991).

7 Conclusion

The last few years (since 2003) have seen a major shift in the approach computer game designers have taken with respect to the integration of custom content in their environment. Along with outsourcing for geometry and materiality, to practitioners of CAAD, they are actively moving away from the need to program within their world building interfaces. Both of these trends are an advantage for students and practitioners of Architecture. Taking advantage of the strength of solid modelling software, not traditionally used by architects, to remove a large source of errors in the integration process streamlined that process significantly with respect to previous authors experience. Combine these factors and even relatively inexperienced students of architecture are afforded much greater ability to design and test their spaces, materiality and interactivity in real time (with all of the benefits Frost, Hoon, Kehoe, Lehtinen, Moloney etc have previously described). In contrast to previous applications of computer gaming technology within architectural curriculum's the introduction of real time physics engines results in architectures responding in a much more sophisticated way to the interaction and experience of their occupants. Affording a direct engagement with disciplines outside of architecture, through computer gaming technology as 'boundary object', introduces an important quantifiable supplement to the traditional qualitative exchange of metaphors.

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ARCHITECTURAL HYPER-MODEL: CHANGING ARCHITECTURAL CONSTRUCTION DOCUMENTATION

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Abstract

More architects and spatial designers are producing complex 3D computer models as part of their everyday design process and documentation than ever before. Parallel to this shift, there has been a rapid rise in consumer computer processing power that has made hyper realistic digital environments a part of our home entertainment. Together, the 3D CAD models and the Computer Gaming Engine could become an architectural hyper-model that renders a digital environment in real time. Such a model would enable users to navigate freely, effectively establishing a new mode of reading space that hovers between 2D drawings and a real space.(Nitsche & Roudavski). This paper will examine how these worlds can merge to form an architectural hyper-model as a valuable supplement to the more conventional scaled 2D construction drawing documentation found on construction sites.

While easily misconstrued as speculative, the ideas presented in this paper outline an on-going body of innovative research currently at the prototype stage. These prototypical hyper-models explore the possibilities of providing construction workers and project mangers access to an architect's 3D computer models on site. These models originate from within conventional building construction drawings such as detailed sections and exploded axonometrics. A process of reinterpretation occurs to locate these drawings and their information within an interactive 3D space. Such operations take advantage of the best of both paradigms. This gives users access to, and control of, the 3D information required for communicating necessary information about the building process. It also provides nodes or hyper-links in the 3D representation that connect to additional information, such as specifications, that are perhaps less formal/spatial.

The paper will show how architectural hyper-models can be used on the construction site - both in the site office and on site using laptop computers and more compact hand-held devices - to decrease on site confusion and enable a faster and more complete understanding of the architect's vision. The paper concludes with speculation on the types of additional information construction workers, architects and designers might want to access in the future and proposes additional technologies that could be provided.

Keywords: architectural hyper-model, construction drawings, documentation technology, entertainment, construction visualization.

1 Introduction

Historically, architects have produced a set of 2D drawings that have abstract information spread across different scales and views. Coupled with the fact that a set of drawings is typically multiple sheets, the proposed building project is difficult to visualize as a complete object and process of construction. Contractors have to piece together information within 2D drawings, which has been collected and packed by architects. This form of communicating has been the established best practice for over 500 years.

Wakita and Linde points to the powerful way computers are being used to create digital 3D models when they comment that we now draw buildings in such a fashion that the computer monitor becomes a type of window through which we are able to view full-size buildings in space. Buildings are drawn in 3-D and rotated into plan and elevation, or rotated and sliced to produce sections, framing and floor plans. This rotation and slicing process helps the architectural technician and student better understand what the construction documents entail. (vii)

The opening paragraph from Gehry Technologies corporate brochure outlines the requirements of a modern construction documentation delivery system: Building projects are increasingly complex undertakings. Tougher building codes and performance requirements, tighter schedules, distributed teams, and the possibility of new architectural forms, all add up to a building design and construction process whose demands exceed the capabilities of 2D CAD and paper based delivery processes. Additional complexity in the design phase has created downstream problems in construction where poor data coordination translates directly into an average of 20% costs overruns during construction. (1)

This research starts to investigate methods of providing non-paper based construction information to construction workers on site.

An architectural hyper-model provides a real time 3D architectural representation within a digitally rendered immersive environment that enables user navigation and interaction. This is achieved by utilizing current generation computer gaming software technology. The notion of hyper draws on two definitions: relating to hypertext or hyperlink, enabling one to hyperjump from place to place without having to visit points in between as noted by Kalay (467); and hyper, meaning over, above or beyond (current digital architectural models). Providing more control and content for the viewer. Currently most CAD programs work within an ‘object’ based mode, using legacy methods and concepts from the drawing board. An architect or designer constructs a building or object in digital space and then zooms in and out, rotating and pan-ing around it. This type of navigation loses any sense of scale, context and relationships between items. Gravity and sense of ground are also eliminated or suspended. These representation modes impede comprehension of the building or object.

Computer gaming software uses an ‘environment’ mode rather than an object mode to display architectural space, giving a viewer centric point or first person perspective view. The shift from object based modeling to environment based modeling changes the way the information can be viewed and understood, providing a scaled space which is navigated by walking or flying and hyper-linking in real time. The first person view gives a stronger understanding of scale and relationships of the proposed building. The current technology enables these spaces to be dynamic, items can be moveable, even picked up and changed, using real world physics.

This ability to create truly dynamic interactive environments enables the hyper-model to provide more than just a walk-through of the proposed design, it offers active links to additional content, such as drawings and specifications. It also allows for details to become truly connected to their location by being hyperlinked in space. In addition, items can be animated to provide construction sequence information, giving contractors a better understanding of the details they have to construct.

The key benefits of using an architectural hyper-model are that sections and details can be connected back to their location in the building through hyper linking, so items are not left floating. Other benefits of using an architectural hyper-model as a method of construction information communication include;

- Scalable view -- can be viewed on any sized screen without modification (desktop and handheld computers)
- Easy navigation control – based on standard computer gaming navigation
- Material identification – with the use of realistic and coded textures

- Interactive – viewer controlled elements
- Real-time physics – ability to introduce 3D objects in the hyper-model, which react with real-world physical attributes.
- Multiples – unlike physical models a hyper-model can be viewed in multiple locations at once (only requiring additional hardware).
- Collaborative environment– real time meetings within the model
- Document management – The hyper-model would be stored online to ensure the latest model is accessed by all.

2 Construction Visualization

Transfer of information between participants in the design and construction process is facilitated by spatial visualizations, typically encoded 2D plan and section drawings and specifications. Acording to Saidi, et al "Construction is an information intensive industry in which the accuracy and timeliness of information is paramount" (1). Construction workers and contractors have expressed a desire to improve their visualization and interpretation of (decoding) construction drawings in order to understand what a designer has documented. It is critical for construction workers to fully understand the designer's construction documentation to reduce construction time and cost by reducing misunderstandings. Saidi, et al proposes, "The construction industry is in need of tools that can provide accurate, reliable, and timely project information to the field." (1)

Professor Kalay, Director of the UC Berkeley Center for New Media, states scale drawings provide a parsimonious notational means of conveying both referential and frame-of-reference (context) information, in the form of floor plans, sections, elevations, and details. However, much of the information that is conveyed by drawing is implicit and relies heavily on interpretation…This heavy reliance on interpretation, and the need to augment the explicit information with implicit assumptions, hinders the effective use of drawings as a means to engender shared understanding (481).

Now that architects are producing 3D computer models the problem is how to get this information on to the construction site. Gehry Technologies comments on "The potential for digital technologies to change the nature of professional practice and address the underlying inefficiencies and conflicts resulting from and outdated process". (2). Gehry Partners provide the contractor with a full 3D CAD model as part of the contract documentation. The CAD software is complex and requires an experienced operator. This leaves a gap between the CAD operator and the construction workers opening up another area for confusion and productivity loss.

In his book Architecture's New Media, Kalay notes that "The opening of a new kind of space made possible by computers and networks promises to revolutionize our perception of reality like no other invention before it and challenges the professions of architecture, town planning, and interior design which have been striving to accommodate human activities in the physical domain for thousands of years." (80)

A study carried out at the Pennsylvania State University using 4D CAD modeling in the education of architectural engineering program to teach construction processes suggests, "students can understand construction projects and plans much better when advanced visualization tools are used" (Messner 1). Johns and Lowe report similar findings with landscape architecture students at Victoria University of Wellington, "Four major benefits of using real-time modeling over physical scale modeling identified by the students were; comprehension of scale, engagement of other senses with sound, understanding space and time, and the ability to interact with others in a virtual landscape." (Johns and Lowe 1)

3 3D computer models

Architects and spatial designers are moving from 2D CAD software to 3D CAD software and creating complex detailed 3D computer models. How can these 3D computer models be used for more than the design process and marketing? It no longer makes practical sense to only use 2D drawings to communicate complex 3D space. Currently most designers end up converting the 3D models into 2D drawings for construction documentation, losing the benefits of the models; relationship of elements, context of spaces, control of view and layer control.

Presently, the most significant challenge resides in how to view not just 3D models on site, but any digital drawings. A number of recent research projects using handheld computer to access

2D CAD drawings on site show little success due to the small screen real estate which hinder the display of drawings formatted for large paper sizes. The processing power required to access a full 3D CAD model is still limited to laptop computers, which are cumbersome and expensive to use on an actual construction site. As most current 3D models presented as rendered images or pre-rendered walk/fly through animations produced to explain the project to clients or for marketing material, have a fixed view, limiting the full potential of 3D CAD models. These factors make it time consuming to produce and limit the use of these images and animations on the construction site. Instead, a hyper-model renegotiates the relationship between architect and builder by assisting builders and contractors to envision the built work and its installation process more vividly. One of the major benefits of these models is to help contractors visualize what it is they are building.

4 Experiments

Two experiments by the author explore the interactive power of the 3D game engine Source™ by Valve Software Corporation through the use of the architectural drawing conventions of the section and exploded axonometric. Both experiments use Ludwig Mies van der Rohe's Barcelona Pavilion to demonstrate the potential of this technology. These experiments were carried out to investigate the potential application of current gaming engines for architectural visualization purposes. Both experiments are based on 2D drawing conventions and developed with the interactive possibilities that the real time 3D game engine provide.

The section pavilion (fig 1) explores the notion of representing a section and its accompanying information within an interactive real time 3D virtual environment, rather that just a flat 2D sheet of paper, which is isolated from its location and heavily encoded. Instead of the sections being referenced from a plan or other drawing in a customary manner, the sections within the pavilion hyper-model are identified by numbered markers indicating their location and upon selecting one of the thickened sections, it moves out from its actual location to sit next to the model.

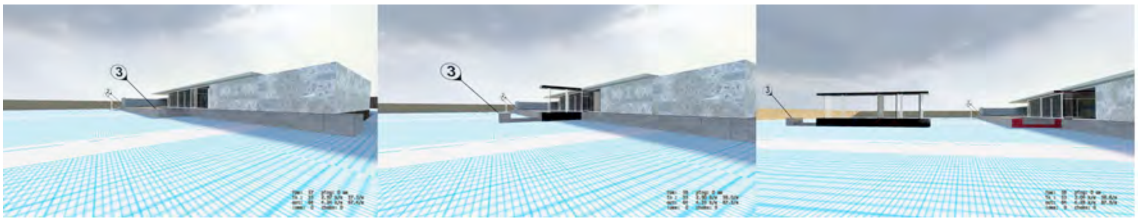

Figure 1: **Still images from Section Pavilion hyper-model**

The layer pavilion (fig 2) takes the exploded axonometric into the interactive environment giving a viewer the ability to control which parts of the Barcelona Pavilion are pulled up off the base, letting a viewer experience the separate elements and demonstrating the "essence of the Barcelona Pavilion. This mechanism facilitates analysis of the different building elements and the relationship between components.

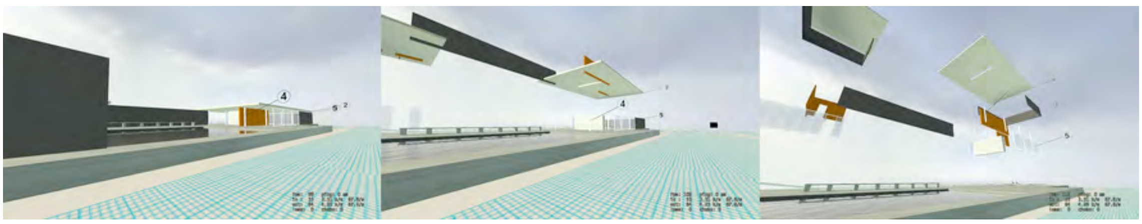

Figure 2**: Still images from Layer Pavilion hyper-model**

It becomes clear from these experiments that an architectural hyper-model provides useful methods of visualization, but can also introduce confusion as conventional drawing methods do. Therefore the research suggests another language needs to be developed that builds on the potential of the real time interactive power of the software.

5 The Hardware

Desktop computers are commonplace in architects and construction site offices, but until recently they have only been used as a digital drawing board. Current CAD software packages work well for designers and architects, but the information is still being documented through 2D drawings. Currently considerable effort and time have been put in to the CAD software industry to enable easier and faster input and control, with little research focused on the delivery of construction documentation.

Handheld computers have been used on construction sites from as early as 1992, but have never been successful due to lack of processing power, screen size, and limited software. Recently handheld computers have increased in processing power and screen resolution which has led to a greater use on construction sites, speeding up communication, mostly for text based information as their has been no useful way to view construction drawings on their small screen (Saidi, et al 2). Intel estimates that, with current software, utilizing handheld and mobile computing on site would boost productivity by 20% to 30% (1)

One problem with handheld units is that the 2D drawings have been formatted for large sheets of paper. While some construction details are viewable on the small screen of a handheld computer, they become hard to reference from a large scale digital plan or section. By changing the method of describing space from just 2D drawings to dynamic navigable 3D space, most of these problems can be solved by:

- Being able to visualize the design proposal in real time
- Having access to construction documentation/3D models on site (PDA PSP)
- Collaborating and communicating in real time between multiple participants
- Virtual meetings in a shared, information enriched 3D online space

6 Future directions

The research so far points to additional technologies that can be added to the handheld computer providing greater functionality. RFID[1] readers and global positioning system (GPS) modules represent potential additive technologies. In-depth analysis of these items exceeds the scope of this research; the following outlines only how they could be developed in the future.

It is predicted that RFID tags will replace barcodes in the coming years, enabling an architectural hyper-model running on a handheld computer with a RFID reader to access location and detail information about tagged items as they come within proximity of that item, all shown in real time and 3D. For example, as steel trusses are delivered on site, the construction worker can be shown the exact location each truss is to be installed So rather than searching through hundreds of drawings to find their location, the information is provided automatically.

In addition to this the architectural hyper-model could be fitted with a GPS module to provide location based information. As a construction worker or architect walked around the construction site with a handheld computer the GPS would locate them within the hyper-model. This would enable a clearer understanding of the location of the proposed building and its elements.

7 Conclusion

Presently paper based scaled drawings are the dominant means of construction visualization within the construction industry. As the use of computers and CAD software within the architectural design process has become standard, the development of the software has progressed along with the up-take of the software technology in architectural practice over the last 50 years. The only change we have seen in the construction documentation is an increase in the amount of information provided.

This research proposes to introduce architectural hyper-models with the aim of enhancing comprehension of construction drawings and specifications. By making the visualization of design proposals faster and clearer, the number of drawings required is reduced, ultimately increasing productivity and quality.

Moving away from an ‘object’ mode based CAD software to an ‘environment’ mode for the visualization provides easier access to the complex information required to build, as building projects are faced with complex requirements and tighter deadlines. The technology used allows the environments of the hyper-models to be truly dynamic; the geometry, location and visibility can be controlled providing more than just a walk-through of the project.

The pavilion project clearly demonstrates the dynamic abilities of the hyper-model as an innovative method of explaining construction information. With the ability to scale from large desktop screens to small handheld computers the content does not need to be reformatted to give access to clients at home or laborers on site. As other technologies develop, such as RFID and GPS, these can be added to the architectural hyper-model providing greater function.

8 Notes

[1] **Radio-frequency identification** (**RFID**) is an automatic identification method, relying on storing and remotely retrieving data using devices called RFID tags or transponders. An RFID tag is an object that can be attached to or incorporated into a product, animal, or person for the purpose of identification using radio waves. Chip-based RFID tags contain silicon chips and antennas. Passive tags require no internal power source, whereas active tags require a power source. (http://en.wikipedia.org/wiki/RFID).

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INSTRUMENTAL ANALOGY

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Abstract

The scalar mediation of the object through the space of representation ensures design methodologies based on similitude or procedural techniques must initially work upon appropriated forms. Given that translation ensures that these forms remain as a trace the architectural object is implicitly reliant on the application of analogy. While still bound to the act of drawing in, on or through the digital distinguishes itself from the explicit appropriation of forms and techniques typical of pre-digital design methodologies because analogy is more than re-presention.

The interaction of data mining and modelling software to act on qualitative and quantitative data sets offers a different design process because it allows analogy to operate as a primary disciplinary condition. Importantly the tension between the analogy, software and data enables a productive play that doesn't immediately prescribe or defer to conventional architectural forms. No longer concerned with re-presentation, analogy is subsequently free to explore and test architectural objects where the 'content' or value resides in the affect of form and therefore undoing the longstanding binary logic separating form and content.

The paper, in reference to specific projects, will discuss the capacity of analogous modes and techniques in translating data into form through modelling software. An argument will be made that the value of this line of design-based research resides in the unique way in which its propositional and procedural opportunities calls into issue the notion of affect.

Keywords: Analogy, Affect, Data, Information.

1 Instrumental Analogy.

Despite the last decade of digitally authored design processes there remains a divide, equally in the academy and the profession, about the intrinsic value of the artefacts arising from these methodologies. The tendency to promote such artefacts as avant-garde, when coupled with a distinctive visual language, no doubt antagonises those who see the instrumentality of these digital tools as diminishing architecture's own specific historic, theoretic and tectonic frameworks. These attacks might be rejected as nothing more than a trace of architectural iconophobia if it weren't for the willingness for digital practitioners to exploit the imagistic facility of these tools. This tactic becomes particularly problematic when the image is asked to establish the value of such forms, instigating a process where these artefacts are propagandised precisely on the demonstration of formal uniqueness. Accordingly for the digital is to possess any worth it is equally incumbent on all parties to move beyond the image and focus instead on the formal implications of the techniques drawing rather than the drawing itself. This worth lies not only in the capacity of the digital to foreground contingent information and data sets but also in the way in which it offers a proliferation in the analogous frameworks that avail themselves in the thinking and making of architecture. These distinctive analogous frameworks offer propositional and procedural opportunities that, once liberated from the concern with the drawing, enable an exploration of broader social issues within notions of performance and affect. Such a position relies on the acceptance that re-conceptualisation of representation from formal similitude to formally generative tool ensures that design instigates an interplay with the act of drawing between disciplinary knowledge and the modes and tools of representation.

Robin Evans (153-193) argues that the tools and modes of representation significantly mediate form because of the scalar process of ideation to realisation. The mediation of architecture by the techniques of drawing suggests a more radical approach where representational space can be deliberately exploited as the primary mechanism to explore and test form. This is in stark contrast to traditional design processes where such an intercession is conceptually problematic because it severs formal and material fidelity. The drawing must communicate, not mediate, form. To rupture the tectonic basis of form making is therefore to contaminate the design process itself. The belief that the integrity of the artefact is established by its link to the 'real' constrains form making to the discipline to precedent, whether it is based on formal or structural and constructional logics. Precedent, as a model that offers a "standard or example for imitation or comparison" (The Macquarie Dictionary 72), can only ever be understood as partial similarity and is only evident as a trace within each 'new' project. The use of precedent is to treat form as analogous to those exemplars and models because each new architectural project requires a unique response. Andrew Benjamin's (11) use of the term 'alterity', is particularly helpful here in that the identification of the uniqueness of each new architectural artefact is a product of the contingency of the re-visiting of the issue of function over time. Each revisiting of function must be premised on the expectation of difference. The dictates of function together with the contingencies of the temporal interpretation of program and the specificities of site ensures that each iteration of form instigates a process of reconfiguration of these factors that renders every project unique. Accordingly privileging precedent as a template or exemplar renders it analogous to the model on which it is drawn. The model, of course, can only act as a formal guide, so that processes wedded to precedent are rendered analogous on the basis that analogy, as a "correspondence between the relations of things to one another" (The Macquarie Dictionary 1381) or "a partial similarity in particular circumstances on which a comparison can be based" (The Macquarie Dictionary 1381), functions as a product of dissimilarity between projects within the discipline rather than a categorical disciplinary similarity of which it can be said to be a part of. Accordingly the dissimilarity within the discipline, rather than outside or between disciplines, renders precedent based design processes as a function of analogy.

The presence of analogy is not surprising given that the scalar mediation of the artefact through the space of representation ensures that all design methodologies, whether they are based on similitude or procedural techniques, must initially work upon a selection of form (Evans 156). It would be naïve to suggest that digital design practice is the first example of design processes that are able to conceive of design methods that act outside specific disciplinary knowledge. There are numerous examples over the last twenty years alone where methods have been actively developed to dislodge precedent. The important distinction between the digital and these other processes is that they tend to function via a deliberate interdisciplinary slippage by appropriating modes of practice from other fields. These processes have been validated through demonstrating the architectural-ness of the artefact rather than the architectural-ness of the process itself. While still bound to the act of drawing in, on or through, the digital distinguishes itself from the explicit interdisciplinary appropriation of forms and techniques because analogy is more than a deliberate attempt to free oneself from the conventional.

Practitioners of digital design practice may appropriate tools outside the discipline but they do so for their capacity to translate information relevant to architecture. The exploitation of the instrumentality of the digital tools of representation are, as such, conceived to work within the discipline but outside a reliance on the re-application of precedent form. The question of form is related to the capacity of the digital to capture and simulate the contingent and temporal through the parametric exploitation of software. For Greg Lynn this allows architects to conceptually approach architecture through inter-relational flux rather than stable form, where the "shape of statistics, or parameters, may yield a culturally symbolic form, yet at the beginning, their role is more inchoate" (39). However, while it is clear that use of parameters and statistics requires an abstract, and often less representational origin for design, this in no way frees such processes from analogy. The digital might be an artificial rather than organic process but this understanding is belied when Lynn describes such processes as natural and evolutionary. To quote Lynn, animation processes "implies the evolution of a form and its shaping of forces; it suggests animalism, animism, growth, actualisation, vitality and virtuality" (39). This may be pedantic, but clearly the attempt to establish legitimacy for the process requires, in this case, the erasure the any indication that the process is analogous. This is particularly evident when Lynn seamlessly shifts the use of the spline from its original role as a geometric method of indexing the effects of gravity on material to an indexing of data. One might tolerate the making of form based on the correspondence to structural performance; however, once this link is ruptured it is clear that analogy is again at work because the spline represents or stands in for information.

The fact that these processes are analogous should not, of course, be of any surprise given that information is immaterial. However, claims that these models transform information cleanly indicate a certain level of criticality. This is not to argue that fidelity between information and form is impossible. NOX's wet grid projects offer a prime example of how the artefact is formed within a strict understanding of analogous performance. This system, either as a way of distributing circulation (Soft Office and ParisBrain projects) or structure (World Trade Centre project) is able to set up an assessment of performance that is directly embedded within an understanding of the interplay of gravity and material. Yet in as much as the analogue computer is not concerned with the actual materiality of the project, the folding of the adopted material system back into a tectonic expression is still a highly interpretive act. To see the outcome of any wet grid as purely a tectonic question is to erase the potentiality of the drawing in a similar same way as when one draws a section of concrete footing as a perfect rectangle. Aligning the mode of representation to a built condition is to somehow enforce a formal discipline on the way one sees the artefact and so limits the offered interpretative opportunities. Nor is there any questioning of either the data's status or actual worth. The privileging of quantitative information fundamentally possesses the danger of the reduction of complexity to statistical averaging, which serves only to promote the normative over the particular. The potential of the digital to generate a range of options is underscored by an acknowledgment that the digital design process can never be automatic and lineal.

If such practices rely on analogy as much as any other, more conventional, practices then the Digital's contribution to design based research exists beyond establishing legitimacy through fidelity to data. Architecture still departs from the selection and then application of form, and the translation of data can occur only once analogous form has been selected. The important difference is that the analogous forms of the digital function as a performative mechanism rather than some type of formal template. As with all technological shifts the disruption caused by theses new methods of formal production offers another scopic regime through which to make and understand the artefact. This, in turn, alters the visual and social understanding of the form. As Martin Jay points out, any consideration of the validity of a particular scopic regime requires us to first "learn to see the virtues of differentiated ocular experiences (and) wean ourselves from the fiction of a "true" vision and revel instead in the possibilities opened up by the scopic regimes we have already invented and the one's… that are doubtless to come." (20). The digital is obviously not natural but to reject its validity would be to implicitly suggest another regime is.

The digital fundamentally reconfigures the way in which form making is thought because the tools and techniques allow us not to erase but instead build on existing analogous modes. The new scopic regime of the digital should be approached then with a certain level of optimistic inquiry. To quote Jay again, what is required is a clear acknowledgment of "the plurality of the scopic regimes now available to us. Rather than demonize one or another, it may be less dangerous to explore the implications, both positive and negative, of each." (20). The significant and distinguishing attribute of the digital evidently lies in its ability to facilitate analogous design practices that approach formal and spatial issues from a point of complexity rather than either formal appropriation, simplicity or clarity. Simultaneously the generative capacity of digital tools forces a mode of engagement where formal instrumentality requires an open exploitation of an alternative scopic regime centred at the site of architecture's real space of work, the drawing. The validity of this line of inquiry is not that it is new but rather than it allows us to re-think and re-interrogate the question of form making. The corresponding recalibration in the hierarchy of representational modes from orthographic projection and perspective to the diagram not only fundamentally re-prioritises the working order in which modes the architect deploys them but in fact expands the repertoire of drawing practice. In this light the various ways of thinking about form, be they ecological systems, the animation of temporal variation or scripting, allow the designer to re-conceptualise the techniques of form making, but also, more importantly, offers alternative ways in which to engage with the social and cultural questions.

If the digital requires an interpretative approach to both the initial selection of form and an anticipation of its performance under the affect of information then it seems reasonable to suggest that the issue of signification might also be factored into the project and not outside the architect's remit. The cultural significance of any artefact is perhaps too important to leave as a retrospective act. One may or may not agree with the prevalence of the image but for architecture, as a social act, it remains an important design issue. This much is clear in P.T.W's use of the bubble analogy for a memorial to the victims of the Indian Ocean Tsunami disaster. The desire to exploit technique fails to register its figural reading within a specific social and cultural context. It is important that architects reclaim a certain level of responsibility for the objects performance both to quantitative data and qualitative cultural information.

It is respect to these issues that I'd like to discuss AARN's scheme for the recent Canberra Parklands Competition, which was for the redesign of a site located on the northeast shore of Lake Burley Griffin at the base of the Parliamentary Triangle. Obviously, as with any truly collective work the trajectories of any specific project can be taken in a number of ways. Personally the initial response to the competition brief developed from the insistence that the design build upon the Griffin Legacy. The desire of the authorities to promote the city through the genius of Griffin is troubling on two counts; first being that Canberra was a product of a single hand, and the second that the city today is somehow a true reflection of that plan. Of course, given that the programmatic organization of the Griffins' scheme bears little resemblance to the present city, it is obvious that this plan has been assigned enormous cultural status. The only real remnants of Griffins' legacy lie in the road layout and the dominant landscape. The hexagonal geometry underpinning the city's organizational logic exists in the aerial view only; experientially the equilateral triangle dominants. The geometric configuration of the Parliamentary Triangle effectively folds the imagistic city emblem together with the logic of the plan's spatial organization. Consequently the decision to respond to this figure seemed relevant because of its assigned cultural significance. However, unlike the Griffin's pure geometric form it was always intended that the computer would lead to a formal and spatial complexity, where form was expected to produce a highly complex triangulated tessellated terra-form that not only resisted the symbolic assignation of the equilateral triangle but also provided a formal logic of variation by which to develop and distribute program. The figure of the triangle was, therefore, a tactical response to the issue of the city's motif that could be then formally redeployed as a rationalisation of curvilinear surfaces that reminds one that there is nothing natural about Canberra's landscape.

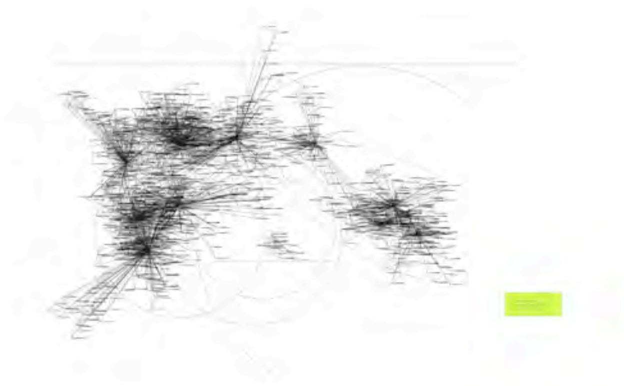

Figure 1. **©AARN**

At this point the triangle acted as a formal guide without defining a tectonic condition. The approach to the formal articulation at the scale of the site required another analogous form. It was decided that a Maya© L Script provided a suitable analogous framework in which to approach the issue of site as an idea of formal distribution (Figure 1). The benefit of the script being that it furnished a skeletal frame that yielded complex tessellated form (Figure 2). The value in adopting this mathematically based script was that the variation in branching angle and length provided a useful analogy for the type of parametric performance the team was after. This performance was further enhanced by defining of a series of zones that, by embedding the effects a range of existing and projected conditions, modified the distribution of this frame. This ensured that the role of analogy was different to those of precedent by delaying form making until the potential of distribution could be assessed.

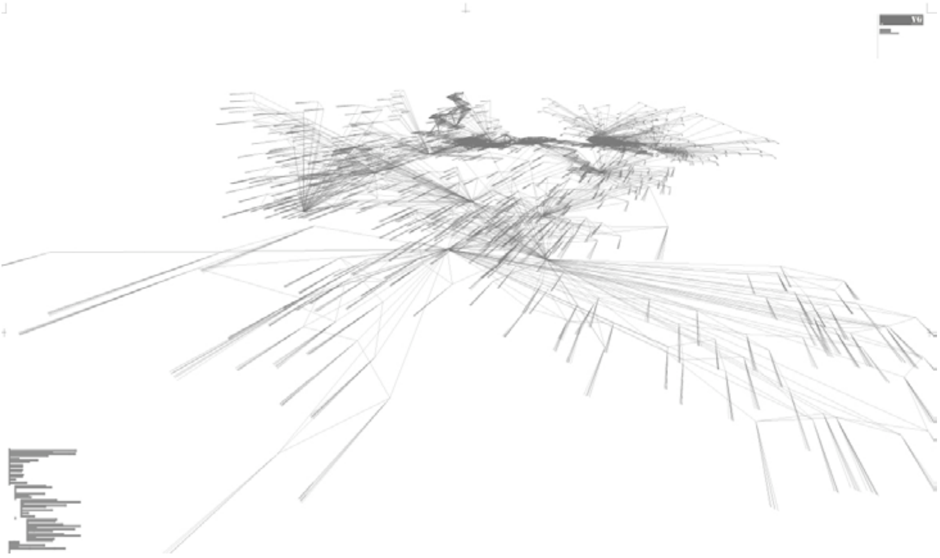

Figure 2 ©**AARN**

The conversion of the L script frame into a complex tessellated landscape, accomplished by a lofting procedure, finally delivers a triangulated form that experientially reinforces the artificiality of landscape (Figure 3). Importantly the approach to program is opportunistic in that the growth of the script suggested that these triangular territories resist the notion of park as a purely recreational space. It effectively allowed the team to think of this landscape as a productive laboratory where the main program, a Museum Of Ecological Succession, sets in motion a gradual temporal reconfiguring of the ground. Therefore it can be said that the selection of the triangle and the script provided analogous forms that together produced a way of thinking about formal and programmatic distribution as a set of performative permutations rather than identifiable built form.

Figure 3 ©**AARN**

The L-script could have been formally interpreted in numerous ways; at certain moments it was tested as a point force modifying the landscape or through aligning visual density to programmatic density (Figure 4) However, the value of the triangulated terra forming process was that it acted first to question the account of Canberra's development as merely the unfolding of the Griffin's master plan and second remind one that the Canberra's landscape is anything but natural given that it is underpinned by a pervasive geometric order. The E.M.S. presents another triangulated geometry that disrupts the city's overarching geometric order, which as a motif acts as a figure without figurative content and returns to enforce an abeyance of signification to the point that its experiential affect assumes primacy. Working to constantly undo the expectation of order offered by pure geometries the experiential affect of form replaces the figure's narrative effect enabling an engagement with questions of signification and meaning without the usual stability expected of a semiotic clarity. While this situates the outcome within a linguistic framework through the provision of emblematic form it is also rendered instrumental when accepting both that the undoing of cultural signification and that the analogous forms allowed another way of conceiving of the landscape operate at a performative level.

Figure 4 **©AARN**

The E.M.S. demonstrates that a strategic cultural and performative engagement of the digital's techniques and tools circumvents the issue of novelty. In so doing the digital endgame of formal dexterity is repositioned within a question of the way it performs. The Canberra Parklands project is by no means the solution to questions facing the digital but as its techniques become normalised it does indicate another way in which it might establish a conversation about the potential in understanding the content in form. No longer concerned with re-presentation, analogy is subsequently free to explore and test architectural objects where the 'content' or value resides in the affect of form and therefore undoing the longstanding binary logic separating form and content. The interaction of data and modelling software to act on qualitative and quantitative data sets offers a different design process because it allows analogy to operate as a primary disciplinary condition. Importantly the tension between the analogy, software and data enables a productive play that doesn't immediately prescribe or defer to conventional architectural forms.

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BUIILDING SKINS AS KINETIC PROCESS: SOME PRECEDENT FROM THE FINE ARTS

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Abstract

The aesthetics of form in motion has been a central preoccupation for the visual arts of the twentieth century, culminating in the establishment of kinetic art as a distinct area of activity in the 1950's. Architecture has traditionally resisted ‘building kinetics’, but has embraced the body in motion, usually on foot negotiating in (subtle) interaction with static form. However, one aspect in which kinetics would appear to be acceptable is at the building periphery, where intelligent facades track sun angles, or moderate air movement in response to internal temperature sensors. On another track is the proliferation of media facades in various guises that transform facades into urban information interfaces or media art works. This paper suggests that both intelligent and media facades set a different agenda for designers who have traditionally worked towards finding the best static mix of performance and elegance. Arguably, intelligent and media facades raises the question of ontology from a designer perspective - what are the design parameters when the outcome is a kinetic system, rather than the traditional static artifact? In order to approach the issue, this paper examines some precedent from kinetic art of the 1960’s and contemporary generative arts, for the insight they may provide. These sources then inform a preliminary outline of the range of parameters that may be considered by designers.

Keywords: architecture, design, kinetic facades.

1 Movement at the periphery

Traditionally, architecture does not move, but it can be designed to embrace the movement of the observer, with Corbusier’s promenade architecture an oft cited example. Bois and Shepley’s “A Picturesque stroll around Clara-Clara” traces a genealogy of the “peripatetic view”, from the Greek revival theories of Leroy, the multiple perspective of Piranesi, Boulee’s understanding of the effect of movement, to the Villa Savoye where architecture is best appreciated, according to Le Corbusier “ on the move”(56). Such approaches can be captured by the statement: static architecture plus mobile observer results in a kinetic experience. This form of kinetics is referred to here as ‘passive’, as while there is motion involved, the architecture itself is inert. Passive kinetics also occurs when appearance of surface, form and space is altered by changing environmental conditions. In this case, buildings are designed to accentuate visual transformation in response to different light intensity and direction, the presence of moisture, and wind conditions. These two forms of passive kinetics – movement of the observer and transformation due to changes in environmental conditions - are often raised when discussing the merits of actual movement, usually with the innuendo that kinetics is best conceived ‘subtly’ embedded in static form. While acknowledging the value of passive kinetics to enliven static form, the focus here is on the implications for design when kinetics is ‘*active’* - defined as *translation, rotation, and scaling of building components*, or the *controllable transformation of material properties* (for example that enabled by smart materials). The demarcation between this definition of kinetics and the passive approaches outlined above, provides one limit to the discussion. Further limits are the focus on the facade or ‘skin’, which excludes for example, interactive internal environments such as intelligent rooms, or the idea of re-locatable / reconfigurable buildings championed by the archigram group and others in the 1960’s.

Within the above limits, there are currently two areas in which active kinetics are being implemented: intelligent skins are being designed with an environmental science agenda; while in a parallel line of inquiry, there is experimentation with a range of approaches to embodying information, known as media facades. Previously I have argued that there is common ground between environmental facades and data driven skins, in that the design outcome is a process rather then an artefact (683). Rather then being realized as a static object, kinetic skins are manifest as a temporal system, an ongoing process based on: *input* obtained from sensors or other interface devices; *control* systems that use logic or emergence; *output* manifest as moving components or transformation of material properties. The question being explored here, is whether this shift from artifact to kinetic process as an outcome, also suggests an ontological shift. What actually are we designing when we consider the kinetic skin? If we go beyond passive kinetics, based on motion of the observer or optical illusion, and consider the design of active kinetics various questions arise, not the least is it architecture. The view taken, here is that kinetic facades are a development of standard architectural concerns. As evidenced by intelligent facades, the possibilities are for a responsive membrane that adapts to changing environment conditions and user occupancy, continuing the trajectory of functionalism. Media facades by contrast, resurrect the cultural role civic architecture once performed as containers of information. Somewhere between the two, and as yet under theorized are new compositional opportunities for designers, such as that suggested by the poetry of a flock of starlings or a Bill Viola artwork. In summary, the potential of kinetics for building skins are to improve environmental performance, resurrect the cultural role of architecture as embedded information, and allow new forms of composition. However, putting design intent to one side, the proposition here is that regardless of the application, active kinetics raises the question of ontology from a designer perspective - what are the design parameters when the outcome is a process, rather than an object?

In order to approach the question, this paper examines some precedent from kinetic art of the 1960’s and contemporary generative arts, for the insight they may provide for the design of kinetic process. Compared to existing precedent in architecture, the range of visual art works that are inherently kinetic is vast. The approach taken is to sample two examples of critique, rather then examine particular works: for the kinetic arts the writing of pioneering artist George Rickey analyses work before the widespread availability of computers; while Melbourne artist / researcher Alan Dorin provides both a useful set of analogy’s and a valuable taxonomy of physical process, which he argues underpins the generative electronic arts. These two sources then inform an outline of the range of parameters that may be considered by designers of building skins as kinetic process.

2 George Rickey’s “Morphology Movement”

Aesthetic outcomes generated by movement can be traced as far back as ancient wind chimes, but the term kinetic art came into being in the twentieth century, with Duchamp’s 1920 work ‘Rotating Glass Plates’ generally acknowledged within western art as the first exhibited work in which the aesthetic is based on physical movement. Other seminal works include Gabo’s ‘Kinetic Sculpture’ (1922) and Moholy Nagy’s ‘Light Space Modulator’ (1930). Anthony Calder dominated the pre-war period with a series of suspended compositions, while the most prolific period for kinetic art was during the 1950’s and 1960’s. In addition to the continuing popularity of Calder, prominent artists include Schoeffer, Takis, Lye and George Rickey. Rickey trained as a painter in Paris before returning to America in 1949 where he started producing steel sculpture based on a system of meticulously engineered counterweights and bearings, activated by air currents and the pull of gravity. He would continue to refine his work for the next fifty three years, while at the same time teaching and writing in the United States.

Rickey's essay 'Morphology of Movement: A study of Kinetic Art ', is one of the few attempts at a formal discussion by a leading artist and provides a useful overview of six general directions for the period up until 1963 (222).

(a) Experimentation with optical phenomena, such as moiré effects;

(b) Transformation based on phenomena such as wheel spokes in motion, or through motion of the observer such as effected by polyphonic painting;

(c) Works where the surveyor physically interacts with the work;

(d) Machines where motorized gears and pulleys cause 'orchestrated' movement;

(e) Light play based on coloured light, shadow and reflection;

(f) "'movement 'itself' usually with economy of means and self effacing mechanics".

The first five general directions all seem self evident, but what does Rickey mean by "movement 'itself'". The term is a direct quotation from the "Realist Manifesto" in which Gabo observes the limits of Italian Futurism - "It is now obvious to everyone of us that by the simple graphic registration of a row of momentarily arrested movements one cannot re-create movement itself" (221). In his morphology, Rickey argues that the ontology of kinetic art is best addressed by dealing directly with actual movement rather then optical effect. He has a particular dislike of the use of machinery, where repetitive motion generates for him, "a more emphatic stasis" then lack of motion. His argument is that true kinetic works are those where the capacity for motion is designed and is intrinsic, allowing an experience of movement 'itself', without the distractions of mechanics, form, relief, colour or figurative associations (225). Rickey's intuition that kinetics can be clearly distinguished, has been subsequently been proven in medical research, where Zeki and Lamb have determined motion is an autonomous visual attribute, separately processed and therefore one of the visual attributes that have primacy, just like form or colour or depth (607).

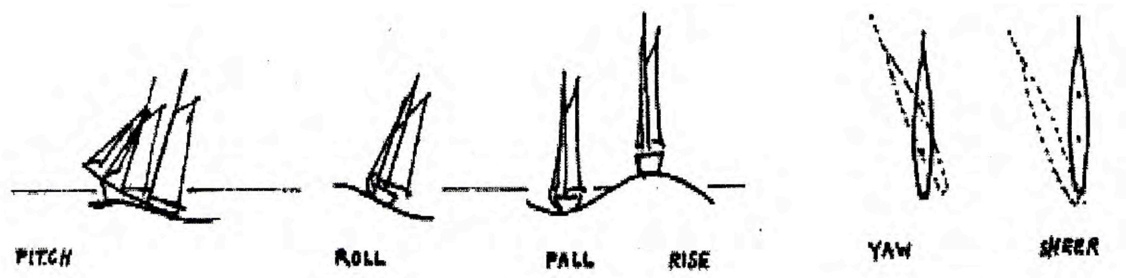

Figure 1**: George Rickey – range of movement for a ship at sea.**

Rickey's continues his assertion that the essence of kinetic art is the design of movement, by articulating a range of examples: the classic movements of a ship at sea (pitch, roll, fall, rise, yaw, shear) ; vibrating springs; the non periodic movement of a pendulum. For Rickey these are examples of a vocabulary of form in motion, small in number and surprisingly simple, "scarcely more" than the twelve tones of western music (226). Continuing his analogy, this vocabulary is arranged as sequences over time in a similar manner to musical composition. Rickey differentiates kinetic art from music, in terms of its openness to chance "introduced by the movement of the observer, which the artist prepares for but does not predetermine, or by incorporating in the object itself, some factor of fortuitousness" (227). Rickey's example of a ship at sea is simultaneously accurate, in terms of indicating axis of rotation or translations in space, and poetically evokes an aesthetic particular to the circumstance. The ship is an object suspended between fluid and air, with movement by sail or engine dampened by the viscosity of water. The hull is floating, able to simultaneously slide or pivot in any axis, movement is directional, but with the inertia of water and wind mediating the propulsion of screw or sail. There is a particular tempo and the sublime evocation of mass and force resolving in slow motion, an example of "movement itself", that provides a precedent for the articulation of a vocabulary of movement for the design of kinetic skins.

3 Dorin: painter, playwright, gardener

A key factor in Rickey's argument for a sophisticated kinetic art was the capacity for a work to accommodate chance, either through making the work open to interaction with environmental forces and / or the anticipated but non-predetermined interaction with users. A contemporary art practice that can trace its genealogy back to the idea of indeterminacy as articulated by Rickey, is a form of electronic art described as genetic or evolutionary. For theorist and practising artist Alan Dorin, a key concept that underpins this approach is ‘process’.

> *“A process is any connected sequence of events or actions, it is closely linked to the concept of an algorithm, a sequence of steps for carrying out a task. The concepts of process and algorithm are linked with those of dynamism and change.”* ("Physicality.." 80)

In a paper that proposes an understanding of physical process is useful for electronic artists, Dorin distinguishes three different types via the example of the painter, the playwright and the gardener: the painter engages with process in terms of colour mixing and application technique but the process is fixed in the final artefact; the production of a play produces a repetitive process, in which the outcome follows a closed script, but is open to nuance in its performance; and the garden in which there is no script but an ongoing process according to natural laws and the ‘pruning’ of the gardener ("Generative.." 49). These examples, according to Dorin, illustrate the three approaches to using process – fixed, repetitive and ongoing.

Where might we position the architecture in relation to fixed, repetitive and ongoing process? The use of the painter, playwright and gardener to articulate differences between the engagement with process as a means to generate fixed outcomes, and those where process is ongoing, is useful in discussing the traditional role of process in architecture. Process such as sketching and study models are used to design, but once realized the experience of architecture, to varying degrees, is affected by nuances of light, moisture and the position of the observer. We may experience variations based on the two types of passive kinetics outlined in the introduction, but essentially the same script is played out. I would argue that architecture typically has operated between the fixity of painting and the experience of the theatrical script, in which nuances in production may affect experience.

The role of process in the early design stages has been revisited by some contemporary architects, who have embraced digital technology to transform traditional practice. In broad terms there are two approaches being developed – the use of animation techniques where geometric parameters are set in motion and in a second category, those who use generative techniques borrowed from computer science, such as cellular automata or generative algorithms. In the first, the typical approach is to make parametric assemblages where the editing of a part updates the whole. The parameters of this associative geometry are then animated, usually in relation to site constraints or program requirements. The result is architectural form that can be set in motion, as a means to generate a fine grained range of possibilities. In the second approach the outcomes are less predictable, as typically form is generated from the bottom up and evolves according to a set of rules. The process generates a variety, and not unlike the example of the gardener, iterations that meet the program grow and are to varying degrees, pruned by the designer. However outside the design stage this gardening analogy ends - despite sophisticated process being used to generate multiple iterations, only one is realized. The outcome may look like a process, frozen animation or containing genetic references to a family of form, but as architecture it is experienced in typical mode, based on movement of the observer and transformation due to changes in environmental conditions - essentially the same script is played out.

By contrast the kinetic skin may, using Dorin’s analogy, be closer to the ongoing process that is the garden. As environmental conditions and user needs change over the course of day, night and seasonal cycles, kinetic skins can potentially undergo significant deformation. Through translation, rotation, and scaling of building components, or the controllable transformation of material properties, the building skin can react and anticipate changes in environmental conditions, or as evidenced by some media facades, the skin can act as a dynamic information interface at an urban scale. There would seem to be the potential for architecture to go beyond the stasis of frozen process or the repetitive script.

3.1 Dorin’s taxonomy of physical process

Some further insight to the question on what parameters are involved when designing kinetic process, may be gained by considering Dorin’s subsequent writing, in which he explores the process of natural systems , which he argues underpins most time based art. He proposes a taxonomy which classifies ‘physical’ process in a “step towards understanding the relationship between physical processes and time-based art” ("Classification.." 73). He proposes five –

pulse, stream, increase, decrease, complex. For Dorin kinetics are the outcome of a process, which can be reduced to five actions. Pulse is a “repeating sequence of events” such as the regular pumping of a heart. The spacing between events in a pulse can be of such a scale that it perceived as uniform stream. These occur at the limits of visual perception – a revolving sphere may be rotate so fast that it appears motionless or so slow that process is not apparent. Increase and decrease are relatively self evident forms of process, characterized by forever higher or lower intensity, in which the nature of the change is constant. The final category is complex process, which “forever change into new forms without reiteration”. Compared to the regular beat of a pulse, or the smooth change of accelerating or de-accelerating intensity, a complex process “will be different to all future and past states of that system” ("Classification.." 74).

4 Design parameters for kinetic skins

The proposition being explored is that the design of kinetic skins sets a different agenda for designers who have traditionally worked towards finding the best static mix of performance and elegance. Rather then a ‘finished’ architectural surface, the outcome is a kinetic process that interacts with users and in response to changing contexts (environmental and socio-cultural). Arguably, the range of design parameters that need to be considered change the essence of design – the architect is realising a kinetic process as opposed to designing a static object. This shifts the emphasis from ‘a’ design solution to the specification of parameters: what input and how is this ‘sampled’ ; the logic of the control system that processes this data; the parameters of the building components or materials that will move in response to the control system. Typically architects engage with the final stage of the kinetic process – the building component or material specification. However if we are to exploit the opportunities offered by kinetic skins designers need to be involved in the design of the system as well as the components. Here the precedent of architects using digital process as a design aid may be useful. Conceptually, the design of kinetic skins is similar to some of these advanced techniques where the designer adjusts parameters to generate a range of outcomes. Except in this case there is no final form, rather the design outcome *is* kinetic process, from which multiple forms will occur over the life cycle of the building.

From this position, the writing of Rickey and Dorin may be useful for indicating where design decisions occur and the range of parameters that may require consideration. This preliminary outline is intended to identify the general range of factors to be considered, rather then the prescription for any particular design approach. A flaw of all generalist models is that the specificity of each project makes some aspects redundant. However, as a means to articulate the ontological shift that occurs when considering kinetic process as an outcome rather then a design aid, the scope of decisions occur around three interconnected groups of parameters. As the diagram below suggests these are:

(1) Choice of input or *sampling;*

(2) The manner in which these samples are processed by the *control* system;

(3) The *tectonic*, or constructional logic and appearance of the skin.

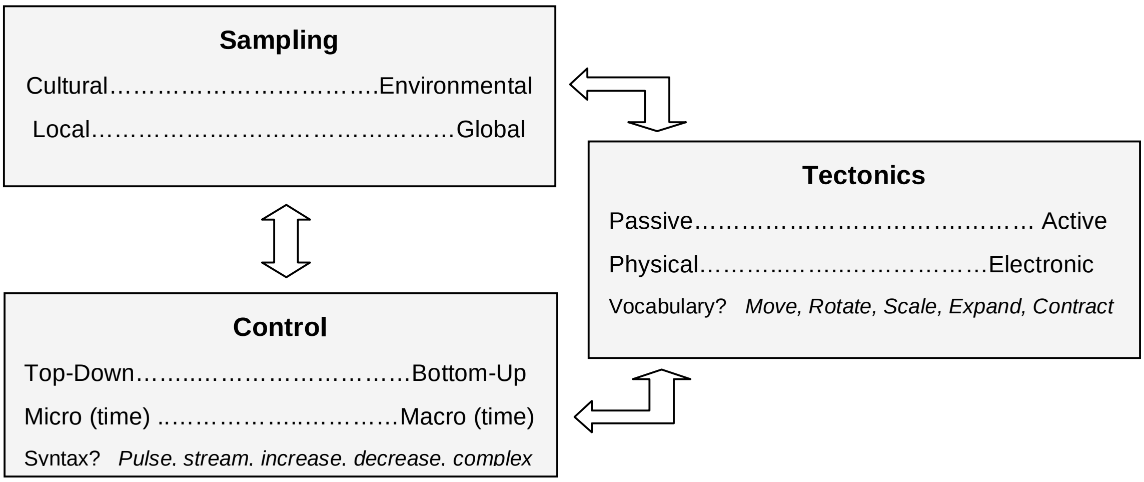

Figure 2**: Design parameters for kinetic skins**

4.1 On sampling

What data will constitute the physical and what Anders has termed ‘virtual space events’ of the interactive skin and how will these be captured or sampled? (402) A range of physical sensors are available, tuned to environmental data, physical movement or requiring direct interaction. These can be complimented by data networks that allow access to remote data. Architecture has a long tradition as a form of public art and there exists an opportunity to sample a range of cultural inputs as well as environmental stimuli. Environmental input would necessarily be related to the local, while cultural input could sample both the global and the local. The design of the input mechanism will obviously be dependent on application, but considering this in terms of a full set of possibilities makes explicit that this is a design parameter and specification excludes or includes opportunities.

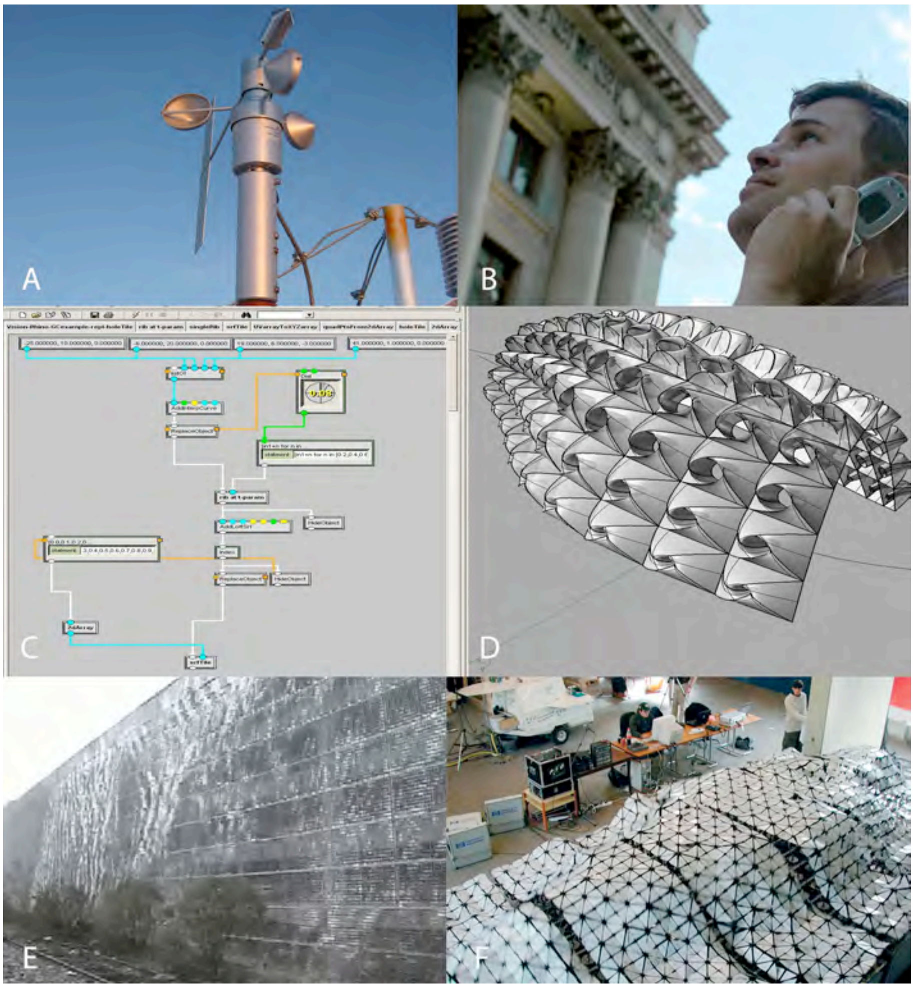

Figure 3: **A/B-sampling data from sensors and information portals; C/D-visual programming interface controlling prototype facade (Janssen and Kramer); E-tectonic wind wall (Ned Kahn); F- agesis hyposurface (Gaulthorpe et al)**

4.2 On control

If there is some form of mediation between input and resultant affect, how might this meet aesthetic as well as performative criteria? There may be an opportunity for auto-poesies in which the aesthetic is to a degree, emergent. Alternatively the personal aesthetic of the designer may be embedded in a similar manner to, for example, such proportional systems as used by Palladio or Le Corbusier. Thus the control system would be located within the spectrum of top-down, in which particular criteria are ‘directed’ and bottom-up approaches where parameters are set for the evolution of behaviour.

Artists and architects considering the design of interactive skins need to consider foremost that the design of process requires a consideration of performance over multiple time scales. This would range from the micro to the macro in relation to human visual acuity and memory. Input may be directly streamed to output at the micro level of real time response, while simultaneously be processed to create macro scale trends that emerge over a longer period.

Dorin’s differentiation between physical and abstract process is useful, given the sampled data could relate to the physical or the abstract and the mediated output could be also be manifest via physical movement or abstract devices such as the media screen. When the control system is related to physical process Alan’s taxonomy of pulse / stream / increase, decrease / complex should be considered. This classification could be interpreted as providing a type of formal syntax for the design of process.

4.3 On tectonics

What technology is available to implement an interactive skin? Typically, composition in architectural design is based on a tectonic approach in which the aesthetic is largely based on fabrication methods, articulation of joints, and materials. As evidenced by the Arab Institute façade by Jean Nouvel, this attitude to engendering aesthetics can be extended to environmental control systems. Similarly the example of the BIX electronic skin by Peter Cook et al indicates the tectonic design of electronic displays can in itself be important. The interactive skin can be manifest in either physical or electronic form and both require detailed design in terms of their physical appearance as well as their performance. We can make a broad distinction between passive systems with minimal ‘mechanics’ such as the wind walls of artist Ned Kahn and more complex mechanical systems such as the Agesis Hyposurface.

Finally, if Alan’s taxonomy applied to control systems can be seen as the syntax, the range of movement possible with physical systems can, as discussed in relation to Rickey’s morphology of kinetic art, be considered a vocabulary of movement. Here the number of discrete actions need to be considered in relation to the chosen tectonic. As suggested by Rickey’s example of the ship at sea, the nuance of movement opens up opportunities to develop a particular aesthetic quality. This suggests a subtle range of terms, each tuned to a particular technology, as a conceptual tool to develop and refine kinetic composition.

5 Post Script

The above parameters are a preliminary view of a more extended program of research to be undertaken at the University of Melbourne. In order to evaluate and develop this conceptual model for the design of kinetic skins, the next stage will be to undertake a taxonomy of available technology using the ‘sampling / control / tectonic’ categories. It is anticipated this will produce a useful design resource, but also act as a research methodology, flushing out gaps for the development of new design approaches and technology.

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PROVOCATIVE AGENTS: AGENT BASE MODELLING SYSTEMS AND THE GLOBAL PRODUCTION OF ARCHITECTURE

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Abstract

Experimental architects are actively pursuing the use of agent based modelling as a way to dynamically simulate behaviour in cities. These efforts appear to mirror the simulations of climate scientists who have also developed dynamic models which are used to predict both global and regional climate change. In climate models it is the earth as a whole, rather than the city, which is viewed from above as a complex, dynamic and total system. In the models of cities developed by architects and urbanists agent based software has given global cities a new and enchanted life of their own. These modelling experiments and simulations have been theorised in architectural discourse as providing a link between the global city and ecological systems. The mix of biological metaphors and concepts, biomorphic forms, cybernetics and networked geometries in agent based architecture work points to the rise and theorization of systems approaches in 1960s architecture. The emergence of agent based software in architecture and urbanism will be situated in relation to its use and potential in ecological informatics, climate models, defense and manufacturing optimization. This will highlight the issues involved in distinguishing between exploratory and exploitative technological innovations. The nature of exploratory innovation is reflected in the desire of architects to visualise the global city as both an organic totality and as a intelligent and complex organism.

Keywords: Architecture, Agent based modelling, Systems theory, Global software markets.

1 Introduction

Climate researchers at England's Hadley Centre have placed on their website a Java animation depicting the earth's future (Met Office Hadley Centre 'Temperature'). The centre based in England is one of the world's leading centres for climate change research. As the java animation runs, the earth spins and pulsates with colour. This visualisation of rising temperature is derived from the Intergovernmental Panel on Climate Change's (IPCC) mid-range emissions scenario A1B. According to the IPCC, scenario A1 depicts a world in which rapid economic growth fuelled by the use of fossil fuels continues unabated throughout the 21st Century. The swathes of colour on the surface of this overheating earth change from green to a vivid red in 2100. It is not hard to be impressed by the felicity of this animation as the earth spins towards 2100. Patches of colour emerge and inexorably flow across the earth's territories. This is a visualisation of data that has been digitised, sped up and animated to depict in one web applet a global view of a dynamic and organic system. This applet is seductive because it gives the impression that this is an authoritative, definitive and entirely natural view of the earth's future. Indeed, for some of us at least, it is comforting because it at least contests the superstitions of the climate change sceptics.

The animation above is an Atmosphere General Circulation Model (AGCM) which is a three dimensional representation of the atmosphere linked to the land and the cryosphere (those places on earth which are frozen). The animation is based on various meteorological datasets compiled by the Hadley Centre over time and these can only be made sense of through a 3 dimensional visual representation. It is easy to be seduced by the felicity of this animation because it gives us a seamless and vivid impression of the earth's future. The animation represents various meteorological datasets gathered from across the land, oceans and the seas and which can only be given life to via a great deal of computing power. This is borne out by the fact that the centre uses the Metrological Offices NEC SX-6 supercomputers and perhaps this is why it is easy to forget that it this is simply a model (Met Office Hadley Centre 'Types'). As a model the applet has all of the limitations, assumptions and imperfections that we come to expect from simulations and forecasts that predict the future. One limitation in these models produced by the Hadley centre is that they only have resolution of a few hundred kilometres an the animation described above represents only one of the IPCC scenarios using a one particular global model (Met Office Hadley Centre 'Types').

AGCMs are related to weather prediction models but because they predict what will happen to the earth in future centuries they employ a coarser grain of detail. The grain of the Hadley applet is 100 kms. AGCMs are also applied to the oceans but these models 'treat the ocean as though it were a layer of water of constant depth (typically 50 metres)' (Met Office Hadley Centre 'Types'). At the next scale down sub-global or Regional Scale Climate models (RCMs) are different from the global models because they show terrestrial and marine landscapes at higher levels of resolution, at a round 50km, and take into account geographic features such as mountains and other topography which are not usually represented in global models. These models are limited to particular areas and run for shorter periods in the order of about 20 years. In contrast, Ocean General Circulation Models (OGCM) are three dimensional visualisations of ocean and sea ice. The centre has also coupled together the above models to produce the aptly named Coupled Atmosphere-Ocean General Circulation Models (AOGCMs) (Met Office Hadley Centre 'Types'). Hadley has also developed Carbon Cycle models which attempt to model information about carbon dioxide in the atmosphere and simulate what the centre describes as 'climate feedbacks'. These models are related to the centre's three-dimensional global atmospheric chemistry model called STOCHEM. STOCHEM models the 'the main agents responsible for the production and destruction of ozone and methane in the lower atmosphere' (Met Office Hadley Centre 'Types').

2 Modelling Global Cities

Like the climate scientists who have used advanced computing to model the earth's climate system architects and urbanists have also begun to use computers to model cities as complex systems. As Diana Periton recently observed in her analysis of the work of the French archivist Marcel Poete 'it was in the eighteenth century that the organic body became the dominant metaphor for the city'. (434) Like the earth in the climate simulation the City has throughout the 20th century been theorised as 'an organism in itself' comprising cells which form a 'social aggregate' exhibiting a 'functional unity' or wholeness (425). For Poete, and many other 20^{th} C urbanists, the city has and continues to be theorised as a living entity which 'develops partly through biological necessity—in order to survive, it takes its sustenance from its environment and propagates itself—but also because it is an intelligent organism, capable of reflection and the exercise of free will' (425).

The architectural and urban diagram has been an important instrument in theorisation of the city as a living entity. As Paul Emmons notes 'the twentieth century has witnessed a new kind of organic schema: the functional network' (441) Architects used diagrams of this network in order for architecture to bridge 'between the microcosmos of the body on one hand and the macrocosmos of the world on the other, reflecting organic metaphors from both directions.' (441) For Emmon 'architectural diagrams need to be understood as not merely transparent to facts but as creative constructions built upon the organic metaphors of body-building-cosmos that animate architecture a vital living body' (455). The prospect that this gap can now be bridged by modelling software rather than by diagrams drawn by hand has given rise to new and vibrant visualisations. These new organic schema appear to have overtaken and given a new life and vitalism to the functional network and bubble diagrams of modernists past. Indeed, using the new digital tools the evocative two dimensional ideograms and cluster diagrams of the Smithson's and team X, amongst others, can now be given an anatomical presence and made into flesh on our computer screen's (Smithson).

In recent architectural research global cities have begun to be modelled, visualised and likened to ecological systems through the use of agent based modelling. Agent based modelling is a method of computer simulation that treats social agents as objects which can interact with each other based on predetermined rules. This allows for complex behaviour to be simulated in and emerge from an interactive system. Agent based behaviour is dynamic and different to systems that approach or reach a equilibrium. In these experiments agent based software allows cities to be modelled with a new mimetic and functional range of locomotion, adaptation, learning, structural optimisation and pattern formation and perhaps even intelligence. This is best exemplified in the work of Michael Batty from the Centre for Advanced Spatial Analysis at University College London. Batty employs the concept of fractals to span between the macro cosmos of the natural world and the inhabitants of cities because he argues that 'fractals are good first approximations to the spatial structure of cities' (Cities 14). One of Batty's experiments is a 3-D GIS CAD Model which he called Virtual London (Urban 44). Virtual London is a three dimensional geographic information system linked to a large database of spatial information which can be mined and visualised. Like the meteorological data underlying the Hadley models the information in this database can be represented in 3 dimensions. The model is built using a digital terrain model alongside aerial photographs and then given three dimensions through the use of Light Imaging detection and Radar Data (LIDAR) (Urban 45). It is then be populated with different layers of data from other databases. This can include data such as building populations, financial data, and crime rates. Batty used Virtual London to visualise pollution and experimented with the model to see what would happen if sea levels rose 10 metres if the Greenland icecap melted (Urban 46,47).

Batty argues that 'cities in particular and urban development in general emerge from the bottom up and that the spatial order that we see in patterns at more aggregate scales can be explained only in this way' (Cities 6). Drawing on the science of Artificial Neural Networks Batty distinguishes between cellular automata and agents. He argues that the actions of cellular automata can influence other cells which in turn 'generates a spatial order at more global scales' (Cities 6). He goes on to say that 'This is because cellular structures are able to simulate the kinds of dynamics that characterize the growth of cities through spatial diffusion in the manner of epidemics, where activities influence those next to or adjacent to them' (Cities 6,7). In contrast, agents are more complex because unlike cells they are mobile. Using these two components, cellular automata and agents, Batty is able to model, simulate and represent cities. However, as Batty himself cautions this approach is not necessarily intended to be 'applicable to cities and city design. Our focus is largely on experiments with models that provide us with analogies as to how cities develop and evolve. In short, the models provide laboratories for experimentation' (Cities 9).

Batty's experiments suggest an effort to develop an architectural discourse enhanced by software alongside concepts borrowed from the ecological sciences and mathematics. This conjunction allows the gap, in conceptual terms at least, to be bridged between the body, buildings and cities and the macro cosmos of the world. Virtual London, in the computer at least, takes on a life of its own. To enliven a city in this fashion in order to bridge this gap suggests that writing computer code and scripts is now a prerequisite to being considered a fully fledged member of the architectural avant-garde. In research Institutes and architectural academy's there now exists a widespread movement in order to advance this kind of knowledge. For example, at the Architectural Association a software product, ANSYS Multiphysics, is used to simulate wind flows around building envelopes at different times during the year. This tool is described in its product literature as 'The analysis industry's most comprehensive coupled physics tool combining structural, thermal, CFD, acoustic and electromagnetic simulation capabilities in a single solution '(ANSYS). The simulations or models created by this product can be linked to animation software such as MAYA Autodesk's digital image creation and animation tool (Autodesk). Using this software architects can use and write their own programming scripts in order to combine and extend the simulation capabilities of these different software products.

Despite Batty's cautionary note about the application of these methods to cities a number of experimental architects are actively pursuing the use of digital software as a way to model and design cities. A plethora of research initiatives and seminars are now beginning to focus on the use of advanced software to diagram and simulate urban processes. For example, the June 2007 Digital Cities conference in Dessau examined how emerging digital tools are being used to both understand and design cities. It brings together some of the leading architectural designers and theorists in the world in relation to digital cities including: Alisa Andrasek of biothing, Gisela Baurmann of amoebe architecture, Alain Chiaradia of Space Syntax, Kas Oosterhius of ONL Architects, Yusuke Obuchi, from the Architectural Association, London Vesna Petresin Robert of rubedo, Jürgen Mayer, J. Jürgen Mayer H. Architects, and Neri Oxman an AA trained architect from the MIT Computation Group in Boston (Dessau). In addition to the obvious connotations of the brand identities of the companies associated with these architects all of these architects appear to be experimenting with, as Neri Oxman of the MIT Design Lab explains: 'attempts to establish new forms of design knowledge and new processes of practice at the interface of design computer science structural engineering biology and ecology (Oxman).' Her work attempts to integrate scientific principles and advances in modern biology engineering and computation within generative processes of design.

3 Systems Theory

The mix of biological metaphors and concepts, biomorphic forms cybernetics and networked geometries in agent based modelling work points to the rise and theorization of systems in the architecture of the 1960s. In the 1960s concepts of holistic and open ended systems were also being explored by Team X. For example, Candilis, Josic and Woods textual description of their Bilbao scheme of 1961 could also be a description of the agent based modelling of contemporary practice.

> 'The systems will have more than the usual three dimensions. They will include a time dimension. The systems will be sufficiently flexible to permit growth and change within themselves throughout the course of their lives. The systems will remain open in both directions i.e. in respect to smaller systems within them as well as in respect to greater systems around them. The systems will present, in their beginning, an even over-all intensity of activity in order not to compromise the future (Sarkis 96).'

In the post war era architects drew and adapted the systems theory approaches which arose out of operational research methodologies developed in WW2 research programs such as radar. A lineage of these approaches can be discerned in the 1960s systems approaches in the work of a number of architectural theorists but notably the mathematician turned architect Christopher Alexander. This lineage appears to have dissapated in the critiques of techno-utopia that arose in the late 1960s and 1970s in the work of the Rowe, Tafuri and architects such as the Krier brothers Significantly systems approaches have re-emerged as architects re-engaged with network theory and the new software products. For example the quote above mirrors the ways in which contemporary architects have theorised global cities as organismic and complex systems. As Nicholas Weinstock and Nikolas Stathopoplous explain:

'Cities are complex systems. The flow of vehicles and people within a city represents the emergent behaviour of such a systems, produced by large numbers of decisions of the individuals and their interaction with each other and the transport infrastructure of each city. Complex systems are by definition nonlinear and sensitive to initial conditions, so that small changes in such conditions may produce turbulent behaviour at the global scale'(54).

In the 1960s biological concepts converged with advanced construction, functional programming and design, alongside various techniques of systems analysis. As Bertalannfy, the founder of General Systems Theory, was to state in 1968 'If someone were to analyze current notions and fashionable catchwords they would find 'systems' high on the list.(12) The concept has pervaded all fields of science and penetrated into popular thinking, jargon and mass media (12).' In the 1920s Bertalannfy had contrasted the mechanistic approach to biological disciplines and he consequently 'advocated an organismic conception in biology which emphasizes consideration for the organism as a whole or system, and sees the main objective of biological sciences in the discovery of the principles of organization at its various levels (12).' In popular culture and science after the discovery of the DNA as Lillian. E. Kay has noted code 'molecular biology underwent a striking discursive shift: it began to represent itself as a communication science, allied to cybernetics, information theory and computers (463).' For Kay, a historian of science, 'molecular biology reconfigured itself as a (psuedo) information science and represented its objects in terms of communications systems (including linguistics)' (463).

4 Ecological informatics and the global city

In the present day the experiments of Batty and other digital architects appear to draw upon the discursive alliances of Ecological Informatics. As Chon and Park assert Ecological Informatics is an interdisciplinary field which seeks to understand ecological systems through 'the use of advanced computational technology for elucidating the principles of information processing at and between all levels of ecosytems' (213). As a field of knowledge Ecological Informatics emerged in the discursive ground that lay between neural networks and the ecological sciences (213). Consequently, spatial models utilizing concepts related to cellular automata and agent based systems have been used in the modelling of forest ecosytems, landscape population dynamics, forest fires, insect infestations and fish stocks. As this field has developed it has begun to focus on the 'advanced interpretation of ecosystems exposed to natural and anthropogenic stress (213).

It might seem curious that a bio-mimetic urge is at the heart of digital architecture. However, the concept of agents allows a direct link to be formed between cities as living entities, a notion as suggested above with a long tradition in architectural discourse, ecosystems and the techniques of digital architecture. Indeed the images of city's produced by agent based software shows cities full of capillarized circulation, organic dispersal and nerve—and naturally, network like—like accumulations. In some architectural proposals, materials, forms and even building type such as towers are now beginning to resemble Haeckel's diatoms as popularised by Darcy Thompson. Agent based software allows the populations of global cities and the atmospheric and climatic forces which act upon them to be conceived atomistically as particles. These particles are given life through agent based modelling, generated by virtue of their unplanned and seemingly random interactions, taking on the patterns and characteristic of larger integrated and global systems. Agent based software allows the city to continue to be depicted as 'an organism within itself.' For digital architects, as Neil Leach has written a 'constructive engagement with biological models is providing new insights into all forms of natural phenomena' (38). He has argued that 'self-generating building systems' would enable 'the translation of the architecture of living things into biological architecture'(38). Leach asserts that, 'it is precisely studies of the 'life-force' within nature-from cellular organizations to swarming and flocking behaviors of insect, plant and animal life—that are opening up understandings of how human beings themselves behave'(38).

For Leach this consideration of agents and swarms in digital architecture leads to the idea that 'Constantly mutating, emergent systems are intelligent systems based on interaction, informational feedback loops, pattern recognition and indirect control. They challenge the traditional concept of systems as predetermined mechanisms of control and focus instead on their self-regulating adaptive capacity'(38). For example, Virtual London model can then be linked back to real time data such as air quality monitors. By embedding avatars into these models we can then explore and presumably manipulate the world that has been created. In Batty's words using various agent based models architects can then organise or simulate these cities in order to 'reveal enormous possibilities for innovative and exciting ways in which we might think about design and planning and the management of change. More importantly these parallel worlds open up the design of our cities to a much wider public, as well as transforming the way we might deliver services. Seek information and engage in new kinds of dialogue'(Batty Cities). Leach has recently completed a design studio at Dessau entitled 'softLAB' in which he states grandly the 'This project takes its inspiration from recent scientific research into the programming of nature. From research into DNA and the Genome Project to the exploration of cellular automata, scientists are attempting to understand the coding of the natural universe. This studio attempts to take the principle of coding or scripting and use it as a generative tool for architecture (Soft).'

5 The global market for agent based modelling

Despite all of these hopes agent based software is still in 'an early stage of market development'. This market has a number of segments and most agent based modelling software can be classified as open source software and is often freely available and distributed under an open license. But also associated with this market a number of proprietary products such as Agent Sheets, iGEN, AnyLogic and MASS (Swarm) Indeed industry insiders have asserted that 'the majority of users adopting the technology are visionaries who have recognized the long-term potential of agent systems'(Munroe, *et al.* 345). For this reasons case studies involving the commercial deployment of agent applications are only just emerging. In Europe Euriobios—an integrated software company involved in software development 'from algorithm design through to implementation.'—has specialized in 'business optimization problems.' For example, Euriobios has used agent based solutions have also been used in order to optimize packaging plant operations. More disturbingly, one area in which agent based modelling is being rapidly adopted and which might drive the development of agent technologies is in the area of defence. For example, the AOS group founded in Australia in 1997 has 'built a multi-million dollar annual revenue stream through partnerships with a variety of defense related organizations using agents to simulate human behaviour in a range of adverse conditions.'(Munroe et al. 347)

Another obvious problem for architects is that agent based modelling is only just being applied to geospatial simulations. As Castles and Cook point out this work involves linking Geographic Information Systems with agent based modelling systems. Such models give the impression that buildings and even cities can be intelligent and cybernetically respond to various situations. The Foundation for Intelligent Physical Agents FIPA an organization that promotes agent-based technology and the interoperability of its standards with other technologies.' The purpose of the organization is to develop standards 'for agents and agent-based systems into the wider context of software development. In short, agent technology needs to work and integrate with non-agent technologies' (FIPA).

In this context, it is useful to consider the type of innovations that are being developed by those architects interested in agent based systems. As Tushman and Brenner point out work on innovation theory distinguishes between incremental and exploitative innovations and more radical innovations. Brenner and Tushman argue that innovations are either incremental or radical: 'incremental innovation, characterized by small changes in a technological trajectory, builds on the firms current technical capabilities, while radical innovation fundamentally changes the technological trajectory and associated organizational competencies'(238). As they explain: ' Incremental technological innovations and innovations designed to meet the needs of existing customers are exploitative and build upon existing organisational knowledge. In contrast radical innovations or those for emergent customers or markets are exploratory since they require new knowledge or departures from existing skills'(238). Across these dimensions the use of agent based software is clearly an exploratory innovation rather than exploitative one. This is because these techniques require architects and urbanists to gain new knowledge in software engineering a clear departure from their current technical capabilities. Moroever, the hope that buildings or cities themselves may one day become intelligent and performative bodies or entities is again a exploratory innovation rather than an exploititative one. This is because innovations can be classified by the way they 'affect existing sub systems and/or linking technologies. Modular innovations affect sub-system or component technology, leaving linking mechanisms intact, while architectural innovations involve changes in how subsystems are linked together.'(238) Again given the rhetoric of architects and urbanists in relation to agent based technologies they must be classified as exploratory innovations rather than exploitative ones.

Some of the issues involved in distinguishing developing exploratory and exploitative innovations can be seen in the development of the climate change models. There is an obvious gap between the climate models and the environmental performance of cities. Currently no urban landscapes have been included in global and regional climate models. This is surprising given that urbanization is a key process which transforms land use and its effects on the earths ecosystems. Climate change models are simulated in land models and then coupled with atmosphere models through the interaction or exchange of heat and water. Moreover, urban classifications are not included in any of the major GCM or RCM surface models. This would imply that current GCMs and RCMs are inadequate for simulating the urban modifications to climate. This calls into question the idea that cities might one day be intelligent organisms which can regulate their own environmental performance in relation to the global climate.

Indeed, the effect of cities on climate is only just beginning to be addressed by climate change scientists. Whilst urban regions only constitute approximately half of the lands surface rapid urbanisation in mega cities points to the need to consider the effects of anthropogenic warming on city populations. It is thus important for climate scientist to begin to look at the feedback effects of cities on the earths climate. However, to do this requires developing data and datasets that are not currently available. Climate scientist are only now beginning to consider how satellite data showing processes of urbanisation can be used in the models. Some of the issues that climate scientists have considered in relation to this is the impact of impervious urban surfaces on both hydrology and aldbedo emissivity and the geometry of objects within cities. These factors effect the transport of heat and moisture between cities and the overlying atmosphere. The Hadley centre has also developed a model called PRECIS which has helped to 'generate high-resolution climate change information for as many regions of the world as possible' (Met Office Hadley Centre 'Types') The centre hopes that this model can be available for use by groups in developing countries in order for them to develop there own climate change scenarios. According to the Hadley Centre these studies can be used for impact, vulnerability and adaptation studies. Architects and urbanists are yet to link this type of model to their own experiments.

Agent based systems allow architects to visualise global cities as both an organic totalities and as intelligent and complex organisms. Agent based systems are an obvious vehicle to achieve this. But, as suggested above these software technologies are exploratory and from this perspective it may be some time before they become exploitative technologies. In other words, it may take a considerable amount of time for digital architects to develop technologies that are able to link together the necessary technological sub-systems in order for cities themselves to perform in an environmentally intelligent way. In architectural discourse it is reasonable to suggest as Batty does that these urban experiments and models using agent based systems are indeed experiments. They are exploratory attempts by digital architects to explore how cities can be created, analysed and simulated using agent based modelling. This type of software promises the possibility of exploring parallel online cities using mobile agents and avatars in order to plan and forsee the urban spaces of the future. It would perhaps be too cynical to suggest that these endeavours all seem to echo and allude to the architectural and urban possibilities to be found in the online game Second Life. This is not to deny the legitimacy of these architectural experiments in relation to agent based systems. But it does suggest that the imperfections and difficulties underlying the seductive image of the Hadley centre’s applet also bedevil the enchanting and dare I say infotainment, agent based images and models created by digital architects. Within the cities of digital architects these avatars and agents are given a poetic and enchanted life of their own. I am concerned that the enchanted life of these cities seems removed in technological distance from an overheating globe on the brink of catastrophe.

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DISJUNCTIVE SYNTHESES OF (POST)DIGITAL ARCHITECTURE AND LIFE

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Abstract

In her recent book, *Architecture, Animal, Human: The Asymmetrical Condition*, Catherine Ingraham maintains a stalwart asymmetry between, on the one hand, human, animal and other life, and on the other hand, the material constraints or framed enclosures of architecture. When we turn to the recent, speculative work of the Emergence and Design Group (Michael Hensel, Michael Weinstock, and Achim Menges) we find a practice that deploys the software of computer technologies as a medium that has become increasingly life-like in its operational capacities and engagements. Rather than an asymmetrical condition, digital architects, such as the Emergence and Design Group, appear to be dismantling the distinction between architectural form and human, animal and other life forms. What we are asked to imagine is a continuum that unfolds in both directions, one infecting the other, organic interpenetrating inorganic, technology intertwined with biological life. What's more, the resulting hybrid of architecture-cum-life in (de)formation, should be apprehended as animated and ever-responsive to the field from which it emerges. The formal complexity that supposedly results erupts unexpectedly from a plane of continuous variation where the emphasis lies in the surface effect. This paper will trace the legacy of the work of Gilles Deleuze and Félix Guattari with respect to key conceptual moves, implicit and explicit, being made by so-called digital architects. Following what can be identified as Deleuze and Guattari's ethics of immanence, this paper will also consider whether an appropriate ethico-aesthetic practice can be engaged to address what appears to be a new architectural paradigm with its attendant desire for an intimate proximity with life.

Keywords: (post)digital architecture, life, ethico-aesthetics, disjunctive synthesis.

1 Introduction

Techniques associated with contemporary experimental architectures undertaken in what could be called a (post)digital milieu are increasingly drawing on the now well-established cross-fertilisation of ideas between computer science (animation, modelling, informatics, computation) and biological science (evolutionary science, genetics, also biochemical science). If we were to render today a list of symptoms that pertain to the current engagement of the discipline of architecture with the above conjunction, conceived as a *bio-technogenesis* of the ever-evolving human condition, we would find that the large question of life, and a vested relationship between architecture and life, recurs across contemporary architectural discourse and production. While architect and theorist, Greg Lynn is regularly identified as a key figure in the artificial animation by computational means of architecture, more recent collaborations such as the Emergence and Design Group (Michael Hensel, Michael Weinstock, and Achim Menges), have begun to explore how architecture, one day soon, will literally respond to life criteria. According to Michael Hensel and Achim Menges, we have much to learn from the chemical reactions that occur across the flexible membranes of cell walls, as well as their associated material infrastructures. American architectural theorist, Catherine Ingraham, on the other hand, prefers to consider things without the aid of augmented vision. The relationship between architecture and life that she posits in her recent book, *Architecture, Animal, Human: The Asymmetrical Condition*, maintains a stalwart asymmetry between, on the one hand, human, animal and other life, and on the other hand, the material constraints or framed enclosures of architecture. Where Ingraham's vision from the middle distance offers a helpful overview, the close vision (literally life magnified) of the Emergence and Design Group threatens a collapse with respect to our ability to create what might turn out to be useful differentiations. Nevertheless, this paper will elaborate on the close molecular vision of Michael Hensel *et al*, as different, yet potentially continuous with the view at a middle distance offered by Ingraham through her historical and theoretical study. To call forth this notion of a heterogeneous continuity between the two points of view on the matter, it will be necessary to return to the conceptual legacy of philosopher, Gilles Deleuze and psychoanalyst, Félix Guattari who unveil an organization of life from another point of view altogether, one that is composed of multitudinous points of view.

Although histories of architecture reveal marvelous displays of the various means by which natural forms have been emulated through the force of human labour, what is remarkable about contemporary developments is the focus not only on biological process over the conceptual illusion of fixed natural form, but on the suggestion that architecture will become living, ever-transforming, or morphogenetic organism in profound, symbiotic relationship with environmental context. Metaphor has given way to metamorphosis. It is necessary to turn our attention to the microscopic, even atomic scale of a world to comprehend possibilities of continuity between what, at the mere human scale of things seems to constellate in patterns of organic and inorganic array. The symptomatology I mention in my introduction draws us to a great surface that unfurls, showing constellations of vital signs, many of which conceal a legacy that is indebted to the writings of Deleuze and Guattari. Their creative philosophy, framed most explicitly in their final collaborative work, *What is Philosophy?* forwards not only a pragmatic aesthetics, but a radical ethics of immanence. Their philosophy demands the examination of contemporary problematic fields and the necessity of framing adequate questions. That is to say, they are less interested in meaning and more interested in use, and how things work in relation to each other such that virtual life capacities can be increased rather than reduced.

This paper forms part of a broader project that is in pursuit of an active ethico-aesthetics that draws on the legacy of Deleuze and Guattari, one that can be engaged in the application of reconfigured techniques that emerge out of the eruptive conjunction of the three disciplines of computer science, biology and architecture. Here I will also ask what is at stake in the complicated encounter between architecture and life. It is necessary to admit that there is nothing new in asking such a question, except that each time we address the question of a life it will have necessarily shifted; new developments in technology and the emergence, as well as the disappearance of ever-new life worlds and life forms demands the reframing of pertinent, context relevant questions. What's more, the constant reframing of problematic fields contributes to an active ethics. The disjunctive synthesis of my title suggests that life and architecture are perpetually drawn to each other, into an embrace, only to withdraw again transformed following the encounter. A disjunctive synthesis also describes processes of differenc/tiation that operate across shifts in scale, and from any number of minor points of view. The conceptual oscillation that circulates in this word of undecided spelling demands that we accept, simultaneously, the determination of the virtual content of an idea and how this comes to be actualised as a species, or parts of some object or organism. As Deleuze explains in *Difference and Repetition*, "It is always a problematic field which conditions a differenciation within the milieu in which it is incarnated" (207). Where the virtual (animating force of life) lays out a field of potentiality (differen*t*iation), that which comes to be actualised (the object, subject, organism) makes virtual life visible, and gives it materiality (differen*c*iation).

2 The Morpho-Ecological Approach

Experimental practitioners such as the Emergence and Design Group propose an optimistic and purportedly unproblematic identification between architecture and life, such that architecture promises to become living organism. In *AD: Techniques and Technologies* they write: “the currently prevailing biological paradigm is taken to its most literal extreme in a enquiry into the consequences of understanding architectures as living entities and the potential benefits of applying life criteria to architecture” (6). The Emergence and Design Group describe an important shift in our architectural understanding of the world that places us in direct contact with what they call the biological paradigm. At the same time, cognisant of historical influence, they pay tribute to the important research of such figures as German engineer, Frei Otto, and through Mark Burry, they pay homage to Antonio Gaudi, amongst others. While Ingraham’s account offers us a history of the relationship between the disciplines of architecture and biology that returns us to their respective formation as identifiable bodies of knowledge, the Emergence and Design Group are more interested in forwarding a manifesto that becomes most clear in their latest collaborative publication, *Morpho-Ecologies*. The opening essay, *Towards an Inclusive Discourse on Heterogeneous Architectures* sketches out a manifesto of sorts, where the “ME [morpho-ecological] approach” is articulated in relation to seven or eight key points, from the rejection of Newtonian physics to the uptake of morphogenetic systems, the deliberate differentiation of material systems, and the emphasis on the construction of material models, and so on. In the preliminary remarks the reader is encouraged to use the book less for contemplating than for using; it is a manual for the explorative designer. What the biological paradigm apparently allows the designer is a material return from the pure electronic realm of digital computation. This return does not constitute a mere retreat to hand-crafted techniques, instead material model-making techniques are clenched with immaterial computational explorations in a feedback loop where neither is supposed to be privileged. The biological paradigm allows us to see how these techniques reflect the way organism and environment also involve and evolve simultaneously.

Though not directly responding to the work of the Emergence and Design Group, the current problem that Ingraham identifies is that “Architecture begins to mistake itself for an organism and life for a technology” (27). Such mistakes, she continues, describe the aspirations of certain domains of current architectural work. Architects employing computational processes that cross-over into biological models and processes have mostly forgotten the slow movement of evolutionary becoming and have placed their bets instead on the speed enhancing drugs of new technologies. For instance, we hear Hensel *et al* insisting “a crucial aspect of this approach is the emphasis on process and the acceleration of an architectural environment” (2006: 58). Here we could also list the work of Foreign Office Architects (foa), Greg Lynn’s studio, Form, and Lars Spuybroek’s studio, NOX. John’s Frazer’s work, framed in *An Evolutionary Architecture*, should also be noted as an earlier development of some of this contemporary exploration. What is remarkable about many of these practices is that their associated discursive production is peopled by architectural theorists many of whom remain fundamentally indebted to the work of Deleuze and Guattari, for instance, Manuel de Landa and Brian Massumi appear in publications by both Foreign Office Architects (2003) and NOX (2004). The Emergence and Design Group, on the other hand, remain far more earnest as they deploy a language that is quasi-scientific and cleansed of distracting references to the like of Deleuze and Guattari. What’s more, they do not intend any level of metaphoricity, as user’s guide, *Morpho-Ecologies* is directed at the student and practitioner of architecture as a manual of ready to go techniques.

3 Error and Life

If conceptual mistakes are being made in the argumentation that supports all the furious architectural activity that currently celebrates the new biological paradigm, this is not necessarily all bad. Michel Foucault reminds us that life can be seen to proceed according to error: “in a sense, life – and this is its radical feature – is that which is capable of error” (1994, 476). Especially when it comes to man, Foucault elaborates, what we have is a living being perpetually out of place and mistaken. Why else do we find it necessary to constantly correct the drift of knowledge? Error and life together create the necessity of chance processes, a productive paradox. Error considered as the chance or aleatory encounter allows the connection of what might have first seemed disparate domains, for instance, computer science and biology, and then, more recently, the entry of (post)digital architecture into the fray, alongside advanced engineering technologies. What is frequently forgotten is how bio-technological research profoundly impacts on ontological identifications. Our bio-technological capacity promises to change who we are as well as the milieu (a world, a habitat) in which we are intimately imbricated.

The new paradigm that the Emergence and Design Technology Group frame identifies biology, the scientific and rational study of life forms and processes of formation as a key partner to architectural investigation. Ingraham argues that what such groups do not adequately study is how the life sciences have an ontological impact on the status of human, animal and other life (2006, 94). In engaging a new epistemological paradigm, to what extent is the human and other occupant likewise ontologically transformed? Too often design process as open-ended experiment in continuity with a 'natural world' forgets the very peculiar fact of the (post)human subject who is perhaps denatured. With respect to the project for a new biological paradigm that the Emergence and Design Group forward, we can innumerate an index of theoretical forgetfulness: 1.) The organism is resolutely left in place. While life forms are transformed through the processes of morphogenesis, organisms remain organized, recognizable and characterized from an anthropocentric point of view. The organized organism also forgets the liberatory and ethical promise of the BwO (Body without Organs) that Deleuze and Guattari forward in their first collaborative work, *Anti-Oedipus*. 2.)The organism is assumed to be 'normal'. Have we forgotten Georges Canguilhem, and in turn, his student, Michel Foucault's critique of the distinction between the normal and pathological? 3.) The fear of the monstrous. Foucault writes "It has not been possible to constitute a science of the living without taking into account, as something essential to its object, the possibility of disease, death, monstrosity, anomaly, and error" (1994, 474). 4.) The vitalism of life is stressed, but rarely do we hear much talk about death. Life is privileged over death, which is to forget the co-presence and co-production of life and death processes. Though I cannot expand on this brief index of theoretical forgetfulness here, it is worth asking what is lost in the shift from one discursive mode to the next, from architectural-theoretical to architectural-techno-scientific.

We habitually forget that for the most part these issues come down to a question of scale and point of view. As Menges and Achim point out, "ecology can be studied at various levels ranging from the individual organism to populations, communities of species, ecosystems and the biosphere" (2006 54). At the molecular level it can seem as though all life belongs to a molecular continuum, which nonetheless perpetually differentiates and unfurls, folding and unfolding through one material composition into another. Matter, as Deleuze argues "thus offers an infinitely porous, spongy, or cavernous texture without emptiness, caverns endlessly contained in other caverns: no matter how small each body contains a world pierced with irregular passages, surrounded and penetrated by increasingly vaporous fluid" (1993, 5). Perhaps we could pause for a moment and consider the world from the point of view of a tick, and consider the ethical lesson Deleuze suggests can be discovered therein. Deleuze and Guattari make occasional reference to the biologist Jakob von Uexküll (1864-1944) to account for the construction of different life-worlds through which living forms unfurl.

4 Life From the Point of View of a Tick

From ever-folding and unfolding distributions of matter there persists the level of human life and its construction of world(s). We see that architecture is distinct from life and frames inhabitation, but this only from a human point of view. There are also multitudinous animal worlds to which we have no access. It is by a detour through Deleuze and Guattari, for instance, that the biologist, Uexküll's ethology is rediscovered. Uexküll's vision of the fleeting life of the blind tick leaping onto its prey is also recounted in both the work of Giorgio Agamben and Ingraham. What's more, the "ME Approach" captures the work of this Estonian biologist to explore his theory of the *Umwelt* (environment-world) as that milieu composed of so many incommensurable, subjectively selected, viewed and constructed worlds. This assists the Emergence and Design Group in their discussion of how individuals interact with their environment, nevertheless, the individual in question remains intact through this encounter. Deleuze suggests that the tick and its world can be defined by three affects: "the first has to do with light (climb on top of branch); the second is olfactive (let yourself fall onto mammal that passes beneath the branch); and the third is thermal (seek the area without fur, the warmest spot)" (1988b 124; see also 1987, 51). This is a world with only three affects, which together contribute to the setting of an optimal threshold and a pessimal threshold of existence. The tick is by no means lesser on account of having so few affects; the tick makes the best of what is available to it. Importantly, "no one knows ahead of time the affects one is capable of; it is a long affair of experimentation requiring a lasting prudence" (Deleuze, 1988b, 125). Isolated and insular human and animal environment-worlds, framed by restricted, monadic points of view are not adrift but conjoined by the virtual, pre-individual plane of immanence. Agamben describes

Uexküll's schema as follows "an infinite variety of perceptual worlds that, though they are uncommunicating and reciprocally exclusive, are all equally perfect and linked together as if in a gigantic musical score" (40). It is a decidedly non-anthropomorphic view of multitudinous environment-worlds or *Umwelts.* The human world in this schema is given no privilege, and varies according to the point of view from which we observe it. What Deleuze calls affects Agamben calls "carriers of significance"(46). The task of the researcher in the field is to attempt to ascertain what these affects or carriers of significance might be, while accepting an absolute exclusion from these worlds that maintains us, paradoxically, in an intimate proximity.

5 Surface Effects

Many of the claims of the Emergence and Design Group appear radical, offering transformative potentials for a more sustainable world and an architecture that is living organism. Ingraham explains this potential in terms of the surface effect, "the surface meshes of computational architectures carry the potential not only for acting as some kind of living surface but also for making profound fields of reparation beyond their immediate boundaries" (29). That is to say, the material management of surface architecture, digitally augmented, might extend itself through these new technologies to attain more environmentally responsive systems. This is a key aspect of the argument forwarded by the Emergence and Design Group, who explain that most form-finding methods result in curved geometries and smoothly differentiated surfaces, as surface curvature allows structural capacity and opportunities for controlling orientation in response to environmental factors (2006: 31). Differentiation here embraces the unique and novel form (37), as well as its appropriate site placement, a form increasingly available as built product through computer manufacturing means. Finally, the curved surface interfaces well will 'nature' in more than a merely metaphorical way.

To this architectural surface of smooth differentiation what needs to be added are new relationships of intertwinement between human and other kinds of bodies and life forms, the immediate, mostly porous boundaries beyond which the environment and associated pressures insist. From the apparent rise of a techno-biological paradigm a new metaphysics, or perhaps ontology of the surface (as distinct from verticality, horizontality, and volume) needs to be articulated (see Ingraham). This surface writhes beneath the touch, is animated, suffers peristaltic movements and evolves over time only to pass resolutely away. The theoretical electronic domain of our computer software-hardware apparatuses shows us this process, but are such processual adventures enough? Guattari in *The Three Ecologies* argues for an ecosophy that accounts not just for the environment, but for social relations and human subjectivity (2000, 28). Guattari argues that an approach to environmental concerns cannot forget the co-presence of shifting social relations as well as the transformative potential of human subjectivity in construction, or components of subjectification (36). It should also be noted that Guattari argues for another paradigm altogether, an aesthetic paradigm, which is also a processual paradigm (1995, 106). Importantly this paradigm always responds by way of a double, and asymmetrical surface articulation between infinite speeds of thought as they pertain, on the one side, to a plane of immanence and, on the other side, to the emergence of finite, manifested states of things and bodies.

The importance of the formulation of a plane of immanence is that it challenges any point of view supposedly achieved from transcendent heights, and instead supports differential points of view as well as the relations between these. Across this plane disjunctive syntheses oblige us to admit difference at every step, that all life progresses erratically, emerging according to a mixture of chance and necessity by way of difference, and that difference emerges, approaches, clenches in an embrace with the other only to withdraw again into an inaccessible outside, a pre-individual, pre-architectural, pre-philosophical zone that allows our very blind durations and processes to continue to unfurl. Foucault describes a life proceeding through error. The question remains, how do we make the best of the encounter in the midst of which we find ourselves? How do we make the best out of what happens to us, however seemingly happenstance? The new biological paradigm offered by the Emergence and Design Technologies might at first seem to open up a radical new future for the designer, but in fact it is not radical enough when it comes to framing political and ethical implications and the very ontological transformation of the agents under consideration (architect, inhabitant, engineer, architecture's own array of conceptual persona). At worst we arrive at a state that can be called the banality of the digital. We are adept in our management of technology, it is our milieu, at least for the initiated. That we can mix techno-scientific motifs with architectural processual moves does not mean that we can identify pressing contemporary problems, or ask astute questions.

6 Disjunctive Syntheses

The disjunctive synthesis admits difference as fundamental, but achieves this while maintaining the condition of heterogeneous continuity. “In short” Deleuze explains in his book *Bergsonism* “the characteristic of virtuality is to exist in such a way that it is actualised by being differentiated and is forced to differentiate itself, to create lines of differentiation in order to be actualised” (97). Differenc/tiation is vital, a vital difference; “Evolution is actualisation, actualisation is creation” (98). The dynamic threshold between the virtual and the actual determines that processes of actualisation develop in such a manner that they bear no relation of resemblance to the virtual. The virtual is that which cannot be represented, and yet which conditions the creative turn toward what comes to be actualised. Processes of actualisation, which are conditioned by the virtual, do not then negate or deny the virtual in becoming different, but erupt as a positive and creative manifestation of virtual forces, or what Deleuze, after Bergson, identifies as *élan vital* (1988a, 103). What forces the interminable irruption of life-matters as manifested in the hundreds of millions of ever-differentiating organic-inorganic life-forms in formation that swarm this planet? Where the virtual pertains to a Whole, for instance, the whole of the plane of immanence, or transcendental field, actualisations create an irreducible pluralism, erupting here and there as so many different life forms, constructing multitudinous points of view on as many environment-worlds. Things change, encounters lead us this way and that, the ethical question becomes, how do we make the best of what happens to us? How do we make the most the event, which necessarily catches us up? This can be applied to the apparently ‘automatic’ processes set in action through the implementation of genetic algorithmic software. The designer continues to act, deploying an automatic technique that has necessarily been framed according to determined criteria. Though we might continue to ask who or what has this designer become? The Australian philosopher, Rosalyn Diprose reminds us that ethics is derived from the Greek word, ethos, meaning dwelling, also habitat, or a place defined as such through our habits. Dwelling is composed of bodily habits, but “to belong to and project out from an ethos is to take up a position in relation to others”(2005 238). An intrinsic awareness of the body allows us to make a place and to make this place in relation to others, that is, to effectively construct an ethics. And it is good to be reminded that “A body can be anything; it can be an animal, a body of sounds, a mind or an idea; it can be a linguistic corpus, a social body, a collectivity” (1988b, 127). It is into this interminable swarming movement of the disjunctive syntheses of difference in which we find ourselves inextricably in the midst. This is where (post)digital architects dare to tread. The curious and simple fact of the matter is that, even through mundane and everyday praxis the designer already operates in the midst of things, handling through the deployment of different techniques one vicissitude after another.

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NEW VISIONS OF THE PAST – TECHNOLOGY AND THE CREATION OF MEMORY SPACE IN SOUTH AFRICAN MUSEUMS

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Abstract

Post-Apartheid South Africa is demanding a revised approach to the construction of museums and memory space, seeking to identify a new form of museum that assists in reflecting the history of Apartheid while facilitating community growth and commonality. This paper examines two differing approaches: The Apartheid Museum in Johannesburg; and The Red Location Museum near Port Elizabeth. Both museums present evolving solutions to the challenge of creating meaningful museum space and exemplify how design technology is responding to emerging questions of how to deal with recent and emotionally raw historical events. The Apartheid Museum follows the experientially based linear model to create a simulated sense of history incorporating persuasive architecture with digital technology. In so doing a slick, international package of the past is produced. In contrast, The Red Museum re-thinks the mode of construction, materiality and linear narrative tradition in museums to create a new kind of space, open and flexible, which is situated in the heart of the township it serves. Dignified and refined, this museum re-positions the past as an entity in the present, acknowledging and celebrating a uniquely African mode of understanding and conveying history. Both regarded as highly successful in their own right, the museums identify ways in which new technology can be applied in the construction of current historical narratives and reveal how technologies can be redirected to allow for the emergence of new perspectives. In this respect, architecture contributes to the construction of new political narratives, using space and technology to subtly convey emotive messages around historical events.

1 Introduction

Post-Apartheid South Africa presents a particularly interesting position from which to gain insights into how technology is affecting differing approaches to the construction of national narratives. This is pertinent in a post-9/11 world fascinated by sites of memory and acts of memorialization. South Africa casts light on new approaches to the construction and facilitation of memory because, after the demise of Apartheid, it began a radical re-examination of existing approaches to the past, in terms of its potential to reveal commonality between people and to use this to facilitate healing in the community (Omar 53). Interestingly, how we acknowledge and access the past, our own memories of it and official narratives are increasingly determined by new technologies- building, communication and museological - that frame and evolve the past in significant ways.

Traditionally museums and memorials of Apartheid South Africa were utilized as physical embodiments of the dominant ideology. Museums were off-limits to black South Africans and their mode of communication highlighted this fact. Large imposing architecture and a static mode of display disregarded the African emphasis on oral tradition and told a deliberately constructed narrative of the past. Joe Noero elucidates that the Apartheid-era approach to memory was one of erasure (the ongoing destruction of selective traces of the past in the present) and clearance (the erection of a barrier so that no knowledge can leak through into the present) (187). This act of selective remembering ensured that the dominant ideology became the only version of the past, dismissing the existence of alternative narratives and disregarding the possibility of personal memory.

To counter this divisive and destructive approach to the past, the post-Apartheid government sanctioned a totally new and open approach to the act of memorializing. To this end, the Truth and Reconciliation Commission was established, to (among other things) bring personal memory to the fore and establish a collective unity. Official institutions of the state were called upon to assist in the facilitation of new narratives and the construction of memory in a way that would acknowledge its place as a living entity in the society (Hall 175). The German theorist Andreus Huyssen identifies this part of memory as a state of being – between living the event and the act of recalling it. He identifies this state as a 'twilight' – the nexus between the past and its recollection. Acknowledging this state renders memory a contemporary act dependent on a past that is understood and altered according to perception, time and representation. Huyssen argues that the role of museums needs to shift away from its traditional position as purveyor of inarguable truth to that of spreading knowledge through its place in the world of spectacle and mass entertainment (2). The use of technology has thrust the notion of museum into question as the real, the authentic and the original become simultaneously valued and abandoned amongst the plethora of the unreal, the hyper-real and the mass produced.

In many ways it is this acknowledgement of the past as an entity in the present that has allowed for memory space to emerge as a dynamic and fluid environment rather than the static stoic version of the past. This, in combination with a celebration of the potential inherent in the tools of mass media has led to a re-visioning of how museums are understood and how they are constructed. It should be noted that this is an active approach to the structure of memory making as opposed to the different question of how to handle the remnant architecture of an existing regime. Neil Leach, Lynn Meskell and Annie E. Coombes amongst others examine this question in detail. In the course of this paper, I will examine two relatively recent museums that have emerged in South Africa. The Apartheid Museum in Johannesburg and The Red Location Museum, just outside Port Elizabeth. Both use technology quite differently to establish diverse approaches to dealing with the past, one aimed at a local community, the other at the international.

2 Experiential Architectures – The Apartheid Museum

The Apartheid Museum is a form of 'experiential' architecture, designed according to a didactic linear narrative. It is based on the style utilized in the United States Holocaust Museum, which iconically established this mode of reflecting history (Linenthal 55). The museum is contemporary in its style and use of materials, very firmly establishing itself within the framework of international museum. The experiential approach to museum design is partially based on the realization that the object-based museology is no longer effective in stimulating interest in the past (Hein 8). Consequently museums have been developing new approaches to the construction of museum space and the mode of display in order to immerse visitors in a sense of history by simulating historical narratives. This approach acknowledges the need for museums to compete with the entertainment industry for commercial success but treads a fine line between simulation and entertainment, authenticity and theatricality. The decision to create such a museum in South Africa was born out of a desire to expand Gold Reef City, a pseudo-mining town and theme park in Johannesburg, into a casino. In order to gain approval for the casino's construction, the company had to agree to produce a 'social development' project. The museum was identified as a means to increase tourism, stimulate the economy and create employment (Findley 125). The context in which this museum was formed surely contributes to its style of production and the audience that it is seeking. In many ways this relationship highlights the way in which the past is readily transformed into a consumable commodity, available for bartering and shaped according to the politics of its creators. Thus in order to be situated within an international context- both in terms of audience appeal and international recognition, the Apartheid Museum seeks to align itself with similar styles of museums around the world. Unfortunately it does so regardless of the level of appropriateness of this style to the South African context.

Architecturally the Apartheid Museum, designed by Mashabane Rose Architects, is modern and sophisticated in style. The experience of visiting the museum is strictly controlled so that the progression through history is articulated as a singular powerful narrative. The architecture is utilized to convey a literal story of South Africa's policy of segregation and discrimination. From the point of entry where visitors are assigned identities as 'whites' or 'non-whites' and directed along separated paths of concrete, steel mesh and photographic evidence of passbooks, the architecture facilitates a simulation of the realities of Apartheid. The visitor is guided along a seamlessly linear, evocative path that emotionally resonates due to the controlled lighting, sound and enveloping displays which detail facts of the Apartheid regime. Hard clean lines and a palette of concrete, barbed wire and mesh indicate the lovelessness of a regime, unbending in its brutality. Architect Jeremy Rose refers to it as an "austere prison aesthetic . . . that kind of inhuman space" (qtd. in Swarns). This mode of conveying history relies largely on the combination of evocative architecture that directs the visitors' journey through the space and multimedia technology to intensify the emotive, visceral impact of the experience. The narrative is spelt out in literal architectural terms. Take for example, the 18m tall 'pillars of the constitution', which form the entry to the complex, each with one of the seven principles of the constitution written upon them. Or the use of darkened, concrete exhibition spaces with mesh display cases for artifacts, which allow views between exhibits but do not permit freedom of movement. Or the increased lighting as the narrative moves towards the realm of the new South Africa. Sound effects, lighting and projections all contribute to the impact of the narrative, so that one feels victimized, disoriented and uncomfortable within the display.

However this mode of articulating the past is problematic on numerous levels. It fails to identify a uniquely South African voice or outlook and does not acknowledge the call for diverse perspectives rather presenting a fixed authoritative position on the past. Perhaps most significantly, in aiming for the tourist market it perpetuates the alienation of the local audience reducing Apartheid to a slickly packaged contemporary consumable. Rather than acknowledging that the legacy of Apartheid cannot be confined to a singular narrative, this museum suggests that the past and the present are separate entities articulating the specifics of the past in a generic and exclusionary manner. By suggesting that Apartheid can be understood in a linear way, the museum positions itself as a Western icon, failing to embody the African perspectives that it claims to celebrate.

Yet the museum succeeds in affecting visitors who find it very moving. The clean modern lines and the refined aesthetic of the architecture and interior display are recognizable to an international museum-going audience so that the history of Apartheid is conveyed in recognizable terms. Technology is utilized in way that is familiar, sophisticated and urbane, ironically displaying the horrors of Apartheid within the safe confines of a sanitized and refined context. The narrative of Apartheid has been somehow transformed and repackaged into a global and familiar history. Through the use of an international architectural language refined and slickly modern, and conveyed with multimedia presentations, the history of South Africa assumes a different meaning. This propels it away from its origins as a uniquely African event or experience and generalizes it. It may be argued that this is appropriate for the international audience to whom the museum is aimed in part – making the horrors of Apartheid accessible and understandable to them, but in so doing, it removes it as a personal and local experience. The mode of conveying historical fact becomes fluid and encompassing, but the experience itself is tightly controlled and linear. Rather then facilitating the multiple perspectives of a Rainbow Nation, this controls the narrative and delivers the singular truth of the official post-Apartheid narrative. In modernizing and applying the latest pedagogical approach to memory making, this Museum proffers a step backwards rather than a step forwards.

In her analysis of the workings of the Truth and Reconciliation committee Beth S. Lyons discussed the importance of articulating the details of the past in order to claim ownership of it (par.4.). The act of identifying what happened to whom, when and why is significant in allowing people to come to terms with the past. Contrarily then, this museum generalizes the past, reducing the specificity of both the events and the act of Apartheid itself to a universal 'bad act'. The empowerment inherent in laying claim to a unique past – specifically South African- is radically undermined by its re-situation in an international context. Where the Truth and Reconciliation Commission succeeded was in its personalization of Apartheid, its desire to articulate the specifics of the past and to dismantle the sense of Apartheid as a faceless regime. However in order to construct its narrative for a tourist audience, one with an expectation of readily accessible entertainment and polished presentation, the past becomes generalized. That is not to say that there is not a place for a didactic museum such is this, for the tourist market is very important for the South African economy and the story of Apartheid is an important one to tell. Merely that the solution used here is to apply the technological approach of the United States Holocaust Museum in an attempt to compete internationally, rather then using the successful mechanisms of the design and applying them in a uniquely African way.

3 Socially Integrated Architecture – The Red Location Museum

In contrast, the Red Location Museum is constructed with a revised approach to the making of memory space. Technology is used here to generate a new form of museum, one that more accurately reflects the culture and physical environment from which it comes. Unlike the traditional approach of distinguishing the museum through physical separation from residential areas (thus highlighting it as a civic institution), the Red Location Museum is sited within the urban fabric of the community that it serves. In so doing, it becomes integrated into the daily act of coming to terms with the past. The museum is part of a precinct in the city centre designed to reinvigorate the city, with the understanding that the ongoing process of dealing with the past will be central to that growth and prosperity within the city. Stylistically, the museum incorporates a language appropriate to its context utilizing the inexpensive, readily available and often architecturally disregarded materials of the township in its construction. Corrugated steel, tin and concrete are used to generate a museum of its people, for its people. Externally the edifice is shaped to reflect the industrial aesthetic, for the heroes of this community were Union workers. Its sawtooth roofline is visible above the shacks that make up much of the township it but the scale and materiality remains in keeping with the context there (Findley 141).

Internally it is arranged to encourage an open non-linear exploration of the space – physically open and ideologically encouraging personal interpretation and reflection. The experience of visiting the museum is one that is organic and fluid - so that the narrative of the past can be understood in any number of ways. The central space comprises memory boxes, giant enveloping cases that give a nod to traditional modes of display. Rather than glass, these boxes are clad in corrugated iron and filled with individual and personal accounts of the past. Reminiscent of the Memory Boxes carried by itinerant workers that contained all their precious possessions and tokens of home, these spaces containing everyday items, voice-over stories and images, are poignant and poetic interpretations of a cultural and social icon. The transformation of an African social symbol of precious memory – the Memory Box - into a physical space that can be inhabited and understood on those terms assists in aligning the narrative of the past with personal recollection. The boxes themselves are 6m square in plan and 12m tall, poetic and impressive in scale and size. As if to highlight the need to understand the old in new contexts, the architects have utilized standard steel windows in new ways and applied a rigor to the construction of the concrete blocks imbuing a typical township material with the worth and value of facing brick (Slessor 42). In so doing, the museum generates a new form of memory space, a type of South African museum that is unique in its conception and construction. By reconfiguring the mode of display along with the form and experience of the space, the architects begin to shift traditional notions of what a museum is in the minds of the previously marginalized population. The openness of the design, and its siting in a contemporary sphere, physically, visually and ideologically have all placed the Red Location Museum at the centre of community invigoration and rehabilitation.

Another aspect of the revitalization of the community occurred through the employment of local people in the Museum's construction. Teams of local workers were rotated on the job learning the trade and earning money, ensuring that the act of creating the museum itself became a physical embodiment of the process of intertwining the past with the present. This practical application of knowledge allowed the museum to facilitate a bridge between coming to terms with the past and taking ownership of it in the present. By incorporating familiar building materials in the context of an unfamiliar typology and constructing a new type of museum - one which allows for personal interpretation and oral narratives - the Red Location Museum encourages a rediscovery of the nature of the museum and assists in establishing a personal connection between the local people and the museum that represents their past. This does not mean patronizing the visitor, nor reducing the past to a formulaic experience, but rather allowing for personal reflection on the past and restoring dignity and beauty to sites, materials and modes of constructing narratives that were formerly disregarded as second rate.

Memory in this context is also employed to facilitate economy, but rather than generating an economy based on the consumption of the past, it is based on its production. Furthermore, this economy is based on the transmission of technology and skills to the community for the present. In this manner the Red Location museum allows for the act of reconciliation with the past to contribute to a productive and prosperous present and future. Rather than identifying Apartheid as a contained entity that can be packaged and displayed, this museum acknowledges the nebulous state of memory and celebrates its ongoing place within the society. It articulates the weightiness of the facts of the past and draws them into the present allowing the effects of the past to manifest in the 'twilight' space articulated by Huyssen. In so doing the museum allows for individual recollections and identifications of the past and facilitates unique narratives based on an oral tradition. Architecturally it also incorporates a sophisticated language creating refined modern spaces but grounded in a uniquely African identity. In this respect technology allows for the traditional materials and spaces to be reconceived in a specific modern context- post Apartheid South Africa.

4 Conclusion

In seeking to ground current memory practice in the present, South Africa is endeavoring to incorporate numerous facets of technological advances in order to generate new, more meaningful architectural space. Straddling both the international and local markets, South Africa is attempting to produce new museums that appropriately deal with the raw and recent past of Apartheid. The Apartheid Museum, presents a slick urbane version of the past – utilizing digital language, in conjunction with powerful evocative architecture to situate the past in an international setting and to appeal to a tourist market. By contrast, The Red Location Museum applies technological advances in its use of low cost indigenous materials and redefinition of the basic museum modality to facilitate the construction of a more real, local environment through which to come to terms with the past. Both proffer a physicalized solution to dealing with the past, providing a new "untainted" space from which to construct new narratives. Both acknowledge the significant role that architecture can play in highlighting commonality and use physical space to convey specific meaning around the past and hope for the future.

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USING ALGORITHMS TO ANALYSE THE VISUAL PROPERTIES OF A BUILDING'S STYLE

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Abstract

Residential development within heritage conservation areas is regulated by Development Control Plans (DCP) that provide guidelines about the shape and form that new houses, alterations and additions should take (DIPNR 2004). By understanding that the visual amenity of streets within a city plays an important role in creating a sense of place and community for its citizens (Lynch 1960) they attempt to sustain, through regulation, an urban pattern that has become valued by the community. The visual character of a building within a streetscape is often associated with the style of its construction - a set of visual characteristics that a group of buildings might share. These characteristics include the relationship of the parts of the building to each other, and to the building as a whole, the use of ornament and visible textures, and the scale of elements within the composition.

Using algorithms developed within robotic research that enable a computer to interpret a visual environment (similar to those used in medicine and facial recognition for instance), this paper outlines how algorithms can be used to study the visual properties of the built environment. One of the methodological qualities of computer visualisation that makes it so useful for a comparative visual analysis of buildings is that the representational and symbolic meanings of a buildings style play no part. The organisation of the elements can be analysed without having to interpret their possible meaning at the beginning of the process.

This paper builds on an established interdisciplinary approach, utilising architectural knowledge and computer visualisation to evaluate the visual character of detached housing within a heritage conservation area. The visual environment is analysed using computer software developed to locate the visual boundaries within a view of a streetscape both as an elevation and aerial view.

Keywords: Streetscape, visual analysis, architectural style.

1 Introduction

Planning authorities use words like sympathetic, compatible, historically significant, sense of place or identity when evaluating streetscape character. However such descriptions are necessarily subjective and qualitative, leading to extensive debate and limited objectivity.

How new buildings relate to existing urban settings has become an important point of debate in architectural, planning and public policy forums (Groat, 1988). In difference to new buildings within the natural landscape, or those that are visually removed from the public space of the street, buildings that infill urban and suburban streets visually relate to nearby buildings and become part of the existing streetscape. In a legislative or policy sense the definition of streetscape, as described in the Environmental Planning and Assessment Act is: the character of a locality defined by the "spatial arrangement and visual appearance of built and landscape features when viewed from the street" (Env. Planning Act, 1979). For parties in dispute over the effect of proposed building works within a streetscape, this definition becomes a critical and potentially costly factor (DIPNR, 2004; VicD.I., 2001). Such policies and practices signal the importance of determining some measure or dimension that could be used for describing or defining the visual character of a streetscape. Only by defining these processes more clearly can creative solutions be found for new buildings in areas with a well-established street character (RAIA, 2004).

2 Visual Character of the Streetscape

2.1 Qualitative Measures

While planning diagrams concentrate on the functional and formal requirements of the built landscape, little attention is given to obtaining information about the visual character of the urban environment. Aside from issues purely concerned with visual character, knowing the shape and materials of the built environment might inform urban sustainability issues such as space use and energy consumption. Fisher-Gewirtzman, Burt and Tzamir (Fisher-Gewirtzman, 2003a) adds that "quantitative parameters" such as: the penetration of natural light, wind intensity and density measurements, need to be related to other physical and psychological "qualitative parameters" such as texture, privacy, colour, and nostalgia. Quantitative measures such as the height of a proposed building and other density measures can be determined quickly and accurately. However, measuring the qualitative aspects of the built environment, such as visual character, are open to the interpretation of the individual. Because they are difficult to measure they can be overlooked, resulting in changes that disassociate residents from their "place based communities" (Hull IV, 1993). In cases where the character of a street or locality requires improvement, the challenge is to identify the physical attributes of the preferred character while developing the broader infrastructure and amenity within the locality (Townsend, 2001).

2.2 Analysing Visual Character

Establishing the existing visual character of a streetscape involves a two-step process. The first might be considered as a visual reading of the elements within the streetscape, a process that by its description might allow an objective analysis and a measurable outcome. The second stage involves a decision about the importance of the patterns of elements in relation to others (Alexander, 2003; DIPNR, 2004; VicD.I., 2001). This second stage of the process may remain a subjective analysis; the emphasis that each local government authority places on the importance of visual character will change, as will the meanings that each individual takes from a given scene. However, for buildings to be approved, planning authorities must assess these qualitative aspects of existing urban areas such that decisions can be made about proposed changes. It is this first stage that our research is concerned with, and in particular how the visual properties of a streetscape might be interpreted without first having to interpret its 'style'.

When new buildings are proposed in heritage conservation areas, development is regulated by Development Control Plans (DCP) that provide guidelines about the shape, form and detail that new houses, alterations and additions should take (DIPNR 2004). By understanding that the visual amenity of streets within a city plays an important role in creating a sense of place and community for its citizens (Lynch 1960) they attempt to sustain, through regulation, an urban pattern that has become valued by the community.

2.3 Surfaces of the Streetscape

Urban open spaces are usually defined by the volume of empty space separated by the built surfaces. Teller (Teller, 2003) reflects on this stating that the form of a space is characterised by the relationship of "filled elements" that are within it. Salingaros (Salingaros, 1999b) similarly states that it is the information within the surrounding surfaces of the open space that is perceived, and is of greater importance than an analysis of a plan that is not perceived at all. While Hillier (Hillier, 1984:p1) rejects this based on a building's purpose, which he states is to transform space. The importance of visual perception to inform a building's purpose has been discussed by Lynch (1960:p4), Venturi (1966:p19), and Alexander (1977) in some detail. Differentiations in the surface of the open space caused by colour, texture and ornamentation are considered significant subdivisions within the surface of the streetscape even when their effect on its form may be minimal (Moughtin, 1999; Salingaros, 1999b). Surfaces of the open space that are orientated perpendicular to movement create a local spatial boundary (Salingaros, 1999b); a spatial type that Alexander calls "positive space", which is a fundamental property of coherent urban spaces. Theil, Harrison and Alden (Theil, 1986) state that the visual boundaries within the surface of a space define its degree of enclosure in a more significant way than simply determining how large it is. Research undertaken by Al-Homoud, and Natheer (2000) supports this by finding that vertical objects 'determine our perception of spatial enclosures' more than horizontal elements within urban spaces do.

2.4 Texture of the Streetscape

Texture is a property of all surfaces and is one of the characteristics used to identify visual regions bound by edges within an object. Depending on the scale of the visual information, both symmetry and simplicity can be accounted for in terms of analysis of texture (Schira, 2003). It can be described as the 'structural arrangement of a surface and the relationship that one arrangement has with others surrounding it' (Schira, 2003).

So does replicating a Federation house within a streetscape dominated by federation houses provide a satisfactory outcome for the visual character of the street? This is a debate with wide ranging views, but from a planning perspective, replication of an existing style is considered an acceptable and often desirable solution (Alexander, 2003). Architects might disagree with the premise of this planning solution (RAIA, 2004), but to satisfy the requirements of the planning process, the visual qualities of contemporary buildings must be understood, and they must be understood in relation to the existing visual context.

Craglia, Leontidou, Nuvolati and Schweikart (Craglia, 2004) reflect on the "reinvention of tradition as one of the strategies to enhance visibility" based on the market driven by the "urban tourist", as opposed to the more traditional resident. These sometimes conflicting requirement of the city have drawn a distinction between the modernist tendency to regulate space based on zoning to a post-modern approach where "fragmentation, urban mosaics and the colourfulness of cultural difference" (Craglia, 2004) are encouraged. Craglia *et al.* point out that this "recognition of differences has resulted in a cultural shift in urban studies with the city analysed as a work of art, a representation, and a text, that take different meanings for the various actors in it'. Urban planning ideas originally proposed by Sitte (1945), Lynch (1960), Jacobs (1961) and Alexander *et al.* (1977) are now being discussed from a commercial point of view (Craglia, 2004).

However, Hildebrand (Hildebrand, 1999) offers a reflection on this; he maintains that successful architecture results from an abstract drive to impose patterns on surfaces, that otherwise appear to be random acts of inhabitation. These patterns are the physical attributes of buildings, and help to identify visual regions of interest, that subsequently make them appealing or not (Schira, 2003). Salingaros (Salingaros, 1999b) comments that contemporary building materials and methods used to replicate traditional façade styles might 'minimize the information field' and subsequently not provide the visual field associated with the traditional building. This is an important issue and expands the discussion of streetscape character beyond purely the formal attributes of buildings.

2.5 The Significance of Detail Within the Façade of Buildings

Many researchers have shown that the character of a building often depends on the detail within its façade (Stamps III, 1999). For instance, Brolin (Brolin, 2000) suggests that the visual texture 'composed primarily of small scale details' is the most critical factor to consider when locating a new building within an existing built context. Methods used in architecture to determine scale within a building include massing, where the largest scale is usually defined by an outline of the building itself (Salingaros, 2000b). Elements within the façade such as openings, detail, trim and the material itself will then successively identify smaller scales.

Symmetry is a condition of massing and is manifested through the recurrence of shapes in a regular way, and can help connect elements forming a single element at a greater scale (Salingaros, 2000b). Once formed, this arrangement can be thought of as modular, repeated through the 'economy of thought and action' (Salingaros, 2001)

Bentley (Bentley, 1987) suggests that 'richness' can be created through details within the walls that incorporate patterns of material and colour. Moughtin *et al.* (Moughtin, 1999:p25) suggests that decoration, ornamentation and articulation within a building's façade is the 'means by which a variety of visual experiences are introduced to the viewer'. Hull *et al.* ((Hull IV, 1993) found that decorative style or other distinguishing physical characteristics were highly valued by the residents of houses, and were perhaps highly valued because they distinguished one place from another.

Stamps states that while empirical work on architectural detail is sparse it tends to support the hypothesis that 'detail is an important part of preferences for buildings' (Stamps III, 1999). Salingaros (2003b) reflects that ornamentation 'connects us to our environment'. Also, that successful building facades within an urban space feature a 'continuous swath of high-density visual structure that the eye can follow in traversing their overall form, or focal points of intense detail and contrast arranged in the middle or at the corners of regions' (Salingaros, 2003b). He has shown that ornament and decoration 'subdivide building façades on many different scales' and that the most effective hierarchical scaling creates a fractal geometry (Moughtin, 1999; Salingaros, 1999b) which is independent of any associated scale.

The location of larger details within the façade such as doors and windows are important elements within the urban fabric as they offer the opportunity for natural surveillance of the urban space, reducing the likelihood of crime (Newman, 1972:p80). Whether actual surveillance takes place may be difficult to determine, but the capacity for buildings to provide the opportunity is an important aspect of 'natural surveillance' (Newman, 1972).

2.6 Visually Assessing the Character of a Streetscape

Ellefsen (Ellefsen, 1991) states that planning authorities have a need for specific and objective information about the character of urban buildings and their settings when they undertake studies of the local environment. Understanding that the visual characteristics of streetscapes effect social life within the street has been recognised as an important way of revitalizing urban areas that are socially dysfunctional (Healy, 2004). However, methods that clearly articulate how the physical character or aesthetics of a streetscape might be evaluated and then compared with another are difficult to find. Lillis, and Pourmoradian (Lillis, 2001) found that techniques currently used for streetscape analysis did not establish the basic information required by planning authorities and community groups for informed decision making about changes to the streetscape. They proposed a "toolkit" that relied on a checklist of commonly found elements within the streetscape. An individual would use the checklist to record the visual aspects of the street, but how this information would be used by a designer to develop a new design is difficult to understand. As Stamps (Stamps III, 2003) reflects, those verbal and notated descriptions will eventually become 'physical materials in physical space'.

3 Methods for Assessing the Visual Properties of Streetscape Images

Computer software has been developed that utilises architectural knowledge and computer visualisation to analyse images of the streetscape. The images and description below shows the different ways that the image is analysed to reveal some of its visual properties. **Figures 2 – 12** are an analysis of the image shown in **Figure 1**.

Figure 2 shows how colours within the image can be identified and grouped to find the proportion they occupy. In **Figure 2** colours have been classified as cladding, detail within the cladding, trim and surfaces in shadow. Segmenting the image based on colour can show the proportion of a buildings surface that is exposed to sunlight, covered by vegetation or of a particular construction, such as glazed. **Figure 9** shows a screen from the software that allows the original image to be 'mouse clicked' to accumulate the colour classification required.

Figures 3 shows the conversion of the original image into a diagram where edges, or areas of high contrast between adjacent pixels, are highlighted. This process eliminates areas of low contrast, or regions where edges in the image are not found (the middle of a surface for instance). This diagram can then be processed using the Hough Transform (HT). **Figure 5** shows the Hough acculumator, the resulting graph after the HT has been applied to **Figure 3**. The Hough Transform is an algorithm that detects the likely direction of a line (or edge) that any pixel in the image might be part of (Tucker, 2005a). It shows the angle and distance of all pixels within detected lines from a predetermined origin. Lines with the greatest number of edge pixels within them appear as 'bright' points within the array. This process finds edges that are continuous (such as the roof line) and those that are discontinuous (such as the virtual horizontal line formed by the tops of closely spaced vertical fence palings). Detecting lines that are discontinuous, but perceived by humans as an edge, is an important part of Gestalt psychology (Chalup, 2007; Guy, 2002) and necessary for a visual analysis of existing buildings (Tucker, 2004). The HT also translates lines (or edges) within the image into points, making the array a diagram that can be compared with others. Finding similarities and differences between the diagrams enables them to be clustered, showing where dwellings of the same or dissimilar architectural styles might share particular visual characteristics (Chalup, 2007).

Determining whether an image of the streetscape exhibits more horizontal or vertical lines can be related to feelings of privacy (verticality) or publicity (horizontality) (Al-Homoud, 2000).

Figure 6 is the Hough accumulator array expressed as a polar graph. This locates the angle and strength of the found line in relation to the centre of the image – the size of the bubble relating to its strength. **Figure 7** shows a diagram that considers every pixel in the image as being part of a possible line within the image. By successively eliminating lines that contain only 3 pixels, then 4 and so on, the diagram shows peaks at the most dominate lines at a given angle. This graph is useful for showing where there may be a high density of relatively small line lengths, and how the density of line length is distributed throughout the image. When comparing traditional dwellings, such as a federation terrace, and a modern suburban dwelling this density of visual information can differentiate the two styles (Tucker, 2005a). **Figure 8** shows the graph of line length without considering the angle of the line.

Figure 10 shows the inverse Hough Transform where the dominant found lines (of infinite length) are placed back over the original image.

Figure 4 shows a calculation of the fractal dimension using the box counting method. The automated technique develops the work undertaken by Bovill and Weidemann (Bovill, 1996) and uses methods developed by Fouroutan, Dutilleul and Smith ((Foroutan-pour, 1999) to determine the best approximation for the fractal dimension. Salingaros et al (Salingaros, 1999a) has discussed the relationship between a higher fractal dimension and successful urban spaces. **Figure 11 & 12** show the grid (of varying size) is placed over the image to calculate the fractal dimension.

Figure 1 Original image 1

Figure 2 Colour classification

Figure 3 Edge detection

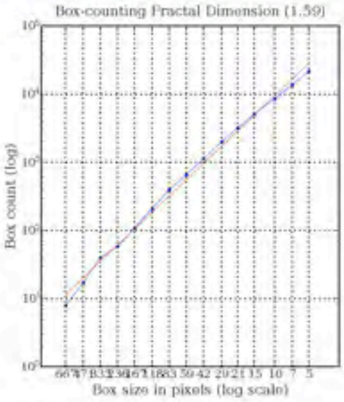

Figure 4 Fractal calculation

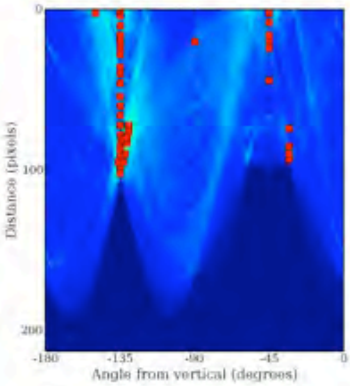

Figure 5 Hough array

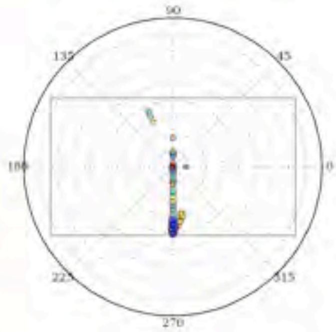

Figure 6 Polar Hough Array

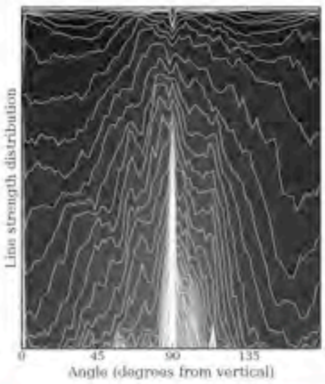

Figure 7 Edge length distribution

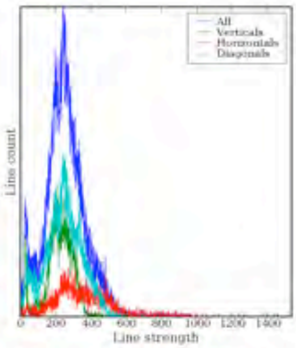

Figure 8 Edge count

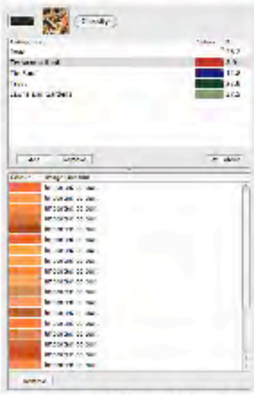

Figure 9 Classification screen

Figure 10 Inverse HT 1

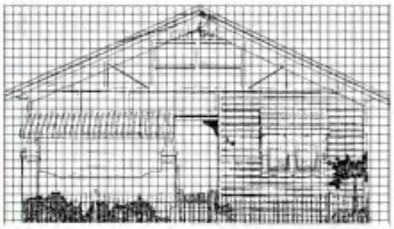

Figure 11 Box counting

Figure 12 Box counting

3.1 Recognising detail within a dwellings facade

An example of how the HT can be used to distinguish dwellings is shown in Figures 13 – 18. **Figures 13 & 16** show neighbouring houses that would have been constructed at the same time, in the same way and in the same form and detail. Over time they have undergone some changes and while recognisable as the same house appear visually different. The differences in horizontal and vertical elements is shown clearly with the HT analysis shown in **Figures 14 & 17**. Using this analysis the detail within the façade is emphasised over the formal structure, more clearly shown in **Figures 15 & 18** where the original image is removed from the inverse HT.

Figure 13 Original image 2

Figure 14 Inverse HT 2

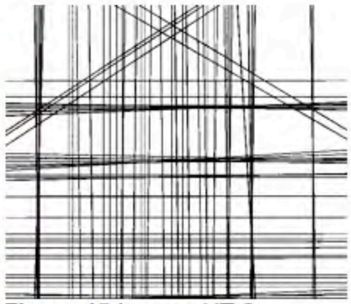

Figure 15 Inverse HT 2

Figure 16 Original image 3

Figure 17 Inverse HT 3

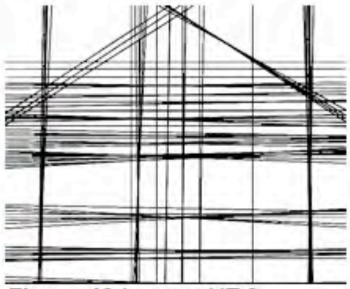

Figure 18 Inverse HT 3

3.2 Colour Segmentation of Aerial Photographs Based on User Selected Classification

Grouping colours within the image that represent a particular visual characteristic provides information about how common the characteristic is within the image. For instance **Fig 19** shows an aerial view of the Hamilton South Conservation Area (HSCA marked with black outline). The HSCA has developed planning controls but does not differentiate between areas within the conservation area that might have a different visual character. The visual character does appear to gradually change when assessing the streetscape, and by analysing the aerial map using colour segmentation, some differences become clear. The analysis shows in **Fig 22** that the naming of a suburb has a marked effect on the style of dwelling that was constructed in the area – the black outline showing the suburb boundaries. Metal rooves (+ timber walls) dominate in the suburb of Merewether compared with the terracotta rooves (+ masonry walls) of houses in Hamilton.

Figure 19 Conservation area

Figure 20 Colour segmentation

Figure 21 Suburb layout

The graph below shows how the proportion of hard surfaces, street trees, lawn, metal roofs and tiled roofs vary when 12 adjacent blocks are analysed.

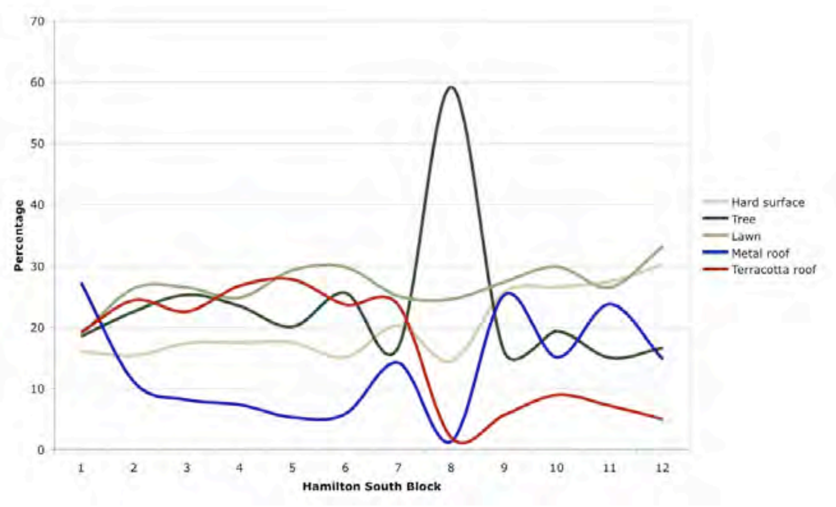

Figure 22 **Graph of variation in colour over 12 blocks within the HSCA**

4 Future work

Analysing the visual properties of modern and traditional buildings can show where they share certain visual characteristics, providing a planning argument for why a contemporary building, for instance, can sustain the heritage value of a streetscape within a conservation area. Understanding the visual characteristics of the built environment within heritage conservation areas might allow new buildings to be proposed that are of a different style, but none the less retain the visual character of the area.

The different methods of visual analysis outlined in this paper are being brought together as a single software platform, where an image can be processed and compared with another. Analysing all buildings within a street or locality in this way provides an analysis of the visual environment that has previously not been possible. Analysing the visual properties of modern and traditional buildings can show where they share certain visual characteristics, providing a planning argument for why a contemporary building, for instance, can sustain the heritage value of a streetscape within a conservation area. Understanding the visual characteristics of the built environment within heritage conservation areas might allow new buildings to be proposed that are of a different style, but none the less retain the visual character of the area.

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ETHICO-AESTHETIC KNOW-HOW: THE ETHICAL DEPTHS OF PROCESSUAL ARCHITECTURE

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Abstract

This paper argues for an ethics embedded in the largely digitally oriented field of research I refer to as 'processual architecture', in terms of Francisco Varela's notion of *ethical expertise.* Processual architecture has been a prominent field of architectural research whose depth of value and substance has eluded many. After the last 15 years or so of digital experimentation, it is clear that digital technology in itself is not the primary issue, but simply part of an equation. The ethical implications of this equation, I argue, can be found through the affinity between Varela's ethical expertise and an idea of the *art of emergence*. Emergence, a construct that describes a contemporary version of the laws of nature, has been used with increasing prominence in architecture in recent years.

Keywords: digital, ethics, aesthetics, emergence, architecture

1 Introduction

> "To tend the stretch of expression, to foster and inflect it rather than trying to own it, is to enter the stream, contributing to its probings: this is co-creative, an aesthetic endeavour. It is also an ethical endeavour, since it is to ally oneself with change: for an ethics of emergence." (Massumi xxii)

The field of architectural research and practice significantly employing digital technologies in explorative, experimental ways is commonly discussed under the banner 'digital architecture'. I prefer, however, to use the term 'processual architecture'. This naming dislodges the centrality of digital technology as that which defines the field, without removing its significant role. It also acknowledges its association with process philosophy (see Rescher; Gare) and processual media theory (Rossiter) and the related tendency to privilege or highlight things 'in-process'. Through early proponents such as John Frazer and, more contagiously, Greg Lynn and others, the formation of the field was characterised by animated diagrams and kinetic objects, moving and gyrating in differentiating fields of data. All the work that defines the field of processual architecture foregrounds – in various ways and degrees – *processes of formation* as constituting key properties or defining conditions of the product. Built outcomes become emphatically responsive, interactive and/or experientially challenging, while design processes become products in themselves (known as 'designing the design'). As a somewhat aesthetically re-inflected extension of the emphases on process and responsiveness in the 1960s, this field of work operates to further unsettle the clarity of distinction between process and product.

While an appreciation of processual architecture involves the new opportunities being explored through digital technology, there is clearly much more at stake than technology and technique. While this might seem obvious in itself, an articulation of a broader and richer project implicit to the field is hard to find. The depth of its value and substance has been far from obvious to many. Its perceived superficiality often arises from the fact that most of the work demonstrates a focus limited to a sophisticated aesthetics of form – sculptural form and/or the sculpted form of a process – at the expense of the socio-cultural or environmental concerns explored in other areas of architectural practice. Some commentators have gone so far as to suggest that the work is unethical (Ostwald; Perez-Gomez). I will argue a different case here.

To suggest that a field of blobs and arty interactives contain ethical potential might at first feel a little jarring. But only so long as processual architecture continues to be considered superficially, because its sophisticated surfaces of appearance can involve a behavioural composition of considerable depth.

The case I make begins with the model of *emergence* and its resonance with both processual architecture and the broader socio-cultural situation of our present era. While the topic of emergence in this field of architectural discourse goes back to its shimmeringly youthful stirrings in the early 90's (Kwinter) and has, I would argue, implicitly moulded the general experimental agenda since that period, it has been referred to with increasing intensity over the past 3-5 years. This is particularly evident in a cluster of younger or more recent architectural practices, such as biothing, kokkugia, Ruy Klein, Arandah/Lasch and the Emergence and Design Group who are explicitly claiming processes of emergence as central to the concerns of their practices.

2 Emergence as a model of composition

The term 'emergence' refers to a model of the fundamental operations of the world and is seen to be "a ubiquitous feature of the world around us" (Holland 2). As such, emergence becomes the name for a contemporary understanding of the laws of nature. As a discursive construct it seeks to explain, often through mathematical frameworks, the way that complex, sophisticated forms of organization come into being through simple, local behaviours and rules, in the absence of any apparent, centralized or dominant control mechanism. The classic examples are ants and cellular automata: where multitudes of individual 'agents' act via simple behavioural rules that together self-organise into patterns or forms of intelligence. A powerfully significant feature of emergence is that it is no less applicable to economic systems, games and urban planning than it is to living and natural systems. With emergence, culture and nature are artfully swept together.

Significantly here, emergence provides a model that describes the nature and organisation of contemporary socio-cultural operations particularly well, and vice versa. It becomes an academic construct for approaching the atmosphere of our present era and defining, to some extent, what it means to be 'contemporary'.

Let's think about the field of our cultural present. The broad socio-economic atmosphere in which we are situated seems to increasingly display *emergent behaviour*: our systems operating as highly responsive, decentralised, self-perpetuating networks demonstrating life-like activity to which no simple cause and effect relations can be attributed. Think of the stock market, reality TV, the intertwinement of media, politics and the multitude, terrorism, climate change, mobile phone swarming. These very contemporary situations are examples of phenomena engaged in perpetual on-going emergence. Emergent phenomena are, in a sense, the *elusive products* of a virtuosic event or culture, but as a 'product' it is inseparable from the multiplicity that creates it and pervasive in that it modulates that very multiplicity. The moment it emerges out of a field it curls back in. In a manner that has been described as "viciously circular" (Bedau 16), there is a feedback of affects between that which emerged and that from which it emerges.

From its earliest conjectures, the issue of emergence has been tied up with the battles between theories of evolution and creationism; the world as machine and the existence of God. It is a construct that seeks to explain how novelty arises, whether that be new species of life, innovative theories or technical objects. As such, emergence intrinsically concerns the process of how things are *created* or *generated* and the constitution of that process. In other words, emergence is an issue of *composition*: the process and outcome of combining things to form a whole.

As soon as that connection is made, the notion of composition as a formal arrangement of parts is given a processual or performative spin, because emergence models processes of interaction or the dynamics of unfolding relations. Composition becomes a performance and pertains to forms only in terms of the dynamic relations in which they are engaged. Rather than composition pertaining to, say, the formal arrangement of a facade, it pertains to the process through which that façade comes into being, the sense of that process in the designed product and the ways in which this performs after being built. While not precluding the possibility of remaining computationally describable at some level, this dynamic compositional glue becomes like the feeling of pleasure and the mannerisms that animate the face into a smile rather than the formal arrangement of a smiling face. And like the dancer, the designer can't perform well without an attention to the transmission of affect between bodies and influences and a practiced grasp of a style of movement. While this is acutely important in the case of the designer, it is also relevant to the subsequent engagements of others with the design products.

3 Ethical Expertise and the Art of Emergence

In his book, *Ethical Know-How. Action, Wisdom and Cognition,* Francisco Varela proposes a model of ethical expertise or know-how. Most western writers on ethics, he claims, tend to focus on reasoning as the central issue wherein ethics becomes an issue of deliberation (23). Ethical expertise, on the other hand, does not centre itself on rational judgements of reasoning or on how this may be applied as ethically instrumental. Rather, it is based on the inextricability of the specific tissue of circumstances or situatedness. With some affinity with Foucauldian and Spinozist approaches to ethics, as well as Felix Guattari's notion of the *ethico-aesthetic*, his notion of ethical expertise dwells in a “skillful approach to living … based on a pragmatics of transformation that demands nothing less than a moment to moment awareness of the virtual nature of our selves” (75). To act ethically, one must behave with sensitivity to the particularities of the situation where there is not a reliance on a set of rules:

“To gather a situation under a rule a person must describe the situation in terms of categories we may call cognitive. Instead, if we try and see correspondences and affinities, the situation at hand becomes much more textured” (28).

Along these lines, Varela has suggested that “intelligence should guide our actions, but in harmony with the texture of the situation at hand…truly ethical behaviour takes the middle way between spontaneity and rational calculation” (31-32).

Described as such, ethical expertise has a close affinity with 'the art of emergence'. Resonating with comments from a number of complexity theorists (Holland; Taylor), Steven Johnson writes that:

“We are only just now developing such a language to describe the art of emergence. But here's a start: great designers … have a feel for the middle ground between free will and the nursing home, for the thin line between too much order and too little. They have a feel for the edges” (189).

It would seem that the art of emergence involves what Varela calls ethical expertise, that together can be usefully referred to as ethico-aesthetic expertise. I should emphasise here that ethics is not about the ‘good’ and the ‘bad’, redemption or claims for redemptive powers. Its about a 'measured' practice of engaging with the world, of how we behave, of what we acknowledge is at stake. Ethico-aesthetic expertise is about the amplification of potential – which doesn't necessarily lead to the 'good' because it magnifies risk. Rather than being framed around the *virtuous*, ethico-aesthetic expertise is about the *virtuouso*: the skilled performer (Virno). Even if there are no easy rules or moral guidelines here, there is an important principle or navigational directive. That is: that the performance of any act strives for a balance between affecting and being affected, between active reflection and the immediacy of embodied response, between sensitive responsiveness and determined agency. This is a politics of action that neither caves in passively to collective desires or beliefs nor holds to individualism, authorship or dictatorship as the power of truth. It is both determined and respectful, pushy and playful. It involves raising both thinking and acting to their highest powers, such that they affect and fold into one another. Or, in short, it involves the embodiment of wisdom.

4 The Ethico-aesthetic Know-How of Processual Architecture

Processual architecture characteristically focuses on setting up conditions or generative systems through which outcomes will emerge. This often involves the inter-relational arrangement of micro-components or agents, each of which are programmed with behavioural rules. The performance of the designer is met with dynamic, life-like diagrams that are themselves configured in terms of behaviours and performance. The strength of the life-like nature of these diagrams (or abstractly experienced objects) means that they become like puppets that the designer guides, but with enough in-built character to take a part in leading or guiding the way. In other words, the design material is not passive but pushy, involving a dynamic between designer and the designed wherein each both affect and are affected by one another. Implicitly, composition becomes less of a set of rules or methodologies and more of an ethics of engagement or ethico-aesthetic expertise.

Ethical dimensions, that others have judged to be missing, are embedded in the way that these emphatically processual architectures foreground and bring into question the nature of our engagements in the world. While all architecture implicitly raises this question, actually (and virtually), the difference here lies in the amplified attention to our engagements that processual architecture ushers into the scene.

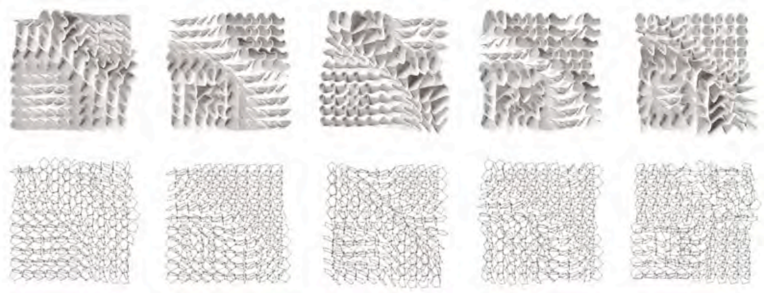

Image 1: **Alisa Andrasek (biothing), *The Invisibles* (2003)**

A specific example of the tendencies of processual architecture that I'm referring to here, can be found in the work of biothing or Alisa Andrasek. In a previously published analysis of one of her projects, *The Invisibles*, I argued for a new mode of composition symptomatic of processual architecture (Ednie-Brown). In that essay I discussed how the digital field system of *The Invisibles* is emphatically, even if invisibly, part of a broader event-ecology through which parameters that do not take the form of digital data nevertheless participate. This involves a complexity of project criteria of many different kinds, along with the tendencies of the designer, knitted together by her habits, attentions, memories, affections and so on – a cluster of potential that can be folded into what we call 'personality', described by Brian Massumi as a 'pattern of preferential headings' (205).

Personality enters into a dance with the potentials of the medium of design manipulation, accompanied by a range of other pragmatic and intangible influences. In the event of negotiating an undulating ground of criteria-meeting-potential, the designer becomes part of a depth of complex relationality such that the totality of the compositional event becomes one evolving 'thing'. Within this larger thing, the developing digital system is a material in the making.

In the cacophony of such an event there is a striving that tempers development: to create or compose this material: the morphologically dynamic system that constitutes the product. The designer leads, but not bluntly or brutally. Likening the process to the training of a pet, Andrasek talks about 'teaching it, guiding it, stirring in certain directions, but at the same time learning from IT' (Andrasek). IT's 'life' flickers forward when IT begins to develop a 'pattern of preferential headings' or an abstract 'personality'. As IT comes-into-being, the compositional event bifurcates into a clarity of differentiation between her and IT. She is no longer the only source of 'push' amidst a scattering of material because she now has an 'IT' (a system) to play with.

Image 2: **Alisa Andrasek and her algorithmic fabric 'creature' (bifid v1.5)**

It becomes, as I like to describe it, a system defined by *tendencies of behaviour* that give it a *consistency*. By consistency I mean the sort of thing we refer to when discussing the consistency of a cake mix. Rather than some idea of sameness or uniformity, consistency is the texture arising from *the way in which something dynamically holds together*. The strength of this consistency means that it develops enough behavioural tendency (or 'patterns of preferential headings') to have character, becoming something of a creature, a term Andrasek often uses to refers to her design systems.

These creatures are constituted by *multitudes* of dynamic micro-interrelations. In both an experience of and an engagement with these creatures the relations that constitute them cannot be singled out: they are never experienced in isolation, not even as some part of a whole. As a multitude engaged in an emergent process of composition, they generate patterns or textures of multiple, mostly invisible, relations: an intricate consistency. So, what we (aesthetically) experience is an all-over, over-all consistency.

The power of this qualitative envelope is such that invisible forces become undeniable. There is a forcefulness of coordinated consistency through which the dynamics of complex relationality becomes *explicitly* articulated. When something can no longer be denied one has to engage with its difficulties and inconvenient challenges (like climate change). Learning how to engage with a complex, wilful and difficult intricacy of relations is tantamount to opening oneself up to a depth of relationality in the tissue of any circumstance. Such an embrace, often denied in order to maintain the ideality of 'control', is crucial to the development of ethico-aesthetic expertise.

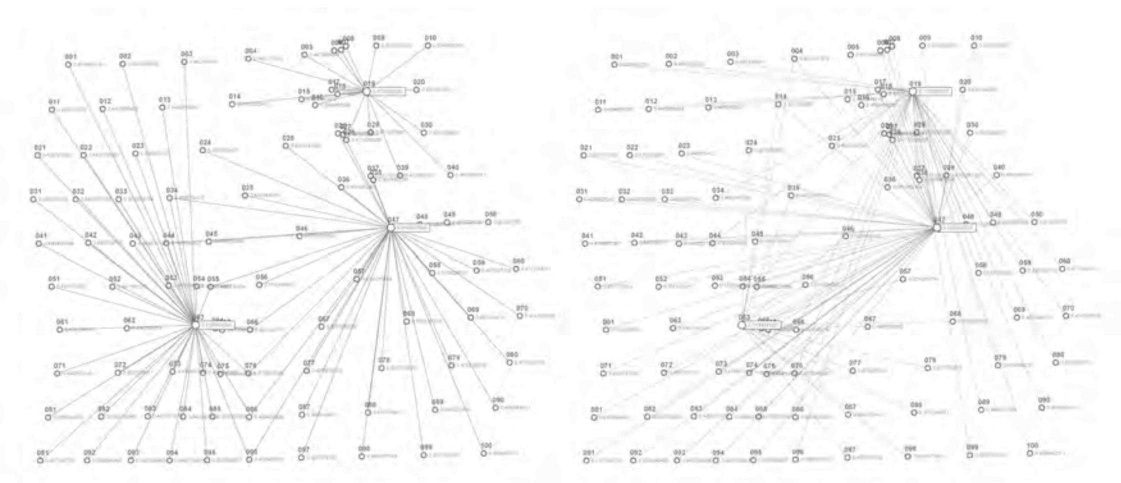

Image 3: **Alisa Andrasek – diagram of algorithmic speed-distribution and cellular relationships: *The Invisibles* (2003)**

In part, one could say that its all about finding a 'balance' between the polar 'opposites' of all conditions (too much order and too little, formality and informality, the one and the many, etc etc). But these are less opposites than categories that define the limits of various states of relation. 'Balance' does not equate to stillness or sweet, peaceful composure, because it might tend more toward a wildly oscillating performance of relation. It is rare for situations to be free of struggles to connect, conflicts of interest/affect or obstacles to sharing/engaging. Extremes of these conditions lead to various forms of war, but milder instances are everywhere: in the dynamics of relation, relevant to political, social, personal and creative assemblages such as the design event.

Design practices that emphatically work with performative, dynamically relational systems provoke a demand for an ethico-aesthetic expertise. Pedagogically, this becomes very significant, in that it raises the issue of how to help students develop this form of expertise. This is less something that can be taught directly than ushered into the studio environment, through the manner of one's engagements with the students and the material they generate, providing a framework that is both firm enough to provide constraint and responsive enough to adapt to material and issues that arise, and guiding design developments such that a productive resonance arises between the design process, the performance of the outcome and an ethico-aesthetic expertise. This approach to teaching is difficult and risky but close to the practice that Sandford Kwinter discusses as the 'cultivation of life', where one must bear the knowledge that, as he writes, we cannot know "where such an experiment will go, and it is one certainly rife with traps and dead ends."(37)

For the sake of pedagogy and discourse, an ability to keep the risk alive while managing to recognise the dead ends when they arise, to twist traps into realisations, and to match firmness with sensitivity, might enable processual architecture to more actively (and ethically) contribute to issues well beyond its usual focus on formally articulated virtuosity – by virtue of its virtuosic capabilities.

Or it might not. But it's worth the risk.

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MEASURING ARCHITECTURE: QUESTIONING THE APPLICATION OF NON-LINEAR MATHEMATICS IN THE ANALYSIS OF HISTORIC BUILDINGS

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Abstract

In the late 1970s the mathematician Benoit Mandelbrot argued that natural systems frequently possess characteristic geometric or visual complexity over multiple scales of observation. This proposition suggests that systems which have evolved over time may exhibit certain local visual qualities that also possess deep structural resonance. In mathematics this observation lead to the formulation of fractal geometry and was central to the rise of the sciences of non-linearity and complexity.

During the 1990s a number of researchers developed this concept in relation to architectural design and urban planning and more recently architectural scholars have suggested that such approaches might be used in the analysis of historic buildings. At the heart of this approach, in both its theoretical and computational forms, is a set of processes initially developed by Carl Bovill for analyzing buildings. However, the assumptions implicit in Bovill's method (itself an extrapolation of an approach proposed by Mandelbrot) have never been adequately questioned. The present paper returns to the origins of Bovill's analytical method to reconsider his original investigation of key works of 20th century architecture and the way in which Bovill frames images for analysis. The aim of this analysis is to question several assumptions present in Bovill's method about the way in which computer technology is used to understand the visual qualities of historic buildings.

1 Introduction

In 1975 the mathematician Benoit Mandelbrot published *Les Objects Fractals: Form Hasard et Dimension.* At the core of Mandelbrot's research is an attempt to understand the geometrical rules that underlie nature. In this work Euclidean geometry, the traditional tool used in science to describe natural objects, is viewed as fundamentally unable to fulfil this purpose. While historically, science considered roughness and irregularity an aberration disguising underlying ordered systems with a fixed state or finite values, Mandelbrot (1977) argues that the fragmentation of all naturally occurring phenomena cannot so easily be disregarded. For example, a coastline is not straight and no Euclidean Geometric construct can approximate the form of a coastline without serious abstraction or artificiality. As a result of this natural fragmentation, mathematicians have shown that the length of the coastline cannot be determined at all (Feder, 1988). Yet, the characteristic irregularity of a coastline may be measured by imagining that the increasingly complicated and detailed path of the coastline is actually somewhere between a one-dimensional line and a two-dimensional surface (Schroeder, 1991). The more complicated the line, the closer it becomes to being a two-dimensional surface. Therefore, coastlines and many similar natural lines can be viewed as being fractions of integers, or what Mandelbrot (1982) describes as *fractal* geometric forms. Thus, fractal geometry describes irregular or complex lines, planes and volumes that exist between whole number integer dimensions. This implies that instead of having a dimension, or *D*, of 1, 2, or 3, fractals might have a *D* of 1.51, 1.93 or 2.74.

Architects and designers adopted fractal geometry as a design tool in the 1980s but, despite some interesting results, it rarely produced an enduring architectural response (Jencks 1995; Ostwald 2001; Ostwald 2003a). In contrast, the history of applications of fractal geometry to the analysis of architectural and urban forms is still evolving and is displaying more promising results. For example, Oku (1990) and Cooper (2003; 2005) have separately attempted to use fractal geometry to provide a quantitative measure of the visual qualities of an urban skyline. Yamagishi, Uchida and Kuga (1988) have sought geometric complexity in street vistas and Kakei and Mizuno (1990) have applied fractal geometry to the analysis of historic street plans; a project that has been extended by Rodin and Rodina (2000). At a much finer scale, Capo (2004) has provided an explanation of the complexity of the architectural orders (Doric, Ionic and Corinthian columns) using fractal geometry and Eaton (1998) has interpreted the layout and decoration of some of Frank Lloyd Wright's Houses as being fractalesque. At a larger scale Cartwright (1991) offered an overview of the importance of fractal geometry in town planning and Batty and Longley (1994) and Hillier (1996) have each developed increasingly refined methods for using fractal geometry to understand the visual and growth patterns of macro-scale urban environments.

Despite these examples, one of the more commonly repeated mathematical methods for the analysis of visual character in historic architecture is Bovill's (1996) extrapolation of Mandelbrot's box-counting approach to determining fractal dimension. Bovill's original contribution to the box-counting method rests primarily in his explanation of its potential application in architecture, design and the arts. Bovill's method has been used to analyse historic and modern building forms along with streetscapes and skylines. Since his original publication, Bovill has offered an extrapolation of its use (1997) and Bechhoefer and Appleby (1997) have used the method to consider the visual qualities of vernacular architecture. Bovill's method has been repeated by a range of researchers studying historic or vernacular forms including Makhzoumi and Pungetti (1999) and Burkle-Elizondo, Sala and Valdez-Cepeda (2004). The following sections examine Bovill's method; the purpose of this analysis is not to criticise Bovill's work but to begin the process of exploring and exposing its potential limits.

2 Founding Assumptions

Before considering Bovill's mathematical method, the philosophical assumptions implicit in his application of non-linear mathematics to architecture are worth examining. For example, Bovill commences his work with the argument that architecture is necessarily produced through the manipulation of rhythmic forms. He expands this to propose that fractal geometry will allow a 'quantifiable measure of the mixture of order and surprise' (3) in such rhythmic forms to be determined and, moreover, that this will reveal the essence of the architectural composition. For Bovill, '[a]rchitectural composition is concerned with the progression of interesting forms from the distant view of the facade to the intimate details. … As one approaches and enters a building, there should always be another smaller-scale, interesting detail that expresses the overall intent of the composition' (3). However, contrary to this claim, the desire to 'maintain interest' or produce a cascade of detail from different perspectives is not a primary formal motivation in any major architectural theory since Roman times (Kruft 1994). Indeed, the opposite is true for much Ancient Greek and Renaissance architecture. In the former case elaborate geometric strategies (including *entasis* in columns) were employed to artificially correct a range of changes that occur when a building is viewed from different ranges. In the latter case, Renaissance architecture was designed to be appreciated from a singular, almost Platonic, perspective viewpoint.

In the second stage of his proposition Bovill maintains that the use of fractal analysis in architecture might explain why some modern buildings have never been fully appreciated by the general public, whereas some vernacular architecture is more widely liked (6). Bovill assumes that modern architecture (by which he means the international style architecture of mid-career Le Corbusier or Mies van der Rohe) will have a lower fractal dimension and, therefore, a lower correlation with natural geometry than historic architecture. In this proposition Bovill repeats Mandelbrot's argument which has as its founding assumption the Kantian belief that nature is innately beautiful and that people are drawn to the appreciation of natural forms because of this. For Bovill, fractal images 'are pleasant because they capture the character and depth of texture that nature displays' (70). Yet, as philosophers have observed, the Kantian belief in the essential rightness, goodness or beauty of nature is not supported by strong evidence and it does not stand up to close scrutiny. Gray (1991) and Ostwald (2003b) have also reviewed Mandelbrot's assumptions and uncovered a range of political and philosophical problems in the aesthetic and cultural values embedded in his work. For example, Mandelbrot is highly critical of Modern architecture while praising Beaux-Arts or Baroque buildings. This is problematic for a range of reasons most notably because it places an undue positive emphasis on higher fractal dimensions while dismissing those that have relatively abstract or plain forms as being alienating. However, despite Mandelbrot's assertions, fractal dimension is not a determinant of good architecture, social responsibility or cultural meaning in the built environment. Fundamentally there is no correlation between fractal dimension and successful architecture. Instead, fractal geometry remains important in architectural analysis because it is one of the few quantitative methods available that provide a measure of visual complexity, or formal density. Also, like many quantitative methods, it provides a powerful comparative tool that assists in understanding visual similarities or differences between multiple buildings.

2.1 Counting Boxes

At the heart of Bovill's method is 'box counting'; a mathematical approach which involves applying a range of different scale grids over an elevation of an historic building and counting the number of boxes that overlay some detail of the architecture. As the grid size changes so too does the number of boxes containing some detail of the façade elevation. This is a typical mathematical operation to produce a log-log linear correlation between the number of boxes counted and the associated size of the grid. The slope or angle of the regression line produced in this way provides an estimate of the fractal dimension of the elevation or plan. Through such an analysis, Bovill concludes, it is possible to see that while all architecture is fractal at certain scales some designs are fractal over a wider range of scales. Bovill uses two examples to explain his case; Frank Lloyd Wright's Robie House and his Unity Temple. In the former case Bovill uses four grids, and three comparisons between the grids. As a result of this analysis he determines that the façade of the Robie House has a range of fractal dimensions from $D = 1.645$ to $D = 1.441$. In an interesting validation of this result, Bovill then considers a window detail from the Robie house and finds, in Wright's elaborate stained glass patterns, a slightly higher fractal dimension. Such a result would not be unexpected in one of Wright's houses of the era (Eaton 1998). For his analysis of an elevation of Wright's Unity Temple, Bovill uses three grids and two comparisons between grids. From this process Bovill determines that the façade of the Unity Temple has a fractal range of between $D = 1.621$ and $D = 1.482$. Again, Bovill seeks validation of his result by analysing a smaller detail in the design; a planter box. In each of his examples Bovill uses elevation images as raw data; a method that has been repeated by other researchers ever since. However, at no stage is this choice of an elevational view questioned.

The human eye reads the world in perspective and it is impossible to experience an elevation; the problems of parallax ensure that in the 'real world' no two lines are ever, perceptually at least, parallel. Why not then use perspective views for analysis? This question is even more compelling when the fact that fractal geometry is about a comparison between different scales of viewing it is taken into account. Bovill even argues that a cascade of detail is critical for leading the eye closer to the building. Yet, Bovill's method doesn't rely on recording the change in detail as the eye comes closer to the building, instead it assumes that the eye (or viewpoint) remains fixed while the amount of detail entering the eye increases. This is akin to placing a digital camera on a fixed tripod and then, after manipulating the lens to perfectly correct the perspective, taking a 2 mega-pixel photo. Then, from the same position and after another level of parallax correction, a 4 mega-pixel image is taken and then an 8 mega-pixel image and so on. This process differs from Bovill's stated view of the purpose of architecture. Viewed in this way, the framing of the raw image data is critical to determining the result of the analytical process. What then might be some alternatives to Bovill's framing of the raw image data?

2.2 Alternative Framings

The following, seemingly more realistic variations on Bovill's method, are alternative ways of framing the image that is analysed. Each variation uses a different combination of view points, perspective planes (and picture planes where the image is ultimately recorded). These variations also introduce the role of the cone of vision; something conspicuously lacking from much fractal analysis of historic architecture. In the following descriptions, for simplicity, the methods are described for orthogonal structures. Also, it is acknowledged that in order to determine the fractal dimension of an image, a comparison of two separate 'grids' is required. Although, for the purpose of considering alternatives, the variations describe these paired grids as one conceptual view or picture plane.

2.2.1 Fixed position, one-point perspective (fig. 1)

This variation involves a fixed viewpoint with the eye at right angles to the dominant surface of the façade, but with no correction for parallax. This variation suggests that all images are in one-point perspective. This variation has the advantage of a consistent rule for setting up the image composition (at right angles to the façade and a certain distance from it based on the dimensions of the building being considered and determined by a standard cone of vision).

2.2.2 Fixed position, two-point perspective (fig. 2)

A fixed viewpoint with the eye/camera not at right angles to the dominant surface of the façade, but with no correction for parallax. This suggests that all images are in at least two-point perspective and that the gathering of data is analogous to increasing the mega-pixel value set in the camera. This has the problem that there is no clear rule for setting the viewpoint even though the image is more natural (the fixed, one-point version is relatively artificial in its framing).

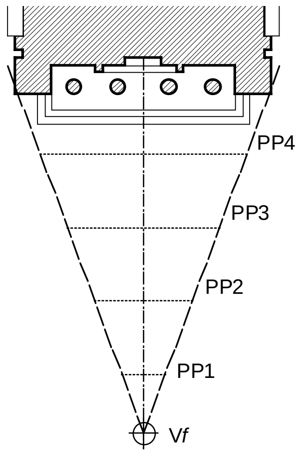

Figure 1: **Fixed position, one-point pers.**

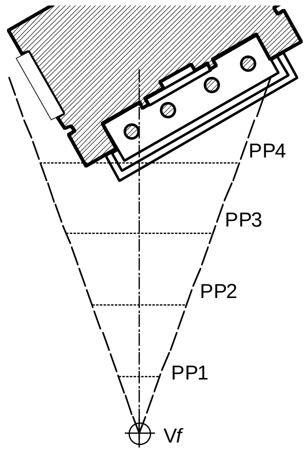

Figure 2: **Fixed position, two-point pers.**

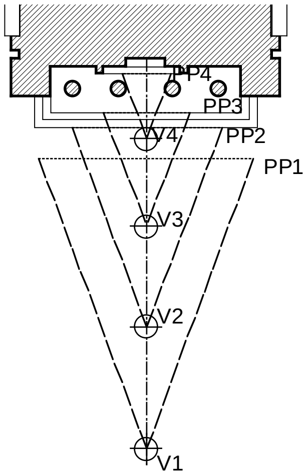

Figure 3: **Variable position, one-point pers.**

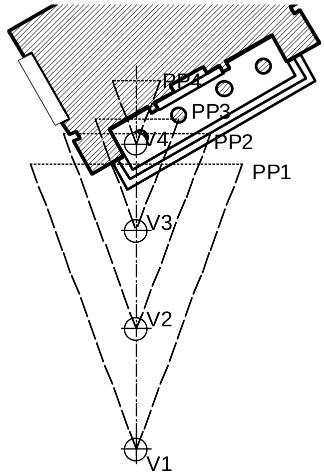

Figure 4: **Variable position, two-point pers.**

2.2.3 Variable position, one-point perspective (fig. 3)

This variation uses a range of viewpoints, starting further away from the façade and moving closer to it, but all at right angles to the dominant surface of the façade. At each viewpoint the standard cone of vision of the human eye determines the extent of the façade that is analysed. This means that, with each iteration, a reduced portion of the façade is considered.

This variation is close to the way a human eye would operate if a person walked directly towards a façade. This variation can be refined to set a range of standard viewing distances along a line to the façade allowing it to be repeatable for a wide range of circumstances.

2.2.4 Variable position, two-point perspective (fig. 4)

A range of viewpoints positioned along a line, starting further away from the façade and moving closer to it, are used. None of these viewpoints are at right angles to the façade's geometry but all are positioned along a single vector to the façade. At each viewpoint the standard cone of vision of the human eye determines the extent of the façade that is analysed.

2.2.5 Variable position, multiple-point perspective (fig. 5)

A range of viewpoints, starting further away from the façade and moving closer to it, are used. None of these viewpoints are at right angles to the façade's geometry and none are in a fixed line between the original view point and the final one (a characteristic of the other variations). At each viewpoint the standard cone of vision of the human eye determines the extent of the façade that is recorded. This is the closest of any of the methods to reality. It suggests that people rarely approach buildings along a single vector and it acknowledges the importance of the limits of human vision. However, it is hard to see how this could be easily repeated for multiple buildings (because fractal dimension in architecture is mostly useful, from an analytical point of view, as a comparative value). Notwithstanding this problem, there might be some ways to use this variation. For example, some houses can only be approached along a proscribed entry path; several of Wright's houses have hedges that line paths forcing a visitor to walk around to the rear to enter.

In such cases, where the experience of the architecture is choreographed, it would be interesting to determine the fractal dimension of the architecture (or even the landscape framed in this way) along the entry route. Such an analysis would produce a valuable numerical expression of the way a designer intends to reveal the visual qualities of a building. An alternative way of using this variation might be to compare the fractal dimension of different approaches taken by people to a building.

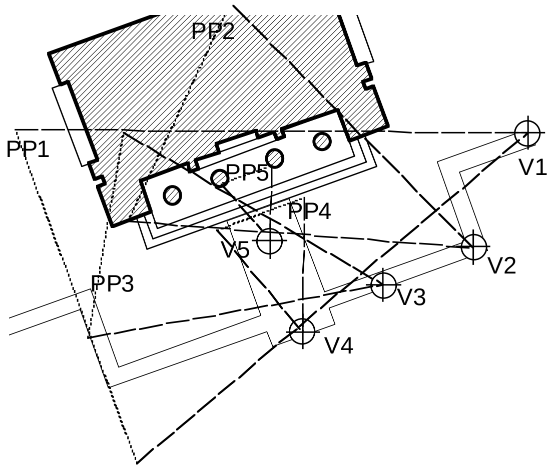

Figure Key

For figures 1 – 5;

V*f* is a fixed viewpoint

V1-5 are sequential viewing points

PP1-5 are picture planes where an image is recorded

Figure 5: **Variable position, multiple-point pers.**

For example, imagine a civic building facing a piazza. A statistical analysis could be undertaken of the way in which many hundreds of people approach the building across the piazza. Imagine that, all things being equal in the piazza (ie. no physical or visual obstacles), there are three dominant paths taken by people. What would a fractal analysis of visual complexity of the environment along these three paths reveal? Would it suggest that people are drawn along similar or different visual paths? Are people drawn to the paths that maximise the visual complexity of the environment? This is certainly the untested assumption implicit in many applications of Mandelbrot's ideas in architecture.

3 Conclusion

This review of Bovill's method has begun to uncover a range of issues that should be refined or corrected before the method can be used as a consistent analytical tool. Ultimately, the analysis of the assumptions implicit in Bovill's method does not undermine its importance, but it does reinforce the fact that this method is not able to be used to make quality judgements about historic architecture. The method may be used to suggest the extent to which a design has multiple levels of detail, but this is not, in and of itself, any reflection of design quality, aesthetics or ethical values. Similarly, high fractal dimensions in architecture are not any more natural than low fractal dimensions; fundamentally architecture is not nature and a higher *D* does not infer that a building is any closer to nature than a lower *D*.

In considering the way in which Bovill frames images of historic buildings for analysis a range of variations have been proposed. Each of these variations are more realistic in modelling the way in which humans experience architecture. They are superior to Bovill's method in all but one, important, way. Bovill's method, for all that it may be unrealistic, has the advantage that it is a straightforward, repeatable process. The method may not result in the most realistic or detailed results, but they are relatively consistent. Finally, the variations set out above, and especially the final one, suggest that there are powerful applications of fractal analysis that have not yet been developed or tested but which will be useful for producing a more nuanced, subtle or detailed, reading of visual complexity in the built environment.

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TRIVIAL TECHNOLOGIES OF EFFECT IN THE HOME

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Abstract

Most accounts of how new technology has transformed the domestic realm focus on the provision of comfort, sanitation and labour-saving devices. In parallel, but typically not visible in these histories, there has been a minor strand of development that we identify as trivial technologies of effect. These are gadgets and devices whose utility cannot be separated from wonder and delight. They bring a kind of non-essential utility for private enjoyment, and so occupy a distinct ground somewhere between function and entertainment. In this sense they can be thought of as aligned to the practice of architectural design, which similarly pursues both functionalism and art.

The paper explores this category of trivial technology through two significant examples of mechanised houses. The first is the house of Jean Eugene Robert-Houdin, a nineteenth century magician and noted amateur inventor. From this case, the form of the magic trick provides a metaphor for our analysis of technologies of effect. The second example is the penthouse addition of the appartement de Beisetgui, designed by Le Corbusier. Here we trace the same lineage of devices in the modernist guise. Finally we briefly examine the present-day phenomenon of the ‘smart house’, and other attempts to rekindle wonder in domestic digital technologies through the designs of Bill Gaver.

In conclusion, we use the inherent ambiguity and irony of trivial technologies to explore the modernist mantra of the machine a habité in a different light, that is less about satisfying functionalism, and more about producing automated and sensory effects.

Keywords: domestic technology, modernism, magic.

1 Introduction

> 'Would it not be possible to go even further and plan our buildings and houses by taking into account the person who frequents or inhabits them, not only to determine their general arrangement and distribution, but also to introduce thousands of specific comforts, services, and time – and energy-saving devices that the adaptation of new procedures from science and industry could provide for domestic life? A house is an instrument, a machine so to speak, that not only serves as shelter for Man, but … must confirm to his activity and multiply the production of his work. Industrial constructions, workshops, plants of every kind are, from this viewpoint, almost fully achieved models worthy of being imitated.'

This passage written by Adolph Lance in 1853 was read by Le Corbusier and, according to Manfredo Tafuri (204-205), very possibly inspired his idea of a *machine à habiter* – a famous motif of modern architecture's lean, functionalist aesthetic. But there is another vision that the passage conjures up: a house full of gadgets and mini-machines intended to enhance every aspect of domestic life. During the nineteenth century the home was indeed transformed by a few key innovations mostly concerned with improved sanitation, cleanliness and cooking (Ierley). In the western world, these have become part of a mundane infrastructure that is assumed necessary for normal domestic life. But what about the 'thousands' of new 'comforts' and 'services' that Lance called on 'science and industry' to deliver?

Attempts to make real this second vision of a mechanised house have given rise to a category of invention that we will identify as 'trivial technology' and which forms the focus of this paper. Instances of this category – think of the Goblin Teasmade – display technological ingenuity which exceeds their utility. That is, the effort in conceiving, building, operating and maintaining them somehow seems out of proportion with the advantage that they might bring to their users. A defining characteristic of trivial technologies is that they do not become part of an assumed domestic infrastructure. Rather, on every use the home dweller feels ever so slightly delighted that something has been done by a machine that might have been done by themself, or not done at all. While core domestic technologies quietly and slavishly perform important functions, trivial technologies ostentatiously do something surprising if not particularly useful. (Our definition is in stark contrast to Von Foester's notion of 'trivial machines' which perform a task without variation and wonder, like a toaster (Gage 771).) A second characteristic of our trivial technologies is that they relate to activity in and around the home. Excluded from our category then are purely decorative and artistic artefacts, media like television and radio, and global communication devices like telephones that are intended to bring value through symbolism and/or the distant content that they present.

Trivial technologies have always belonged chiefly in the domestic realm because it is only here that the disproportionate expenditure of ingenuity and effort can be tolerated. They typically depend on the doting hand of the hobbyist and amateur inventor, who is usually male, and on his leisure time to tinker. Further, trivial technologies are intrinsically comical. A theme explored, for example, by the absurd machines of the illustrators William Heath Robinson and Rube Goldberg, those built by the Swiss sculptor Jean Tinguely, and those simulated in Aardman's animations of Wallace and Grommit (Lewis, Hulten). Comedy arises through a kind of satire on the seriousness of technology, and through a glimpse into the unrealistic mind of the amateur inventor.

What can this seemingly fringe category of technology tell us? We will explore their significance through two key examples of trivially technologised houses, and consider how they aim to produce effects that are over and above satisfying merely functional needs. It is precisely because they go beyond the mundane that they sharply focus consideration on what their point and meaning is. By concentrating on those inventions embedded in, or connected to, the house, we also consider what they tell us about the relationship between technology and architecture; particularly to question modern architecture's appeal to functionalism and the *machine à habiter*.

2 The Priory: the house of Robert-Houdin

'The Priory' was the home of the French magician Jean Eugene Robert-Houdin who performed in Europe in the mid-nineteenth century. He was widely regarded as the greatest magician of his day, and subsequently as the greatest of all time (Dawes 121, During 118; Metzner 160). Robert-Houdin's house of gadgets is significant for two reasons. First, it is one of the earliest attempts to create a mechanised house and was contemporaneous with the writings of Lance as quoted above. Second, as we will argue, the invention and installation of his trivial technologies owed much to the nature of conjuring. To underline the significance of this association between trivial technologies and magic, it is important to realize that conjuring in the nineteenth century was a dominant form of entertainment that exploited the latest advances in science and technology to produce ever more amazing tricks: new understandings of electricity and electromagnetism; new materials such as invisibly thin steel wires and larger glass sheets for optical illusions; and the increasing sophistication and miniaturization of mechanical devices (During, Steinmeyer "Science" "Discovering" "Hiding"). Like other great nineteenth century magicians, notably John Maskelyne in London, Robert-Houdin was a trained clock-maker and accomplished amateur inventor (Dawes, Christopher). And during his life he created many examples of automata and trivial technologies including an alarm clock, patented in 1837, that on being activated lighted a taper for a candle or cigar (a distant ancestor of the Goblin Teasmade perhaps?) But success in magic lies not merely in technological invention. It depends critically on how technologies are deployed to create effect. This can involve disguising or mis-conceptualising the role of the apparatus, and the boundary between the apparatus and the actions of the performer. It is here, in the deceptive deployment of technology, that Robert-Houdin appears to have excelled (Steinmeyer "Hiding" 139). His 'mysterious clock', for example, presented a face and hands that kept good time although they were clearly seen to be separate and disconnected from the clockwork mechanism.

After a short career of entertaining the public and the powerful of Europe, Robert-Houdin retired to The Priory near Blois in 1849 and applied his technoscientific-magical thinking to novel devices for his new home. He installed a system of alarm-clocks to wake servants, with ringing bells that could only be turned off by those affected leaving their beds. These ran off a central master clock - a kind of early network arrangement - that allowed all clocks to be brought forward or back if desired. Unknown to the servants, their actions of opening and closing doors in the house kept the master clock wound. Other domestic technologies at The Priory were: an automatic timer-based horse-feeder, a temperature-activated fire alarm, and burglar alarms on windows and doors. Of particular interest is the entry gate that was some distance from the house and triggered a bell when post was delivered or needed to be collected. When visitors rang a bell at the gate, it could be remotely unlocked at the house, and a name plaque next to the gate rotated to change its message from 'Robert-Houdin' to 'Entrez' (Robert-Houdin). When visitors then opened the gate a further variable sequence of rings was initiated that sent a signal to the house about the familiarity or otherwise of the party.

Robert-Houdin's domestic inventions take the form of magic tricks, and we argue that this reveals a reoccurring pattern in trivial technology. As in magic performance, all of his devices were designed to lurk unseen, waiting to deliver an encapsulated moment of effect for a targeted audience in the space of the house: horses, servants, visitors, those caught by fire or those being burgled. And also like magic, the moment of effect was accentuated, and depended on surprise (the rotating plaque, the changing alarm setting), and disguised the role of technology (the entry gate sensor system). It also often involved a kind of performer-spectator relationship between someone 'in-the-know' and someone haplessly affected (master/servant; host/visitor; master/horse; household/burglar). These early programmable message-sending devices can be considered as a kind of prehistory of information technology and the smart home.

The Priory, as an early mechanised house inspired by magical thinking, provides a model of technologies of effect. Unable to justify their existence on utilitarian grounds, they wait for their moment to create delight, at least for their owner and creator. Rather than sinking into the invisibility of necessity, they keep visible a relationship between a performer/designer and a spectator/user. Robert-Houdin’s domestic inventions also establish the reoccurring tropes of trivial domestic technologies of effect. First, they are connected to servitude, mediating a relationship between master and servant. Industry's new modes of technologically regulated work and technologically mediated power were thus brought into the home. Second, many of Houdin's devices operate at the threshold of the private interior of the home and the exterior world, aiming to enhance connectivity across this boundary. This is most evident in the elaborate and ingenious system of entry bells, and less obviously in his obsession with alarm clocks that can be seen as part of the wider role of the modern clock in creating a fundamental relation between the private domestic realm and the public realm of work and the city via accurate time-keeping and information (Kwinter 18).

3 The Appartement Charles de Beistegui

For our second house, we stay in France but jump forward some eighty years to a little discussed domestic work of Le Corbusier. The appartement Charles de Beistegui is a small roof-top addition to an existing nineteenth century building on the Champs-Elysées in Paris, constructed in 1929 -1931. It was built for the wealthy film-maker client Charles de Beistegui as a modern party penthouse. This was no prototypical house for the ordinary contemporary man, but rather a bespoke design of extravagance. The appartement featured an extraordinary and surreal walled roof terrace and garden from which the visitor's gaze was obscured and frustrated: only the top half of a few iconic Parisian monuments were allowed to be viewed. The design incorporates many technological devices that are apart from the core domestic technologies of environmental comfort and constructional efficiencies. This house therefore presents somewhat of an anomaly in the oeuvre of Le Corbusier.

In contrast to Corb's more famous villas of the period, the fabric of this building – in structure, spatial arrangement and skin – does not absorb and perform all the work of the 'machine for living'. Other more trivial and wonderous technological artifacts embellish the design. For example, while candle-light powers the only sources of interior lighting, electricity is devoted to mechanized systems for moving doors, walls and even garden hedges on the roof top terrace that otherwise obstruct any view of Paris. Here, as Colomina has described, electricity becomes what Corb describes as the 'docile servant' (Colomina 297). Electricity also powers the retrieval of cinematographic views of Paris that are collected via a periscope device on the roof and projected on an interior screen which unfolds via an automated mechanism that moves the room's chandelier out of the way. Thus the otherwise obscured view from the terrace is further abstracted and automated. As Tafuri has described, technology is here employed 'in the service of game' to make a *boite à miracles* (203).

The overtness of technological embellishment is captured in Le Corbusier's own description of the appartement, as summarised by Peter Blake, who commented that only a 'Frenchman in love with modern machinery would ever describe a landscaping project in terms of the length of electric cable required to make it function' (Blake 60). Blake reasoned the motivation behind the mechanically moving hedges on the roof top garden terrace of the apartment as an example of Le Corbusier's desire to manipulate nature in the mode of the classical. However this does not seem an adequate explanation. The technologies in this apartment can be read as analogous to Robert-Houdin's house of technologies, but now embedded in, and modified by, the context of domestic modernism. There is an updated endeavor to modify the master-servant relation, in this case by replacing the tasks of servant help with automation. There is also an emphasis on the boundary between the modern interior of the apartment and the exterior city of Paris. The apartment and roof terrace quite literally becomes an apparatus for capturing, modifying and projecting the environs: the relationship between house and city is made artificial and mediated through apparatus.

Despite the appartement de Beistegui's overtly frivolous and showy use of insignificant technologies for sensory enhancement and wonder, by-and-large Corb's explorations in domestic technologies cannot be seen as intentionally light or humorous. It was perhaps this taking oneself too seriously that the French filmmaker Jacques Tati was to exploit. However Tati also sought to make a serious critique of the effects of modernism and the technologies it brought to disrupt the French environment (Penz 64). In his film Mon Oncle of 1958, it is the modern, functionalist house that is both a central character and subject of satire. As in Corb's appartement, Mon Oncle's house is embellished by a sequence of trivial technological devices that again focus on the threshold between interior and exterior, surveillance and labour automation. For example, the front garden features an automated fountain in the form of a metal fish that spouts only when unfamiliar visitors and guests arrive at the gate and ring the bell. While inside, the kitchen features other devices in the family of the Goblin Teasmade, such as an automated steak-grilling flipper.

Jaques Tati's humorous critique of modernism was followed by postmodernism's general dismissal of the dogma of functionalism. However recent criticism by the likes of Stanford Anderson, Mark Wigley, and Beatrice Colomina, have overlaid more subtle interpretations that complicate modernism's original appeal to, and ownership of, the functional. For example, Anderson contends that functionalism in modern architecture cannot be taken at face value for it was indeed a 'fiction'; in two senses of the word: as a simplistic error of interpretation, and as an intentioned and conscious rhetoric or story-line (21). Functionalism, for Anderson, is in fact a misleading and 'weak concept', inadequate for understanding the complex *raison d'êtres* of modern architecture (19). In particular, he reads Le Corbusier's 'functionalist villas' like Villa

Savoye as a talisman for new ways of modern living: as a *machine à habiter* it is propositional and suggestive, but not deterministic.

As suggested in the introductory quote of this paper by Lance, if we assume that Tafuri is correct in attributing the concept of a *machine à habiter* to nineteenth century sources, this also throws its meaning into question. Indeed one alternative meaning that has been offered takes an alternative translation of the machine as an apparatus for 'the production of stage effects', and arrives at 'a contrivance for the effect of dwelling' (Wesley 122). This alternative reading, while by no means of universal application, is illuminating in the case of the appartement de Beistegui.

4 Today's 'Smart House' and its alternatives

Jumping forward 60 odd years to the present, have we now reached a new incarnation of trivial domestic technologies on a mass-scale rather than through the rarified examples of the amateur inventor or the architect designed penthouse? Since the early 1990s there have been numerous predictions of the transformation of the 'dumb box' into the 'smart house' through automated information systems (Millar 128; McCarty 9). These promises of automation build upon earlier uses of trivial technology, with, for example, more sophisticated alarm clocks, surveillance and movement detection, information gathering, home-help replacement, and remotely operated control for devices of heating, cooling, lighting, entertainment and so on. The following description again updates the trope of servitude:

'You arrive home after an elegant evening at the theatre. As you pull into the driveway, outdoor lanterns snap on to help you steer clear of the rosebushes. Inside the house it's toasty 72f, with just a few lights on. The electric fireplace has just started up, and the soft music emanates from the stereo. In the kitchen, freshly baked apple pie is waiting in the oven' (Hamilton).

Here the enticing promise is made of ghosts of former servants who can prepare the house for the returning master. However, it was noted in 2000 that although some 4 to 7 percent of American homes were now equipped with computer operated networking of services and entertainment, but many proud owners of these new incarnations of a 'machine for living' do not know how to operate them (Lovine). Other pioneers of integrated domestic technologies like the MIT Media Lab, also admitted that they were somewhat stumped as to what the point of much of this technology was; perhaps too trivial yet not wonderous enough to catch on. (Time International)

At the same time as the smart house phenomenon, which favours utility while concealing its new devices and their controllers, we see other more artful experimentations with alternative technologies in the home as exemplified by the work of technologist Bill Gaver. Gaver's domestic artifacts exhibit a kind of technological ambiguity and wonderment that is reminiscent of magical apparatus. They continue the exploration of the connection between those inside the home and the immediate outside. For example, the Drift Table, that predates Google Earth, provides dwellers with a virtual balloon journey by presenting digital maps through a small hole in the surface of a coffee table. Similarly the 'Video Window' provides a view of the exterior streetscape on a computer screen mounted on a wall. And Gaver's 'Key Table' mediates entry to the home: the force of dropping keys and other objects on the table changes the orientation of a picture hanging nearby (Gaver).

5 Conclusion: Technologies of effect

The desire to bring industry's technological ingenuity to the aid of domestic life, beyond the survival and comfort-related activities of cooking, cleaning and sanitation, gives rise to the category of trivial technology. From the examples of trivially technologized houses that we have considered some themes emerge. Trivial technologies thrive around the mediation of relationships between people in the household. Firstly they invoke servitude; they intervene in, or simulate, the relations between master and servant. Secondly, a key site of mediation is the boundary of the home; the gulf between occupants and visitors or other outsiders. For Robert-Houdin, this was embodied in an automated entry gate that issued bell signals. For Le Corbusier's appartement, technically-assisted connection with the outside was realised through a periscope and an automated hedge which revealed selected views of the city. In the present-day smart home, the boundary is marked by an emphasis on security alarms and internet connectivity. While in Gaver's work, the Video Window and the Drift Table allow the viewing of the house's immediate environs, and the responsive Key Table intervenes in the act of entering the house.

What these persistent themes tell us is that domestic trivial domestic technologies should not be dismissed as merely the work of over-zealous boffins who cannot quite grasp the difference between the efficient world of industry and the social world of the home. Rather, they exhibit a deep concern with the ambiguity and irony of technology. They represent attempts to rise above the purely functional and mundane infrastructure that we take for granted. Like the realms of magic and architecture, they can produce momentary sensory effects that are wonderous. And what they also tell us about architecture is that its appeal to technological functionalism is never straight-forward. Even for a so-called functionalist like Le Corbusier, architecture had to satisfy both biological needs (heating, lighting, circulation etc.) and aesthetic phenomenon, which for Corb was encapsulated in profoundly sensory terms: ‘the physiological sensation, an “impression”, a pressure by the sense, a compulsion.’ (Le Corbusier 126). This sensory effect is what lifts mere building into architecture.

Our investigation of gadgets and devices in the home, drawn from the nineteenth and twentieth centuries, forms a kind of pre-history of the smart house. We argue that this pre-history is important for understanding the current condition and future possibilities of the latter. The trivial technologies examined here mark an uneasy meeting point between technological functionalism and aesthetic design. It is this uneasiness that is carried forward in today's smart-house, often unreflectively with inherent tensions unresolved.

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DESIGN WITHOUT CAUSALITY: HEIDEGGER'S IMPOSSIBLE CHALLENGE FOR ECOLOGICALLY SUSTAINABLE ARCHITECTURE

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Abstract

Deploying Martin Heidegger's thinking on technology, this paper attempts to show an internal contradiction inherent in our technologically oriented approach to sustainable design.

Heidegger's thinking on technology, which has had an influence both on the ecological movement and on architecture, situates the problematic shift toward modern technology at the beginning of the enlightenment with the emergence of new understandings of both the subject and the object. Each of these revolutionary understandings contribute to the reframing of nature as knowable and (therefore) controllable. Nature thus moves from a position of mystery and wonder to that of a disenchanted, predictable system, allowing the appearance of a technological orientation in which nature is framed in advance as something simply manipulable for our benefit.

Unlike the Classical Realist account of nature that emerged from the enlightenment separation of subject and object, Heidegger's formulation of the real, of nature, does not allow the same confidence in causality and control. However, design, as the engine of technological innovation in modernity, appears inseparable from the modern technological understanding of causality and control and the framing of nature as a mere resource. This problematises the possibility that design, as it is currently conceived, can contribute to achieving an ecological sustainable relation to nature.

Keywords: technology, Heidegger, ecological, sustainable, design.

1 Introduction

Any discussion of technology would be incomplete without consideration of the thinking of Martin Heidegger. His often-difficult formulations of the relation between modern technology and our life-world has informed quite diverse practical and theoretical trajectories. His work prepared the way for that branch of philosophy now referred to as the Philosophy of Technology (Ihde). His thinking on technology informed the radical counter practices of the early ecology movement, particularly 'Deep Ecology' (Naess). In architecture, Heidegger's thinking was deployed in theorisations of place and identity, popularised by the writings of Norberg-Schulz, and later in perhaps more considered ways by critical architectural theorists, such as Kenneth Frampton, in their attempt to formulate an architectural practice to counter the perceived globalising and homogenising tendencies of late modernity.

In this paper I want to return to a key aspect of Heidegger's thinking on technology, lay it out in relation to his broader critique of rationalism, and clarify, in a way that I believe has not been previously articulated, the profound ecological implications, particularly for the design professions, of Heidegger's critique of modern technology.

2 Life-world and Earth

For me, Heidegger's most revelatory contribution to philosophy centres on his insistent explication of the absence that grounds all presence. It is the power of the recognition of this absence that continues to shake any pretence of the possibility of rationalist foundations (in every domain, including architecture). The mapping of this absence over the course of his work followed a rambling philosophical path.

Since Descartes, philosophical explanations about how it is we can have knowledge of an object, had begun with two premises: a subject that is present to itself, and an object that is independently present. With this schism between self-present subject and ever-present object in place, the tradition was left to construct shaky explanatory bridges showing how a subject present in its own 'internal world' could have certain knowledge of an object present in an 'outside world'.

Heidegger's early work, most famously *Being and Time*, firstly undermines the priority given to a self-present subject. It shows that our noticing of something as something in the present is not on the basis of our being self aware subjects (thinking things), but on the basis of unnoticed experience of the everyday life-world of our past and an unnoticed projection of our everyday projects into the future. In other words, it shows how our absent past and absent projected future allows things come to presence as the present.

However, because its starting point was located in the everyday being of human beings, Heidegger's early work contained an anthropocentric bias. Within his work lurked the problematic implication that humanity, in this case human projects and practices, still determines the way the world comes to presence. To redress this implication, Heidegger deployed a great deal of his later work toward demonstrating that neither human subjectivity nor human projects and practices determine the way the world comes to presence.

Central to achieving this, Heidegger took the familiar concept of 'earth' and made it strange (Haar). On one reading, Heidegger's earth names the totality of the universe, nature, the real, before it is brought into our world as something for us. Importantly earth is never merely an object, a thing; it is instead the potential that shows up as things, objects, when brought into our world. But neither is world and earth a dichotomous pair. World is one disclosure of earth, but never its totality. Thus in opposition to the rationalist tradition, earth cannot be made entirely present. It is a potential that is only disclosed to us in its encounter with our particular practices and projects. Countering any implication of anthropocentrism, this disclosure is not a one-sided affair, dependent simply on our human projects and practices. Earth is a potentiality with its own force, its own trajectories, that struggles with the interpretive forces of our world that attempt to disclose it. Prior to its disclosure in our world, earth, as potential, is thus also an absence.

Considering his total oeuvre, then, Heidegger paints a profound and radical picture of struggle between two absences — the absence of the subject and the absence of the object — between which our world comes to presence.

3 Regime of Modern Technology

Heidegger's discussion of technology, particularly the danger of modern technology, may initially appear disconnected from his critique of the historical valorisation of the separation of self-present subjects and ever-present objects. The two however emerge as intimately intertwined.

In The Question Concerning Technology, Heidegger draws a distinction between modern and pre-modern technology. Heidegger points out that under the dominion of modern technology our relation with nature becomes one of demanding and challenging — a relation for which he uses the German neologism 'Ge-stell', sometimes translated as 'enframe' or 'set-up'. Rather than being open to what nature offers to us, nature is instead forced to reveal itself in ways we have formulated in advance. For Heidegger the essence of modern technology is thus its enframing or setting up of nature in terms of human interests to the extent that nature is revealed one dimensionally as a resource for human use.

To demonstrate this with an example from our contemporary context, it is evident that even the nature we believe we are defending from this very exploitation by designating reserves, parks and wilderness, is ultimately framed as having some anthropocentric purpose: to service the tourist industry, as a sink for green-house gases, to maintain biodiversity for some future medical, economic or human survival endpoint, and so on.

Scholars attempting to elucidate Heidegger's account of the process by which the modern technologised West comes to be enframed in this way, and how this relation to technology differs from the human-technology relation in the pre-modern world, draw upon particular moments in Heidegger's texts. Michael Zimmerman, who works meticulously through Heideggerian arguments with a focus on the ecological repercussions of technological enframement, highlights what he sees as the key mechanisms of enframing.

Beginning with the modern condition of subjects standing apart from objects, Zimmerman describes the steps that lead us to enframe and consume nature:

> Heidegger defined human existence as the existential clearing in which the body, ego, feeling-states, memories, thoughts tools and natural things can appear. Tending to conceal that it exists as this clearing, Dasein becomes absorbed in its dealings with entities. This falling into the world and away from one's own being stems from the fact that Dasein's being is inherently mortal and finite. Indeed, the clearing that lets things be is in effect no-thing at all, but finite, mortal nothingness or openness. Forgetting this openness lets Dasein work unself-consciously with the instruments of everyday life, but such everyday forgetting can be aggravated when the mood of anxiety (angst) threatens to reveal Dasein's mortal nothingness. Fleeing from this disclosure, Dasein plunges into inauthenticity, which involves two related aspects. First, inauthentic Dasein conceives of itself as a stable, self-grounding subject, thus transforming Dasein's uncanny nothingness into a defendable thing: the ego-subject. To defend itself, the ego-subject sets out to control all entities. Second, since Dasein cannot succeed in turning itself into a fixed entity, inauthentic Dasein continues to experience a sense of existential lack or incompleteness. One way of overcoming this lack is to full up the self by consuming even more entities. Death-defying inauthentic Dasein, then, seeks to protect and complete itself by dominating other people and devouring the planet. (110-11)

I have a sense of unease with this and similar philosophical formulations of the emergence our anthropocentric exploitation of the planet. The steps in the argument do not appear entirely compelling. Why is control of all entities the necessary outcome of becoming a 'death-defying' ego-subject, and why should the subsequent existential lack necessarily lead us to consume entities?[1] Also, in the one text where Heidegger painstakingly lays out the relation between our enframent by modern technology and its repercussions in terms of consumption of the planet — *The Question Concerning Technology* — he does not mention our flight from mortality, which is a theme in other works. While it may be the background of the text, it is certainly not the thematic hinge he wants to emphasise. For me there is another understanding of Heidegger's text, that is not necessarily more correct, but is perhaps more revealing for design as its strives to achieve ecological sustainability.

4 Causality in Modern Technology

In *The Question Concerning Technology*, Heidegger makes the paradoxical claim that modern technology arrives before the appearance any actual modern technologies (22). Heiddegger's chronology appears to be: firstly the arrival of the *essence* of technology, then the arrival of both modern science and the appearance of modern technologies,

> It is said that modern technology is something incomparably different from all earlier technologies because it is based on modern physics as an exact science. Meanwhile we have come to understand more clearly that the reverse holds true as well: Modern physics, as experimental, is dependent upon technical apparatus and upon the progress in the building of apparatus. The establishing of this mutual relation between technology and physics is correct. But it remains a merely historiographical establishing of facts and says nothing about that in which this mutual relationship is grounded. The decisive question still remains: Of what essence is modern technology that it happens to think of putting exact science to use? (14)

The essence of modern technology that I contend Heidegger is trying to show now enframes us is the product of the shift that initiates modernity itself: the radical new understanding of the self, and the radical new conception of the nature of the very stuff that constitutes the universe. This shift has come to be summarised in the now rather innocuous phrase, the separation of subject and object.

As discussed at the outset of the paper, the separation of subject and object arrives with the privileging of an understanding of our relation to the world as one of a self-present subject located in a universe of ever-present objects. This understanding is evidenced in both the modern scientific apprehension of our universe, and our everyday apprehension of the world. For modern science, the entities that constitute the universe are *a* particular way (a position described as Classical Realism). Once it is understood that entities are *a* particular way, then it becomes possible that we can come to know the way they are — this is the orientation necessary to found modern science. In a more everyday context, when we reflect on our own relation to the world the entities around us appear in much the same way as they do for science — as objectively and permanently present. For Heidegger, such reflection is secondary to unreflective coping, but in modernity it has been taken as primary.

The consequence of the shift to our modern conception of self and world should not be underestimated. Understanding that the entities constituting our universe are a particular way (not flux, not transformable by whim of God, or so on), brings with it the conviction we can come to understand these entities, to understand nature as it were, and as a consequence that we can come to understand the causality inherent in nature. Heidegger spends a deal of time in *The Question Concerning Technology* discussing pre-modern and modern notions of causality. His assertion that ‘wherever instrumentality reigns, there reigns causality’ (6), identifies causality as being at the heart of our instrumental relation to nature. Clearly, it is a small step from the belief that we can understand causality in nature to the conviction that we can control it. Understanding causality and controlling causality can be seen as the twin origins of science and technology respectively.

5 Design Hubris

At this point, the implications for ecological sustainability and for design also become clear. With modernity’s belief that causality in nature could be understood and therefore controlled, technologies have been increasingly deployed with the confidence that their outcomes can be predicted. While the design of each individual technologically mediated intervention would have been intended to cause a (local) beneficial outcome for some portion of humanity (grounded in ‘care’ in Heidegger’s terms), their cumulative impact on the ecological systems of the planet is now considered by many to be potentially catastrophic. If this scenario is accepted, then design could be characterised as the well-intentioned engine driving the proliferation of technologies that now threatens the planet.

Designers, and not least architects, are enframed within a view of causality which instils confidence that designed outcomes have predictable effects. Tellingly, this confidence is no less evident in the responses to the perceived ecological crisis, where design is confidently being advocated to develop solutions to overcome the very problems that confident designing has created. Confirming such a view of the designer, Heidegger refers to the ‘engineer in his drafting room’ (which could equally be the architect in his/her studio) as being part of an enframed system, ‘an executer, within Enframing’ (Question, 29).

Modernity’s understanding that the entities constituting our universe are *a* particular way and operate under the rule of causality, marks a momentous shift: in pre-modernity nature is apprehended as mysterious and marvellous; in modernity nature is apprehended as systematic and operable. This shift is, for me, no better illustrated than in the surreal (yet quite serious) design for a solar umbrella consisting of trillions of satellites launched from earth and intended to stop global warming (Brahic). The pre-modern understanding of the mystery and wonder of the sun’s warmth *granting* life to all beings on earth (for many pre-modern cultures the sun and God were one), has shifted to a modern understanding where the sun’s warming of the earth is a calculable system that we do not merely believe we can understand, but have the hubris to believe that we can control.

6 Design Humility

Heidegger’s conception of the real, evident in his own formulation of earth as absence, does not offer a foothold to causality in the same way as modernity’s understanding of the real as presence. In *The Question Concerning Technology*, Heidegger refers approvingly to the work of Werner Heisenberg, whose formulation of Quantum Mechanics lays down a challenge to the Classical Realism of modern physics that is as radical as Heidegger's own challenge to traditional philosophical formulations of the real (23). For Heidegger, the real, earth, is not a particular way, and cannot therefore ground the sort of causality that allows the impacts of design outcomes to be anticipated.[2] Thus Heidegger's critique of any generalisable causality, does not encourage intentional action through the vehicle of design (in all its meanings and domains) as it is traditionally conceived.

Perhaps because of this recognition, I cannot help but feel a sense of frustration in my encounter with Heidegger's thinking. This frustration is particularly evident to me in my role as a design studio tutor and coordinator of the sustainable stream of the senior design years of a professional architecture degree, where I have been unable to incorporate, in any meaningful way, Heidegger's radical stance. So-called ecologically sustainable design is invariably premised on the expectation that design interventions can be developed in which certain identified causes of the current environmental crisis can be ameliorated. The success of such interventions depends directly on causal chains, such as the relation between building energy use, green-house gas emissions and global warming. But when causality itself is universally challenged and all certainty relating to the outcome of a design intervention is removed, then confidence in the act of design is undermined and the effect immobilising.

Hesitation may be the reaction Heidegger would wish in the face of the recognition of the enframing of modern technology. To conclude *The Question Concerning Technology* Heidegger advocates an (active) non-action— articulated in his much-debated call to 'let be' — as the appropriate response to the relentless demands of modern technology. Such an orientation is of course problematic in a studio context where it is completely mismatched to pre-framed expectations about design and architecture and their heroic role in inventing new worlds. Heidegger's conservative calls to focus on the 'little things' (Rojcewicz, 213ff), on life's everyday routines, run entirely counter to the innovative and radical attributes of design that are now valorised. But in the context of a world of unrelenting change driven by the vehicle of technologically mediated design, Heidegger's may indeed be the radical position. As Gianni Vattimo has pointed out, what designers proudly depict as innovation, has become nothing more than the maintenance of the ordinary,

> …in a consumer society continual renewal (of clothes, tools, buildings) is already required physiologically for the system simply to survive. What is new is not in the least 'revolutionary' or subversive: it is what allows things to stay the same (7).

As if in a final dismissal of causality and the possibility of our control over it, Heidegger argues that we cannot even choose *this* course. Even if there were a recognition that the causality that governs design is flawed, and that the certainty sustaining our technological striving for the new is groundless, Heidegger does not allow that we have the power to direct such an outcome (Rojcewicz). To do so and expect a benign result would simply be another act of enframed designing. Our course, on Heidegger's account, is granted to us, not designed by us.

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7 Notes

[1] The only line of reasoning I can propose to support such an argument would take the following course: that the separation of subject and object resulted in a normalised understanding of self-present subjects and ever-present objects. But the objects that constitute the universe, nature, are not in fact ever-present. Their (varying) appearances for us rely on their involvement in the shifting projects and practices of our world. From our side, there can be no firm ground for any object except the groundless ground of our world. Likewise there can be no firm ground to the nature of our own selves except in the groundless ground of our world. This apparently nihilistic formulation that is dependent on, and highlights our, worldedness (mortality), undermines the possibility that there is an ever-present object perceivable by self-present subjects. We therefore flee from contemplation of this nihilism by technologically facilitated consumption. Heidegger writes that "The emptiness of Being can never be filled up by the fullness of beings, especially when this emptiness can never be experienced as such, the only way to escape it is incessantly to arrange beings in the constant possibility of being ordered as the form of guaranteeing aimless activity. Viewed in this way, technology is the organization of a lack." Martin Heidegger. The End of Philosohy, trans. J. Stambaugh. New York: Harper and Row, 1973. P. 107.

[2] In summary, causality can only operate within a specific world of technologically mediated projects and practices and not beyond it. As long as science, for example, can strictly maintain the parameters of a 'world' (through a replicable experimental set up for example) then predictability may be attainable. The obvious problem with any design intervention is that it transforms the very world in which the causally based prediction was developed. Because the real, earth, is not <u>a</u> particular way, new aspects of earth are revealed in the struggle between this new world and earth. Thus predictions made in the world in which the design was developed about the impacts that design may have, need not hold in the new world that the design itself brings into being. The long history of unanticipated outcomes of design interventions might be used as support for this view.

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GREG LYNN'S EMBRYOLOGICAL HOUSE PROJECT: THE "TECHNOLOGY" AND METAPHORS OF METORSMOF ARCHITECTURE

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Abstract

This paper offers a close reading of one architectural text engaged in "knowledge transfer": the use of evolutionary biology discourse as an explanatory account and authority claim supporting Greg Lynn's Embryological House Project (2000). This essay addresses the twin conference themes of knowledge transfer and the potential threat posed to the specificity of architectural techniques. By offering a detailed reading, this paper argues that information transfer is not an innocuous activity, but involves the critical transformation of source material. This paper argues that technology transfer should acknowledge the workings of an ever-present technology, the "technology of architecture". This term designates the set of techniques governing the reworking of material from domains exterior to architecture, into material pliable for architecture. In this paper architecture's evolutionary theory borrowings, provides an exemplary instance of information transfer marked by displacement, not straightforward transmission.

1 Paper

> Once again architecture, in search of its lost object, is contaminated by this model fever. Christopher Alexander is already a precursor, and models can now be seen everywhere. They become the architectural avant-garde, bringing a kind of scientific guarantee given the tool of mathematics (which through science in its own domain become techniques when applied elsewhere – a phenomenon little understood by those who believe in a sort of osmosis whereby architecture, through the application of mathematical models, can itself become a science.)

Diana I. Agrest, "The Misfortunes of Theory" (1974)

Knowledge has become an economic phenomenon. As one economist, Dominique Foray argues, since the 1970s, new economic formations have emerged: knowledge-based economies, defined by the proportion of "knowledge-intensive jobs". (Foray, ix). Foray observes that, "science and technology tend to be central to the new sectors tending to give momentum to the upward growth of the economy", and that these realignments "are reflected in an ever-increasing proliferation of jobs in the production, processing, and transfer of knowledge and information." (Foray, ix-x) Over the last fifteen years, architecture's engagement with the disciplines of science and technology parallels this broader historical transformation of post-industrial societies. The economic calibration of knowledge, its "economic characteristics", and status as a "good" and the financial valuation of knowledge transfer and reproduction, are not addressed by this paper. However, I wanted to mark the origins of the term "knowledge transfer" in the discipline of economics, because this paper is concerned with one architectural case of "knowledge transfer" and the complexities attending this move, where the economic term "transfer' becomes somewhat inadequate to the task of describing the reformation of scientific claims within the discipline of architecture. This paper investigates one architectural transformation of evolutionary theory and argues that the reformulation and rewriting of material extraneous to architecture involves another technology, the "technology of architecture".

Greg Lynn's Embryological House Project (2000), is one of a number of widely circulated contemporary projects that mark architecture's intersection with the specialised discourses of biology (AD 26-35). The text accompanying the publication of this project forms a central document for this paper. The presence of two specialist disciplines, biology and architecture, and the intriguing question of their intersection is staged in an impressive seamless movement in the opening paragraphs. After a series of digital renderings of his design, with intriguing captions such as embyo and egg, captions seeming to signpost the place of biology in this project, Lynn's text opens with architectural claims about new, contemporary modes of production and aesthetics:

> The Embryologic Houses can be described as a strategy for the invention of domestic space that engages contemporary issues of brand identity and variation, customisation and continuity, flexible manufacturing and assembly and, most importantly, an unapologetic investment in the contemporary beauty and voluptuous aesthetics of undulating surfaces rendered vividly in iridescent and opalescent colours. (Lynn, AD, 31)

This detour from biology via traditional architectural concerns marks the interface of two discourses, and the project of reworking one via the other. The point of intersection begins to be clarified in the next sentence "The Embryologic Houses employ a rigorous system of geometrical limits that liberate models of endless variations." (Lynn, AD, 31) Addressing brand identity and variation allows "recognition and novelty" and "design innovation and experimentation." (Lynn, AD, 31) All of the implications of this form of production, which Mario Carpo terms "non-standard seriality", "mass producing a series in which all items are different" will not really concern us here, but of interest is the deployment of economic terms from late capitalist modes of production to form the links between discourses. (Carpo 99) The final part of Lynn's first paragraph provides the next linkage in the chain. The chain has so far moved from economies of production/consumption, to an aesthetic claim, to design techniques, back to avant-garde aesthetic terms (innovation and experimentation) and finally a larger picture emerges in this last sentence:

> In addition to both design innovation and experimentation, many of the variations in the Embryologic houses come from an adaptation to contingencies of lifestyle, site, climate, construction methods, materials, spatial effects, functional needs and special aesthetic affects. (Lynn, AD, 31)

The word "adaptation" is possibly drawn from biological discourse and this connection seems more substantiated by the next paragraph which begins, "There is no ideal or original Embryologic house. Everyone is perfect in its mutations." Moreover the "formal perfection derives from "a combination of the unique, intricate variations of each instance and the continuous similarity of its relatives." And then after indicating that the variation occurs in the relationship between the generic envelope and a fixed collection of elements, Lynn delivers his final sentence of the second paragraph and makes a larger historical claim, "This marks a shift from a modernist, mechanical technique to a more vital, evolving, biological model of embryological design and construction." (Lynn, AD, 31) Here borrowings from the discourse of biology are marshalled to produce a new internal history of architecture. This is one of the strategic effects of citing biological discourse. It shapes a certain mode of contemporary architecture as a more naturalistic mode of production. The place of a new economic formation ,"mass customisation", is eclipsed by the realignment of the new "biological" mode within a longer architectural history premised on a binary formulation: of older mechanistic versus new biological paradigms.

The appearance of words normally exterior to the discipline of architecture - adaptation, mutation, relatives (and of course embryology) - all of which are biological terms raises the intriguing issue of the strategic effect of these citations in an architectural discourse. The first three terms in particular are closely associated with evolutionary theory. The next part of my essay involves a close analysis of the disciplinary outlines of evolutionary theory in order to investigate the status and meaning of the scientific discipline's particular terms when they are displaced into architecture.

Evolutionary theory seeks to account for a particular kind of biological change: variation, the ways in which variations in organisms give rise to new species, the ways in which those variations are transmitted over generations, the mechanisms of heredity, how these variations are "selected", that is survive, the belief that some of these variations may be beneficial, and that there is a correlation between variation, adaptability and survival, demonstrating that adaptation ensures greater survival. (Jablonka and Lamb) The field is vast, specialised and complex, and most importantly, full of disagreement, hesitations, qualifications and uncertainty. These contests mark the place of evolutionary theory as a social discipline, comprised of competing or different accounts. Some of these disagreements can be recounted by exploring the complexity of terms such as mutability and variation, two of Lynn's key terms.

Evolution is in one sense a biological version of history. It seeks to account for change. Transformation, difference and the persistence of certain transformations, their triumph, is viewed, and noted. Evolution relies on a model of temporality, like history, to understand and judge its material. It operates with a notion of inheritance, the traits transmitted from generation to generation. These qualities and their persistence can only be known retrospectively. Only by looking back can scientists decide which traits and behaviours have been transmitted and selected over time. There are many debates as to whether this is a slow process that is gradual (very, very gradual) or whether there can be rapid genomic restructuring. (Jablonka and Lamb 70-71) (And it is not clear to me what rapid might be in terms of evolutionary time). Moreover what constitutes the targets of selection – genes or individuals, groups or species - has been debated, most adamantly by Richard Dawkins and Stephen Jay Gould. (Jablonka and Lamb 38) Moreover, it is possible that the evolutionary process may be entirely random and any historical model premised on causality and determinism might fail due to the operations of contingency. In other words, individual agents (at the level of individuals, groups or species) may play no part in the persistence and reproduction of survivable traits.

Variation is complex and entails several possible mechanisms. Heritable variation occurs through genetic mutation and also sexual reproduction. Mutation, with which Greg Lynn is concerned, refers to changes in DNA sequences. However the reasons for these changes are variable, caused by internal imperfections in the copying process, or by other internal activities, or by external causes. However, mutation is not considered to be a primary factor in variation. Mutation rates are deemed to be low, because lineages with good heredity needed faithful transmission dependant upon accurate copies of genes.

The second form of variation, one that Lynn does not address, although it is considered to be the primary cause of difference, is sexual reproduction. Sexual reproduction produces enormous variation and is the most obvious source of genetic variation. Offspring are never equally mixed and equally weighted clones of their parental material. The importance of sexual reproduction as the most obvious source of variation was skewed early in the last century when a number of theorists, such as Hugo de Vries and William Bateson had argued that evolution occurred in big leaps. For de Vries "the driving force in evolution was mutation, a process that suddenly and without cause irreversibly changed the germ plasm (a part of the chromosomal material set aside for eggs, etc, whatever gives rise to the next generation). Mutation "produced a new type of organism in a single step." (Jablonka and Lamb 23) This thesis remains highly controversial. Mutations are new genetic variants but in evolutionary terms, their importance is always measured within a longer time span. Will the mutation survive into the next generation and will it be selected?

I have spent some time outlining some of the major disagreements in evolutionary theory in order to establish the ways in which major terms and theories remain under contest in this expert discipline. These quite different investigations of key terms introduce a number of levels of complexity in the problem of accounting for cause and effect in evolutionary change. Terms that I had assumed were stable, become much more complex due to the range of possible explanations. These disagreements are not noted in Lynn's discourse, and through this omission, key terms destabilised in evolutionary theory become much more stable and certain when deployed in an architectural setting. Later in the paper I will address the issues generated by this transformation; the problem of how we should read such specialised technical terms when they are radically disjoined from their former expert domain.

In part I have given such a long account of the outline of the discipline of evolutionary theory because I am interested in marking the radical incommensurability of parts of evolutionary discourse with architectural modes of production. I note this disjunction in order to later address the problem of how we should read the architectural use of evolutionary theory when architecture cannot fulfil some of the key criteria of evolutionary discourse. Two dissonant architectural areas stand out for attention because of their strident deviation from the originary scientific discourse . One is the limited definition of evolutionary variation in architecture and how variation operates (Lynn's focus on mutation not sexual reproduction), and the other domain entails the difficulty of imagining how the evolutionary selection mechanism would operate in architecture.

Since computer software simulation programs do not have the biological capability to breed and reproduce, it is understandable that Lynn would focus on mutation rather than sexual reproduction. Mutation however, creates new variations in genes, within one reproductive cycle. It offers a shorter time span. Mutation engages directly with the problem of iteration as a copying process, since mutation is a differential process in copying material. However, as I noted above, in current evolutionary theory, mutation rates in lineages that survive are deemed to be low. So whilst mutation occurs it is disjoined from evolutionary success.

Another problem occurs when evaluating variation in architecture due to the production cycle of design. Evolutionary history, imagined here through the mechanism of selection across generations, is the only way of measuring transmission and survival of variations (no matter their source). Variations need to be heritable across generations. Even if we take the time between human generations to be sixteen years, it is in no way equitable to the temporal dimension of computer iterations. Perhaps we're talking about fruit flies or e.coli bacteria with shorter time spans. I'm presuming because of the title of the project "embryological" and its morphology that we're referring at the very least to a mammalian embryo. The non-correlation of evolutionary time and design or production time remains problematic in this discourse.

Even setting the issue of temporality aside, another problem persists: the selection mechanism, Evolutionary history is a form of history written for victors. There may be many contingent factors that ensure the survivability of certain traits over others. Success in this endeavour can only be known and judged after the fact, never in the midst of the event and given that selection operates as a mechanism outside and above individuals, it may never be able to harnessed and determined by them, and certainly not in their lifetimes, since it must be transmitted and evaluated across generations. In other words, any architect or generation would have to leave the evaluation of their work to a historical process. Only the long span of time confers success and legitimacy on the project's claims to adaptability and mutation as a form of success. Otherwise any architectural project could just be a mutation that has no benefit or success in evolutionary terms. It could just be one mutation amongst many.

I have noted three effects in this operation of "knowledge transfer" of evolutionary theory into architectural discourse: the production of a new internal history of architecture, the selected deployment of terms associated with a scientific discipline to produce new modes of description of architectural production and the production of a certain stability around terms that are unstable and contested in their original scientific domain. Moreover, I have suggested that a radical incommensurability prevents us from using evolutionary theory to evaluate current modes of architecture in evolutionary terms.

Attempting to read architecture's use of evolutionary theory as extensions of a scientific, technically expert discourse has produced a certain number of difficulties. Architectural design and production is not an extension of evolutionary theory but a distinct discipline. Even when architecture shares similar techniques with scientific fields – such as data modelling techniques used to model flows of weather data or the mapping of molecular energy landscapes, techniques which have been discerned in Greg Lynn's processes, the displacement from original fields of use, generates intriguing differences. (Lenoir and Alt 347) My concern is these differences and the status of these distinctions.

I will confine my discussion, for the sake of brevity to the function of language in marking these differences. I have focussed on the discontinuity of meaning in the appearance of terms generated by one discourse when deployed in another. If the terms of evolutionary theory which erupt in architecture do not achieve the complexity of expert, technical scientific discourse what are the reading conditions that govern our understanding of these words in architecture? I will argue that these terms function metaphorically.

Susan Sontag, in the opening paragraph of her book Aids and its Metaphors, quotes Aristotle's work Poetics to offer a succinct definition of metaphor, "Metaphor consists in giving the thing a name that belongs to something else. (Sontag,1988, 5). This definition denotes the ways in which metaphors trade in the traffic between resemblance and difference. Aristotle's use of the term occurred in a text on literature, but Sontag's book reminds us of the migration of metaphor from a specialised tool of literature and its studies of figurative language, into a form of analysis of ordinary language and technical languages, occurring within many disciplinary domains in the twentieth century. The role of metaphor as a component of non-literary language was inaugurated by the work of early twentieth-century linguists such as Roman Jakobson in his study of folktales. In the later twentieth century linguists and anthropologists increasingly focussed on the role of metaphors in so called ordinary language (Lakoff and Johnson, 1980,) Apart from Sontag's study of metaphors in certain medical conceptualisations of illness such as cancer and AIDS, a number of philosophers of science have studied the role of metaphors in conceptualising science, in particular biological discourses (Kay, Jacobus, Keller, Shuttleworth, Keller, Tuana). These studies examine metaphor in order to understand the ideological function of knowledge formation. But they also suggest the ways in which shifts in a discipline's knowledge domain are given shape by new metaphors.

Aristotle's attractively brief description of the figurative function of metaphor should be supplemented by the definition it has acquired since the later 1970s. In their study More Than Cool Reason George Lakoff and Mark Johnson observe, "a metaphor is not a linguistic expression, it is a mapping from one conceptual domain to another (Lakoff and Johnson, 1989, 203). This account usefully describes the appearance of terms from evolutionary theory in the discourse of architecture. A metaphor generated from the importation across disciplinary borders, provides a shorthand way of grasping a relationship between apparently dissimilar discourses or practices. Deploying metaphors is a compressed, shorthand mode of communication, and a way of producing a new proximity between geographically and conceptually distant material.

The work of analogies in the traffic between architecture and other disciplines has been investigated by architectural historians and theorists over the last twenty years. A number of writers have investigated architecture's distinctive use of material from fields exterior to itself, most particularly, the relationship between philosophy and architecture. (Ingraham, 1988, 1991; Speaks; Wigley). The studies by Ingraham and Wigley attempted to examine how architecture functions metaphorically for other disciplines. Ingraham argued that architecture operated by force of its metaphoric status in culture, apparently designating the proper forms of inhabiting space (Ingraham, 1991) and Wigley examined the functioning of architectural terms such as foundation within philosophy, a discourse in which architecture was mobilised to ground philosophy's authority claims.

A more recent architectural study, Adrian Forty's Words and Buildings, presents a detailed analysis of both language and scientific metaphors within the history of architecture. Forty traces the emergence of certain metaphors within architecture and sometimes evaluates the historical success of particular metaphors. His definition of metaphor concurs with that offered by Lakoff and Johnson, the "characteristic of an effective metaphor is that it borrows an image from one schema of ideas and applies it to another, previously unrelated schema." (Forty, 100) Perhaps most importantly for the argument I am making here he notes that "metaphors are never more than partial descriptions of the phenomena they seek to describe … indeed were they to succeed in total reproduction they would cease to be metaphors which subsist through likeness drawn between inherently unlike things." (Forty 84) Once material has left its original disciplinary field (such as evolutionary biology), there is always the possibility that it will start to operate as a metaphor, a point of resemblance and as a substitute for the discourse it has left behind. In fact this is precisely Ingraham and Wigley's argument about the metaphorical status, and power of architecture in culture and in philosophy.

Architecture, of course, is not unique in transforming material extraneous to its discipline into metaphors. However architecture provides a spatial formation and realisation of these alignments. It gives evolutionary theory a spatial imaginary, and one that is distinct from, although proximate to, the uptake of evolutionary theory into economic and managerial business models of late capitalism, a project externalised by the founding of the Journal of Evolutionary Economics in 1991. The discipline of architecture's capacity for spatial realisation marks the distinctive work of architecture in moments of knowledge transfer, as particular disciplinary domains are reformulated in crossing the border into architecture.

In response to the very interesting initial proposition offered by this conference in its call for papers, as to whether knowledge transfer "threatens the consistency and specificity of architectural techniques" I would argue that there is always an ever present technology of architecture that converts material into spatial realisations, and realigns external material into forms of knowledge interior to the discipline of architecture. These operations could be usefully described as a "technology" of architecture, reworking Michel Foucault's famous observations on the "technology of sex" as a set of techniques. (Foucault, 90) I borrow this term from Foucault to use it strategically as he does, in order to disrupt normative definitions of technology as inventions and techniques. Foucault deploys the term technology outside its usual domains in order to denaturalise one phenomenon: sex. He mobilises "technology" to designate the systematic techniques organising a field of knowledge, even one which appears biological and thus natural. He redefines the etymology of technology in order to denaturalise knowledge formation and to argue that intellectual domains are determined by structural rules and techniques determining what counts as knowledge and what questions can be asked at a given historical moment. A discipline is not necessarily marked by the sum off its internal knowledge but by its operations, "The 'economy' of discourses-their intrinsic technology, the necessities of their operation, the tactics they employ, the effects of power which underlie them and which they transmit-this, and not a system of representations, is what determines the essential features of what they have to say." (Foucault 68-69) For Foucault, technology is a useful term to visualise the apparatus that organises knowledge formation and insistently mark the nexus of knowledge and power.

The strange mutations of scientific discourses when rewritten in architecture, of course marks architecture's inside; a terrain where external ideas are not merely imported but formulate new internal histories and theories in architecture, where the technology of architecture realigns material into its own disciplinary formations. Older architectural terms and questions are both continued and discontinued in this formation. Evolutionary theory offers a model for investigating notions of generation without a human operator (autogenesis), the rearticulation of temporal rupture as a mode of innovation (an avant-garde investment in the new) and the use of evolutionary theory as a model of history to establish legitimation via the historical validation of adaptation, selection and survival. Biology offers an ecological model of the environment imagined in network and information terms. The 'organism" or embryo offers a source for form generation. This "Nature" would almost naturalise the workings of ideology, producing a transparent and readable nature, different to that posited by one philosopher of science who describes the "mystifying and recalcitrant chaos of higher level organisms". (Keller, 1995, 81) Architectural processes are modes of projection, of transference as well as transfer. As methods they inscribe the force of human editing, selection and rewriting of material. These social operations form a discourse, ensuring that its tactics and modes of legitimation are all too human, even if its surface may appear otherwise.

If the terms of evolutionary theory are evacuated of their technical complexity when deployed in Lynn's architectural articulation, this does not make them uninteresting or unuseful. Analogy can mark the place of a complex process of creative appropriation. Analogies may well be the starting point for a process of creative generation. They image a new relationship between apparently dissonant material. They visualise an idea or operation and make it known in the first place so that it can be further investigated and provide the primary point of creative work. The difference between technical expert uses of evolutionary theory and their more analogous use in architecture might be better understood through the difference between the claims of creative usage and authority claims.

In denoting the difference between creative and authority claims, few contemporary architectural commentators are a scrupulous as John Frazer, in his book *An Evolutionary Architecture*. Early in the text, he distinguishes between a scientific hypothesis and a design hypothesis and he insists on the nature of inspiration. (Frazer 12) Even a distinguished and careful critic such as Mario Carpo, in a recent essay theorising Lynn and Bernard Cache's use of software simulated designs to form a variable set, a "non-standard series", slips effortlessly into a problematic analogy, remarking on an "algorithmically defined fixed genera and endlessly morphing species". (Carpo 106) And for all of the reasons I've argued above, this evolutionary analogy, whilst striking, does not bear the weight of close scrutiny, since architectural production fails to fulfil the criteria of evolutionary theory. However as a metaphor, an applied borrowing from one conceptual schema onto another conceptual schema, it denotes the production of a new relationship to produce different knowledge within our discipline; in Carpo's example, to rewrite models of authorship and aesthetic criteria. Moreover metaphors have rhetorical force because they function figuratively; they offer a striking image, a visualisation of an idea, and their effect can be ascertained by comparing the differences between an abstract formulation "mass producing a series in which all items are different" and the fixed genera/ endlessly morphing species metaphor deployed by Carpo. I can remember the latter phrase and visualise it, but not the former.

The slide between creative analogies and authority claims lies at the centre of our discipline. Deterministic and authoritative accounts of design, rather than acknowledgements of creative appropriations prevail in architecture. The remarkable appropriation of contradictory or contested and difficult theoretical material into compressed syntheses and useable models is an extraordinarily creative process, but by no means is it logical or inevitable. It evades scientific authority claims but makes the claim of creative authority. I do not see this as problematic, unless we fail to make the distinction.

A larger project might further extend the symbolic significance of evolutionary theory in contemporary architecture in order to investigate the historical conditions surrounding this kind of "knowledge transfer". Michelle Le Doeuff in a study of imagery in philosophical discourse argues that the "meaning conveyed by images works both for and against the system which deploys them." (Le Doeuff 3) Functioning as points of tension and sometimes contradiction, images can 'sustain something which the system itself cannot itself justify, but which is nevertheless needed for its proper working." (Le Doeuff 3) As an architectural historian I would speculate that the use of evolutionary biology metaphors not only demarcates an outside to architecture but alludes to a larger exterior context, one that supports our work but is invisible in our naturalised presentations of evolution: the various alignments of evolutionary theory and science and knowledge within the complex political and social formations of post-industrial capitalism. This is a subject for another paper.

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INTEGRATION OF DESIGN AND TECHNOLOGY

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Abstract

Certification Boards visiting architecture schools regularly demand more ‘technology’ in the curriculum, and an increased ‘integration’ of design and technology in the teaching programme. The persistence of this over many years, despite substantial changes in what is meant by technology, suggests that it is not easily achieved, or by any means a straightforward matter. Their reference is to building technology which now needs to be distinguished from information technology where students are often more competent than their elders.

Building technology is seldom theorised (with a few notable exceptions) by either design theorists or those who teach technology. Even so called hi-tech architecture (which uses marine technology aesthetically rather than technically) is not theorised.

It is sometimes assumed that everything taught in an architecture school should be useful or necessary for a competent architect. Each subject claims this status, but this essential knowledge already crowds the curriculum. The level of understanding demonstrated by the students nevertheless appears to be minimal when compared with their precocious design abilities.

It is proposed that integration with design of half-understood technologies is too much to ask of any student during, or even after, five years of study. This paper starts to unravel some aspects of the teaching of technology and discusses issues around the notion of integration.

Keywords: Technology, integration, education.

Every architect knows that technical issues are crucial in practice, where they act as a stimulus, constraint and directive for design. The importance of technology in architecture is unquestioned, but its role in the teaching of design (itself a contentious subject) is another matter. I have had the privilege of teaching with David Green of Archigram, an exceptional architect and teacher (as recognised by his RIBA award) and who has always been fascinated by technology. He has talked about the difficulty of being challenged by external examiners, in their demands for an increased technological component to the course and the request for the 'integration' of design and technology. The repeated persistence of this demand over many years by Visiting Boards suggests that this is not easily achieved. Further, this leads to the question of why this demand remains unchallenged.

Charles Walker has conducted (unpublished) research into the roles of Visiting Boards. He informs me that the Boards feel they are making a most useful contribution to the schools, while the schools in turn resent the enormously time-wasting bureaucratic processes and report writing involved. The Board members generally are senior practitioners (seldom technologists) with substantial experience to offer, but the visit does not contribute to the teaching in the schools. Further the students are often only marginally aware of the process. Walker claims that what the members of the boards are looking for is what they perceive as 'buildability' in student designs. That is the designs must look as though they could be built. He claims that more sophisticated and less visible consideration of technology, such as environmental control systems, are often ignored. This concern might be interpreted as with the consideration of tectonics and with the aesthetics of technology (for which there is substantial precedent) rather than the seamless integration into design. Paradoxically the integration has to be demonstrated by being articulated.Integration has been challenged by Tafuri who proposed instead "a systematic control of the links between production and information, with an entire program for reintegrating communications and technology" (Tafuri, 396-397). Integration can be seen as an attempt to control and command. There used to be talk of integration of studio with theory, but then theory branched out on its own (for a while at least) and sailed under its own steam and became its own justification. The call for integration is a call to gather such errant children back into the fold as one by one they leave the protective umbrella of the master. The call to integrate technology could be regarded as an attempt to get it under control.Demands for integration often reveal themselves as a will to power. "In 1983, a group of seven full-time members of the academic staff at the Auckland University School of Architecture came together to form a sub-school within the School, which they called the 'Integrated Design Sub-school'' (Ward and Hunt, 34). This became known for its involvement in a local political debate rather than for any of the designs produced - or for that matter the technology involved. This "radical departure" did not continue and has not been evaluated.It is necessary to be careful about the conventional wisdoms concerning technology. Many of the vaunted technological changes of the last century have been improvements and refinements rather than a re-thinking of technology. The piston engine universally used for transportation is over a century old and the railway is even older. Even aeronautical technology has not changed substantially in the last half century. Building technology has been notoriously archaic.Further what is meant by technology in architecture has changed, in that we now have to distinguish building technology from electronic technology. Certainly there is little reluctance by students to involve themselves with information technology and the revolution that has occurred in this area seems to have happened without an excess of comment. ANY magazine attempted an online discussion about "the mechanical in the electronic era" over 10 years ago but typically the technology let it down (ANY). Visiting Boards consist of experienced architects who are generally less competent with digital technology than the students, an issue seldom noted except by Burry has pointed out: "With the insurgency of new digital design tools to the design studio, new pressures and often irreconcilable differences have produced, in many cases, and unbridgeable gulf between the fuddy-duddies, whose currency is the sagacity born from experience, and a generation of digitally adept school-leavers, who not only have to assimilate the priorities associated with a traditional way of practising that increasingly becomes irrelevant, but are also in the key position to point towards new ways of operating without the benefit of any meaningful apprenticeship in as yet untried modes of practice" (Burry, 32).The fuddy-duddies are not necessarily in touch with the latest building technology either, otherwise presumably there would be no need for CPD. Conditions of production and construction are changing rapidly with the use of information technology and the close association with design becomes an increasingly possible daily reality. Recently in a furniture design studio run by Jeremy Treadwell at the School of Architecture and Landscape Architecture at Unitec New Zealand, the most successful design utilised a shuffling back and forth of files between a laser cutter and model both utilising computer technology. This might be seen as a connection, or even a separation, rather than an integration, between design and technology, with the computer file as the medium of exchange.If technology is a misnomer for buildability and some of what is taught as technology, is current codes of practice, it is, by definition, instantly obsolete. As global practice becomes more common, local codes and practices become less and less relevant. It is often said that architects tend to be stuck with what they were taught in architecture school, which makes what they do learn even more crucial. It certainly seems that many teachers of the technologies are frustrated with the level at which they teach their subject to an unappreciative bunch of students. One way to change this is to make the teaching of technologies into building science, but it is not clear what the theoretical base of such techno-science is. Some would say it is pseudo-science when it is claimed that what is being taught are the underlying principles, because science itself is endlessly revising, reviewing and contradicting its principles. Are not these so-called principles more rules of thumb? Design theory once claimed that it was teaching basic principles, but then it theorised the problems with the idea of basic principles and abandoned the idea. It has been suggested that changes in the teaching structures “are analogous to those in teaching architectural history with the presentation of specific information being supplanted or augmented with the discussion of general theory” (Smith, 6).Design teachers do not discuss building technology at a theoretical level either. This suggests that the accusations of the technology teachers have more than a grain of truth when they accuse the studio staff of playing down technology. What is more, design staff tend to patronise the technologists because they are suspicious of them teaching design. Yet when the technologists act as consultants they are slaves to student ignorance. It seems an impossible bind, in which technology is resisted by both students and staff - as indeed the technologists seem to have been have been saying for a long time.The assumption of the staff (along with the members of the Boards) is that technical know how will improve design. This is an article of faith with all of us, but it is not self evidently true. The students have no evidence for it and some behaviour suggests otherwise. How many of us have been in studio marking sessions where the technologists point out that our top graded student gives no indication of technological awareness while bottom marks have been given to a student who has fulfilled all the technological requirements as neatly laid out by the program?Senior students often win competitions against practicing architects who also use recent graduates as their designers - while complaining loudly about their technical ignorance. It seems that students often see technical issues as some kind of a diversion from design - however many times we tell them otherwise. Experienced technologists are necessary in the office and on the building site, but they don’t win competitions or get validated in architecture schools. This is confirmed by the experience of design technologists when they come to architecture school to upgrade their qualifications, and find (initially at least) that all of their experience and talent doesn’t necessarily produce the top graded design. The students also know that their heroes (or rather the heroes we have taught them to respect, such as Koolass, Hadid, Gehry) produce work that makes demands on technology, rather than the other way around.Pompidou (1971 Piano and Rogers) made a fetish of the technological systems, but it can be argued that they had been led to that position by Archigram who forged an architectural language out of the technologies invented by Buckminster Fuller. They combined the impossible idea of an architecture that moves with the theories of Reyner Banham who described them as “designing for pleasure, doing your own thing with the conviction that comes from the uninhibited exercise of creative talent braced by ruthless self-criticism” (Sadler 196). Tafuri had described Archigram as: “celebrations of formlessness [which] take place under the banner of technological utopia” (Sadler 195). Lloyds and the Hong Kong bank continued the fetishing of technology and it could be argued that much so called ‘hi-tech’ architecture has been concerned with the articulation and the aesthetization of obsolete technology. For instance many of the details of marine technology used (e.g. wire rigging and tensioning devices) are the very things that marine technologists work hard at eliminating - following the lead of aircraft technology. However while the designs are driven by the technology they are an expression rather than an integration of technology.Technologically driven architecture has always been designed by engineers, from the Crystal palace to cars, trains and airplanes. But what is strange from this is that the technologically driven is also concerned with the poetic. In the schools however as Vesely says: “How much do we need to be informed, and what and how much should we know as architects and designers? Current education is mainly oriented towards technical subjects, and yet most of these subjects are already firmly in the hands of engineers who are usually better qualified and equipped for the task. There is no doubt that architects should be at home in that field, but they don’t have to emulate the work of engineers or claim to be technological experts”(Vesely 65-66).In the schools technology is also subjugated to design. This disallows technology an independence, a theory, a world of learning. The dominance of design is of course encouraged by design staff, and technologists play along with the best will in the world. The technology subjects are seen as support subjects and, like all servants, they are always ‘a problem'. Smith says "If a subject is not presented on its own terms, for its own purpose, such as should occur in a quality liberal arts program, but rather is introduced specifically as background for another area, it is my conviction that it is best to incorporate the presentation of the principles of that subject as an integral part of the other area rather than as some separate, prerequisite" (Smith 6). Then subjects would be selected by the student's area of interest from theory, to structure, or sustainability, with each subject self sufficient with its own theoretical and disciplinary base.It seems that the desire to retain 'the architect's rightful position as head of the building team' goes against the very spirit of technology, which is anonymous and produced by acephalous teams. Yet architecture schools don't use teams much - for which the usual explanation given is the problems of assessment of the individual contributions. But there is also the question of disciplinary base, where in order to be inter-disciplinary you have to know your discipline. Arup's deputy chairman talks about working with Daniel Libeskind. "We exchanged metaphors. If the form were closed it could be a mineral deposit, or if an open transparent steel-framed building, it could be a lantern or beacon. If it were heavy it could be hacked out of granite, or was it buildable out of special masonry" (Campbell, 26).The fantasy of integration is that of being able to totally shape the world and is of course the kind of dream that drives architects. (To have everything in the 'architects 'purvue' as is said in the invitation to this conference). However this may no longer be possible. The difficulty is that there are so many important issues to be integrated with everything on the curriculum claiming utility as its justification. Usefulness as a criterion for inclusion has led in the past to the neglect of important academic areas. It may be that technology can only be taught at a theoretical level in Architecture schools. It has long been argued that architecture is not building, but about building. In this sense the Boards are looking for evidence that the students know about building rather than concerned with what they know.

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PROSTHETIC SURFACE – DESIGN MODELS FOR A DYNAMIC ARCHITECTURE

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Abstract

The research investigates strategies of dynamic surface formations in a transfer from sartorial fashion to architecture. ‘Remote Control Dress’ (Hussein Chalayan), ‘Dress becomes Body (Rei Kawakubo) and ‘A-Poc’ (Issey Miyake) are precedents of specific technologies and techniques that produce responsive, performative, or phenomenal dresses. These garments can deliver generative surface methods for an architecture operated through the user. The research frames key parameters (cutting scheme, constructive line, programmatic insertions, and operative field) and their respective characteristics and interrelations in analysis. Thus, principles are derived and channeled into performative design models in a media rotation with a conversion between digital and analogue modeling. The paper discusses the potential of these dynamic design models in a design process that addresses the change capacities of architecture in a shifting cultural and programmatic context.

1 Introduction

What is the structure of change? What capacities are required of form in the shifting spatial parameters of a transitional environment? Architecture is a prosthetic device, and, similar to other cultural expressions like language, fashion or art, submissive to continuous transformation. A successful prosthesis is able to answer a number of change conditions, but also undergo a process of modification, differentiation — in short, a process of evolution. Prosthetics can be mapped according to ‘technologies of the body’ (Quinn 52) that range from restorative (replacing lost functions), over normalizing (imposing new social or aesthetic norms) to reconfiguring (changing the contextual relations) and enhancing (increasing functions or properties) aspects.

While most prosthesis are devices (objects), the paper researches the potential of prosthetic surfaces that register change conditions and react as a dynamic system. The mutual congruence of methods, techniques and effects in fashion and architecture surfaces is used to identify concepts for organization, structure and detailing of form alterations in a responsive, performative, interactive system. The different concepts of prosthetic surfaces are then applied to the architectural design process.

Sartorial fashion is rapid, ephemeral, experimental, thus a predestined medium of cultural phenomena. In fact, fashion is composed of change (Wilcox 6). In this context, shapes have increasingly emerged that show an alteration, variation or transformation in form and material. Works by Hussein Chalayan, Rei Kawakubo (Comme des Garcons) and Issey Miyake reflect change as adaptation to a user. They are a species different from generic functional tailoring; heralds of a territory in which the permanence of shape, form and program are challenged. Instead of styles and determined shapes, these fashion experiments reveal fields of elasticity, intensity and compression (Grosz 127), employ programmatic insertions and digital extensions, or are operated through mechanical gearing. Thus, substance and formation of these surfaces are latent, as changes emerge in phases and ranges, shifting from one programmatic and textural condition into another.

While illustrative and representational comparisons between effects and techniques of body, dress and architecture have been explicitly framed (Evans, Wilcox, Quinn), Hoodge further discusses parallel practices between fashion and architecture, from design and organization, to production techniques and form effects: 'Both fashion designers and architects begin by taking an idea, and, working out its practical requirements, translating it into a three-dimensional structure using flat materials' (Hoodge 17).

In addition, this paper suggests that fashion and architecture share a number of principles or concepts embodied in structure and material through which a surface formation can be made fit for change. Rather than using visual similiarities (produce an object that looks like it), or shared platforms (use the same software) the paper uses a cross-reference of shared methods in fashion and architecture for an identification of principles that produce a type of prosthetic surface (changing in basis, effects and phenomena).

The fashion examples discussed in the following establish different types of surface prosthesis. Each is based on a three-dimensional concept with inherent methods, materiality and production techniques. Once abstracted, a combination of these strategies and principles may deliver Design Models to be applied in the architectural design process. The Design Model is a generative engine that administers technique and transfer in different media and materials. The paper explores in which way a fashion reference might be transformed into a Design Model that produces an immediate, three-dimensional formation with material and structural facets, yet devoid scale and program. These Design Models might then enable multiple, specified, heterogeneous, differential conditions, and become strategies for a new spatial semiotic.

2 Surfaces: Design Model and Parameters

Architecture is already processed as a continuous formation that organizes spatial sequences through surface effects (Benjamin 5). Increasingly, software programs are used to develop and organize design projects through the deformation of surface under data impact (Lynn "Animate" 10). Infinitely variable while located in a digital realm, the transfer of zero-thickness objects into material, structure, depth, occupancy becomes an issue.

In contrast, the technique of fashion production is immediate in form definitions, material and structural explorations in the product milieu – on the body. Thus it can deliver an organizational paradigm to articulate architecture not as primarily engaged with form generations, but with a material or structural immediacy. Change conditions, a shift in functional profile can then be formatted as material and structural principle already in the design phase.

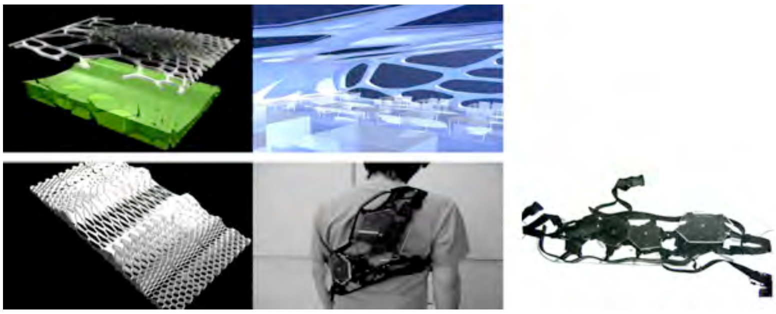

Figure 1: **Design Model and Media Applications (Toshimune Suzuki, Elastic Space Studio, Sydney 2005-02)**

In answer to these requirements, the Design Model forms idea and concept, independent from site and programmatic demands. It contains 'packages of organizational or compositional principles' (Un Studio 18). The Design Model regulates (describe, administer, explore) fabric, detail, structural and aesthetic components. Its formative power derives from a capacity of perpetual transformation in response to process and data, through a multiple iterative conversion and exploration in analogue and digital media (Herbert 22).

The Design Model enhances project precision and aesthetics through coherence. The essence of an idea is maintained even if it evolves through different shapes, because framework and settings are constantly edited and adjusted. Once established, the Design Model can be employed on various levels, scales, and application. A Design Model can define strategies for body-formatted devices, or interior façade prototypes, to organizations of urban structures (Fig 1).

The works by Chalayan, Miyake and Kawakubo demonstrate concepts and principles that connect with a Design Model typology with dynamic, phenomenal, responsive, elastic conditions. Though all fashion examples exist in a range or phase conditions, they differ in operative modes. Each addresses change options in an individual manner, through specific characteristics in structural or material prototyping and detailing within their architectural section. The specificity of those concepts can be framed by number of selected parameters. Strategies for cutting scheme, constructive line, programmatic insertions, and operative field (Reinhardt) were applied and developed into a series of Design Models in the Elastic Space Studio and Prosthetic Surface Studio [Master of Architectural Design, Sydney University, 2005-06, research spatial constructs and surface formation for responsive, interactive environments].

Responding to the concept approach, these parameters interplay in the formation of a prosthetic surface. The *cutting scheme* is a strategic mapping device that organizes the sum of descriptive lines within an ambiguous surface. Aspects of potential shapes, forms and operations are changed, programmed and optimised until the moment of cut, when the form becomes definite. The *constructive line* is the control mechanism in construction or production, it is hem, seam, line of coalescence, where materials are joint. This line defines a contour of exterior shape and interiorized sub-sections, and becomes a major agent of change when repositioned. Both cutting scheme and constructive line describe concepts that originate in a fashion context, yet might be applied to architectural design. The *programmatic insertions* are alien volumes inserted after fabrication or predetermined densifications implemented in an ambiguous or prepared structural field. They are ephemeral electronic/digital extensions, programmatic pockets or independent occupational zones that produce a recoding of the surface field. The *operative field* shows the effect of surface conditioning and formation through techniques, changing the operative field, visible as structural or material contraction and expansion.

Sato describes the 'rethinking [of] received ideas and the modes of production' as a major path for the derivation of new creative solutions (Sato "Making" 23). The paper thus focuses on effect, mechanics and technology behind shapes and their operations, and the implications on methods of surface organization, techniques, structure and material detail applied to architecture.

3 Fashion Works: Surface Transformations

The 'Remote Control Dress' by Hussein Chalayan, 'Dress becomes Body' by Rei Kawakubo (Comme des Garcons) and 'A-Poc' by Issey Miyake are works chosen to demonstrate strategies for Design Models with a dynamic potential, applied to the architectural design process.

Though their effects vary, they depart from similar premises. None of them is based on a cutting scheme that resembles generic clothes. These shapes are oversized, deformed, idealized. Some are independent objects, statically self-sufficient, detached from the body contour, thus already mediate between dress and architecture. Their surfaces range from ambiguous to intense textural fields, they reveal a depth in operation through which they can responds to programmatic or sequential shifts. This depth is registered into the system as the structural coding of a mesh, the mechanical gearing of a shell, the conjunction with diverse textural layers or digital networks, or through temporal insertion of subvolumes.

Although these fashion explorations display strong figures, the form is not yet defined. A tendency towards unfinishedness, indeterminacy, and incompleteness is shared. These works request the wearer to finalize the product in a post-productional form definition. The ultimate forms needs to be cut from the fabric, electronic signals have to be given via remote control.

They produce these effects as individual approaches, clearly legible concepts that are materialized, in this manifestation as dresses.

3.1 Design Model 1: Programmed Mesh

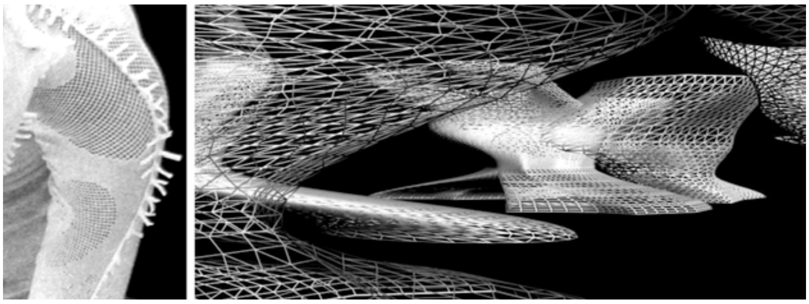

Figure 2: **Mesh Configurations.**
Left: Detail of Issey Miyake, 'A-POC' (Miyake, Issey and Fujiwara, Dai. A-POC Making. Weil Am Rhein: Vitra Design Museum, 2001)
Right: Renee Fu, Prosthetic Surface Studio, Sydney 2006-02

One Design Model for an intentionally delayed form definition process is a *coded mesh configuration* (Fig 2). 'A-POC' (Issey Miyake, 1998) uses such a principle of surface formation that displays diverse zones of compression and intensity, programmed through digital weaving techniques. Here, shapes, colours, applications a similar range and depth of variation as the former basic technique applied in the Miyake production explored ('Pleats Please')

Miake reverses traditional techniques of fabrication, instead, 'a thread goes into a machine that, in turn, generates complete clothing using the latest computer technology, eliminating the usual need for cutting and sewing the fabric.' (A-POC making: 68). A-POC is based on the raschel knit tube, a fabric volume of variable length executed in a one-and zero binary language that translates 'sink' and 'surface' machine signals into the movement of an automated weaving (Fujiwara 71). This technology is a continuation of a mass-production based on Jacquard's automatic loom technique combined with the pre-digital code of Hollerith's punch card indexes (McCarty and McQuaid 101).

In the mesh fabric, 'lines of demarcation create a pattern of surface design that in turn becomes structural seams' (De la Haye 34). Its respective zones differ in threat properties, luminosity, ornamentation, layering, densities and expandability. The mesh frames the blueprints of potential dresses. From a potential form and number of clothing items (dress, shirt or skirt, ect), one future item is selected and cut free (Kries 66, Quinn 150).

The structural code of the mesh gives an area in which the cut can be applied. It thus uses a delayed cutting scheme, in which the customer defines the ultimate shape. Quinn classifies these garments as 'shapeless designs' (153), yet these garments receive their shape in operation. The programmatic code inscribed in the mesh uses an elastic or expansive depth that results in an interval behavior (Hiramitsu). The interval frequency determines another potential adaptation; it mediates between production shape and body contour, and contour and highest pitch of movement, adding a micro-scale change option to the surface texture. The homogeneous character of this surface fabric abandons a determined constructive line, in favor of an operative field that reacts to change conditions in total.

This Design Model of a *coded mesh configuration* is characterized by a three-dimensional structural code, an interval range between diverse programmatic zones, and a sequential duration of various occupants. It is a 'ready-made, ready to be remade' (Simon). In the design process, it enables perpetual connections, size and scaling operations. Incorporated in a static shell, the design model may be used for a differentiation of programmatic zones, as an interior architecture device. This mesh definition is of course one amongst many. Other options may shift in purpose towards parametric deformation, or inserts stable fields between nodal points, etc.

3.2 Design Model 2: Remote Controlled Shell

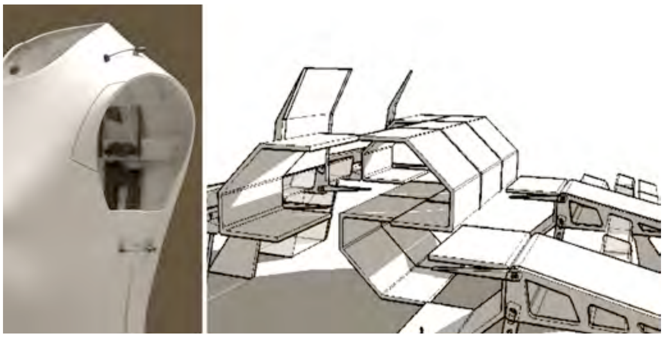

Figure 3: **Remote Controlled Shell and Hinges**
Left: Detail of Hussein Chalayan, Remote Control Dress (Image by author, Exhibition Wolfsburg, 2005)
Right: N Patankar, Prosthetic Surface Studio

The ‘Remote Control Dress’ (Husseyin Chalayan, Before Minus Now, 2000) suggests the Design Model of a *remote controlled shell,* supplemented and organized through hinges. (Fig 3) Based on industrial technology, modularization and standardization, the prefabricated form transports abstract notions of speed, dislocation and otherness. Chalayan investigated the basic idea and its techniques in a series of dresses with slight variations.

Made in composite materials of glass fiber sheets and resin, the dress is cast in a preformed, specially designed mould (Evans 270). The composite layers equip the shell with a resistance and depth; their surface is a three-dimensional material entity (Bettum 73-74), with diverse strata, light transmission effects, and modulated zones.

The cutting scheme is an idealized shape that incorporates diverse component parts. It follows the ‘mechanics of form’ (Wilcox 4) with a rigid smooth shell that echoes naval or automobile aerodynamics. Once this surface is cut, hinges, gears and wheels shift the fragments into formation, rendering its component parts ready for maneuver.

Chalayan uses a heterogeneous system of different materials, in which a composite skin responds via mechanical elements to a remote control order. This connection to data streams equips the surface formation with performative capacities. It opens along engineered constructive lines, to reveal secondary textural layers, or discrete zones of the body. The remote control system also enables an immediate response to data networks (news and communication lines), ephemeral or invisible environments (electricity, radiation, temperature zones) and virtual worlds. Though the shell displays a set tectonic frame, it really operates in a territory (Steele “Radical” 53) through the integration of virtual information or simulation of alternate realities.

‘Remote Control Dress’ proposes not an ideal but a composite system, defined by intricate stable connections of previously disparate components (Lynn “Body” 139). Skin, mechanics and data establish an operative field that formulates connections along lines of intensities. It thus establishes integral roles for specific element conditions -configuring available and absent states equally.

The Design Model of a *remote controlled shell* frames techniques of industrial design such as automobile, aeroplane and boat building, suggesting a production transfer. It is in fact already a classic of adaptable, flexible, modular or mobile design systems, that produce precise yet limited change conditions, and predominantly dislocate the object. But altered by informational data streams, it enters a territory independent or not transferable to material conditions. These data might even be processed onto the surface instead of merely controlling the mechanics of the form. Then, the prosthetic surface becomes a screen, a door to an alternate reality, and another passage in a global world. Yet another application might address a shift in scale in technique – the fabrication of an aeroplane hangar (Fig 3) generated by the same principles becomes than a territory in itself, and requires substantially different methods than the mere production and assembling of a singular plane.

3.3 Design Model 3: Prosthetic Insertions

A crossover between elastic interval and independent forms is the Design Model of the *prosthetic insertion* that made a singular appearance with Comme des Garcons. 'Dress Becomes Body' (Rei Kawakubo, Spring-Summer, 1997), termed 'Lumps' Collection, is a series of synthetic gingham dresses with stretching performance.

The key strategy of this Design Model is an abstract distortion of pattern (Quinn 144), or deviation from anatomical form (Haye "Radical" 32). Padded insertions run asymmetrically over torso or shoulder, protrude from rear or bust (Evans 268). These 'Lumps' are an addition or expansion of specific areas (material inversion), a deformation of the overall body shape and experience (habitual-perceptual inversion), and an inversion of system inherent logic: 'on her dress she wears a body' (Haye 32). Kawakubo confronts perceived individual contours with extended perimeters, thus initiating a 'reciprocal transactions between body and space' (Sinclair 432).

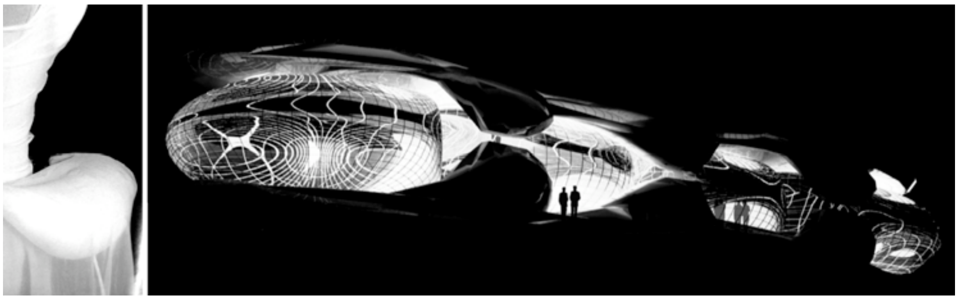

Figure 4: **Insertions and Operative Field**
Left: Detail of Comme des Garcons, Rei Kawakubo, "Lumps." (Grand, France. <u>Comme des Garcons</u>. London: Thames and Hudson, 1998)
Right: H Chen, Prosthetic Surface Studio

Insertions vary from independent programmatic to inherent structural solutions, and enter the fabrication process at different phases (Fig 4). While clearly distinguishable in a semi-transparent elastic fabric as interruptions of a close-fitting cutting scheme, in a different dress version they remain disguised in a checkerboard gingham fabric. The first suggests an unaltered cutting scheme in which an elastic fabric moves back into original position when temporal insertions are dislodged. The constructive line changes in contour due to the stretch capacities of the fabric. The operative field results from reversible alterations of the pads in form, size, location and duration. The second cutting scheme integrates a calculated permanent infill; it produces stable oversized body zones. Once the insertion is taken out, the structural deformation frames an absence; it defines a range of reference for spatial and programmatic alternatives without interfering with the exterior shape after construction.

This Design Model is characterized by a 'lumping technique', in which an 'operational field of potential interventions' is organized through a recombinative logic and thus provides 'ranges of different programmatic protocols' (Kolatan 79). It produces a programmatic topography in a range of conditions between nodal points set by a constructive reference line. While the exterior shape is unaltered, an inbuilt structural reservoir may provide unoccupied zones that can record later insertions. Or the interior structure defined a prosthetic surface formation in which movable layers of different size; height and atmosphere divide spatial sections along control lines.

4 Conclusion

The structure of change in architectural design can be informed by strategies of surface formations in the fashion realm. The paper has discussed a transfer from fashion to architecture that delivers principles and techniques to be exchanged between both realms. Reworked in operative and behavioral Design Models that deliver structural, material and detailed solutions, a new spatial semiotic can be framed.

The characteristics of surface formations in each Design Model produces a dynamic architecture that is singular and specific through rearrangement or appropriation of component parts or zones, through the impact of a user. This interaction between architecture and occupant is unique because it is simultaneous, post-productional and unfinished. As Sidlauskas remarks, ‘the wearer demands maximum adaptability, acknowledging, indeed affirming the provisional nature of human inhabitation, whether concrete or cloth’ (Sidlauskas 261). Then, the provisional becomes a virtue, and the nature of change receives a quality that is not precisely controlled, but intuitive and emergent.

Change effects on form, techniques of material and structural conditioning, and underlying principles and generative Design Models have been a major focus of the paper. Yet a close surveillance of Miyake’s approach to work ethics suggests that a fabrication of the raw material is at the core of techniques and thus of the creative design process: ‘I start with making the fabric – we work from the yarn, we find, we invent.’ The architect is then not a generator of form manifestations but of material, material use and production that are of equal importance. There is no sense to shape without the matter it is made of.

Each technology delivers its own application. In a system of invention and investigation, analogue fabrication machinery and computational programming, or techniques of conversion can be misused in order to submit new knowledge and applications, to deliver new results. Each explorative approach, manipulation, transfer frames an experiment and partial solution in material and structural matter. In the same manner, a transfer between principles of related fields or shared software programs and their applications might open new possibilities.

Kawakubo insists that ‘creation is not something that can be calculated’ (Grand 11) – yet new architectural solutions can be found, extended, and processed through techniques and transfer.

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COLLABORATION AND ALTERED PROCESSES

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Abstract

The architectural technologist could be defined as a designer whose methods are driven by the intimate and experimental use of varying digital technologies. The technologist, in this scenario, is a designer by training, but typically, seen primarily for their technical expertise. Through an emerging practice of the architectural technologist as a design collaborator, an identity is forming of the technologist as a designer who balances general issues of architecture with an analytical mind towards digital/computational methods. Collaboration exists ultimately in the realm of design (not in production) but introduces a shift in process, where design involves the construction of digital means and the critique of process by all participants in the collaboration. This paper describes the necessity of this type of collaboration in relation to several specific design projects, to which Sean Ahlquist / Proces2 participated as the technologist. At issue is the technologist's degree of influence on the processes, the level of exchange between designers, and the resulting influence on the success of the design. Three projects will be discussed to show the range of collaborative interaction. In one scenario, the technologist worked within a stratified and somewhat traditional process based on the applying digitally-derived systems to a specified form. A second scenario looked to find a generative, computational method through the collaboration. The intent was to discover an architectural pattern that had an advanced level of complexity, and simultaneously provide data for fabrication and construction. The last project saw the collaboration as a necessity to produce an array of highly complex 3-dimensional forms and provide means of communication between the highly digital environment and analog means for analysis and fabrication.

1 Introduction

In collaboration with an architectural technologist, design exists within the critique of both process and product. Design is validated in the logic of the process and its relevance to the performance of the final output. Within the eyes of the architectural technologist, the ultimate desire is to completely merge the relationship between a digital / generative process, and performance of the product, as well as its fabrication, balancing consideration for both design and process. In the projects described in this paper, the technologist would be considered an active participant, but with different levels of influence within the design process and to the final outcome of the design. The topics of each project differ considerably, but in the exchange between the designer and design technologist, there is a noticeable shift in methods of communication and processes that generate the architecture. Consistent in this shift, though, is the significance of digital, systematic processes as a mechanism to both conceptualize and realize the design.

2 Applied Geometries

The Jellyfish House[1], designed by IwamotoScott Architecture with Proces2, was created through a relationship where the architectural technologist was necessary in satisfying a digital component within a multi-faceted and largely theoretical project. The project looked to describe an architecture based on distributed systems, and networks. The technologist, in this case, was not so much invested in the derivation of the concept, but more so in the design and discovery of the digital methods that could geometrically express the concept. The process was separated between studies of planning at an urban scale, refinement of form at the local (dwelling) scale, and application of the skin/structure system to the individual dwelling. Through the linear process, collaboration was shifted from being an inclusive exchange of ideas between each level of the project, to determining the best means of communication and translation between the different stratified levels of the design process. The process delivered a geometrically complex design, but only with the technologist as a thin layer within a hierarchical design approach.

2.1 Project description

The Jellyfish House is a theoretical proposal designed for the exhibit "Open House: Architecture and Technology for Intelligent Living". The exhibit hosted a series of projects that consider emerging technologies, digital and material, and how they may influence the design and nature of a future domestic environment. The proposal looked to the Jellyfish to develop a notion about an architecture that can function as a series of distributed, adaptive, and sensing networks. These networks apply to various conditions of the environment (both internal and external) and factors of domestic infrastructure (structure and mechanical systems). Performative elements are built within a singular surface that wraps the entirety of the house and also links to the surrounding landscape. The surface is a thickened structure, a "deep surface" that acts as the sole means for housing all of the systems, both transforming and fixed.

2.2 Process

IwamotoScott uses a process of research into materials, technology, and organizational logics to develop work that investigates perceptual and experiential phenomena. With the Jellyfish House, the initial impetus was to add into the process a higher level of digital experimentation, one at the level of complex digital modeling. Specifically, work that was previously done by Proces2 in studying cloth dynamics with Delaunay[2] and Voronoi[3] tessellation methods was layered into the concept about distributed and integrated networks. These two methods of tessellation were applied to the form of the overall house as a network / structural skin. The form of two twisted intertwining boxes was central to the design. The critical nature of the process came in developing the logic for the pathway that applied the skin geometries to the form of the house. The necessity in collaboration was in communicating between designers in a language of both design and digital modeling technology.

The overall method worked in three somewhat distinct modes, executed in a linear fashion, and challenging the notion of design communication and feedback. The complexity of the desired geometric pattern demanded that several softwares be used. Translation between softwares exacerbated the linear nature of the process and shifted the discussion from commentary about design to challenging the fluidity of the process. Models and data were translated between software such as Rhino, Autodesk MAX, Excel, and GenerativeComponents[4]. The nature of the process forced a shift in what is defined as feedback for analyzing the design. In a more traditional process, design is developed and refined through viewing iterations of the final outcome. The complexities of the process, in this instance though, meant studying the design through analyzing the product at each step of the process, and viewing snippets of the final outcome. Critique was of the logic of process and design established at each step. Again, it was necessary that collaboration meant discussion of technique not just of the outcomes.

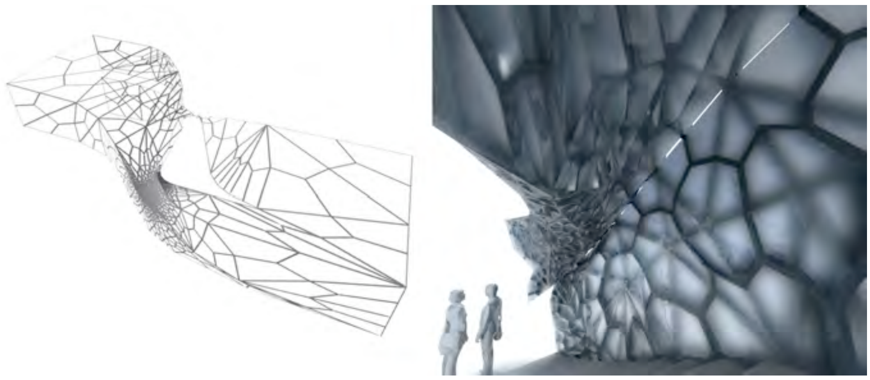

Image 1**: Delaunay / Voronoi tessellation and sample region of parametric component model**

The connection between the Delaunay / Voronoi tessellation and the concept of distributed networks expressed a condition where process and concept were intended to be seamless. The Delaunay algorithm in MAX subdivides a surface where advanced curvature demands higher subdivision. In the spatial planning of the house, the moments of higher subdivision corresponded with areas that needed density in the network. As the method of skin definition and shaping of the overall form were on distinct layers of the process, exploiting this connection between process and concept was limited. Surface curvature was a formal device for expressing a series of continuous spaces. The tessellation was a pattern applied to the form. It was a formal expression as opposed to an adaptive, influential condition. For the process to inform and advance the design, the collaborators had to bridge the design intents with the details of the digital tools. For the technologist, the issue laid in designing the appropriate and logical variables for controlling the tessellation / skin system. For IwamotoScott, understanding the logic of the variables was necessary for guiding the manipulation of the form. With limited exchange between different levels of the design and amongst the tools that drive the design, the desired product was always elusive. This moment exemplifies the struggle between a digital, systematic approach, and a linear, formalistic approach where image and result outweigh the product born intimately of method. The split in design approach was evident in the *thinness* of the skin; its minimal responsiveness and investment into the formal logic of the massing.

3 Generated Complexity

The Airspace Tokyo[5] project, a collaboration of Thom Faulders with Proces2, describes a relationship where the technologist was embedded into the experimentation and generation of the conceptual and physical implementation of the design. There was not a significant shift in process for the collaboration rather a recognized need for computational methods to achieve the conceptual intention. The intention for the design was to generate an architectural pattern that had a depth in complexity along with a component of unexpectedness. This spoke to a generative method of design where the outcome was an aggregation of both controlled and uncontrolled conditions. While virtual, in the sense that the process lived within the digital realm, the product was always seen as architectural where conditions could be controlled to respect materiality and the product was always usable for fabrication of the screen itself. The situation expressed compatibility between technologist and collaborative designer, one where automation in design process was accepted and desired.

3.1 Project description

The design is for an architectural screen that wraps a 4 story residential building in Tokyo. The impetus for the design was to create a narrow buffer zone around the building, protecting it from the intense urban environment immediately adjacent. Previously, a thick band of vegetation bordered the site, and had provided such a shield. The new building allows for a slight 30cm depth for the architectural screen. While narrow in section, the screen intends to engage the natural and urban conditions. The screen mediates wind, diffuses and reflects light along it surfaces, and acts a light rain screen for the adjacent walkways and balconies in the building. Views inward are mediated by the shifting variegated cellular pattern. The system needed to have a depth and effect to where moving through and along it presented a shifting and ever-changing perception of the pattern. Much like a tree canopy or the structure of a sponge, different angles of the architecture provide different expressions of the system, in this case, a layering of voids and shifting views.

3.2 Process

Faulders work places an emphasis on research and application. His designs view architecture as a responsive and dynamic medium, looking to both digital and materials systems to explore such realities. With the Airspace Tokyo project, digital technology was pursued to create the means for generating an advanced level of complexity in the pattern of the screen, and directly providing the architecture for the project, the data for construction of the screen. From the outset, it was an experimentation in method, but one that demanded algorithmic and scripted procedures. It was desired that the method be clear and generative; where the results of it being obvious in its systematic nature but devious in revealing itself, not easily discernable. This was accomplished through layering variation into the system, and layering the very system back onto itself. There was a desire for the outcome to be somewhat unexpected, and an acceptance that no two iterations of the process would produce the same result. The slight shift in process was a willingness to trust the method, let the system aggregate, as designed, impose controls where necessary and produce a highly systematic, complex pattern. In collaboration, both designers engaged the details of the computational method. But, constructing the series of algorithms and computations to produce the design was left within the hands of the technologist. Where the product was generative, it was necessary and allowable to have this level of autonomy within the process. Collaboration succeeded where both parties understood the affects of the computational variables to the result, but the construction and mechanics of the digital functions where left solely to the technologist.

To produce the balance of systematic and unexpected results, the method layered together a series of modeling and computational procedures. Pairs of patterns were generated from the process and subsequently compressed into a single layer, producing a higher level of complexity and unpredictability. To produce a single pattern, an intricate polygonal framework was created, using tools of subdivision and tessellation in Autodesk MAX. Exposing variables with the meshing algorithms, varying levels of subdivision were generated in loose recognition of the building programming. A cellular, parametric component, constructed in GenerativeComponents, was then aggregated throughout the framework. To produce a higher order of complexity, two layers of cellular panels where compressed into a single skin. Welding the two layers together produced additional orders of the system where new shapes of apertures emerged, beyond the basic open-cell construct. To add a layer of control within the system, computations were added to the component responding to basic material assumptions, limiting the thinness of the pattern at certain moments to ensure stability. Design was in developing the set of computations and variables that allowing tuning of the balance between unpredictability and control.

Compared to the initial study of foliage, we saw a system where the logic could be mathematically described, but the perception was of something unpredictable. This was a foil for both the method, and the product of the method. The tools were manually constructed as a set of commands, variables, and hierarchical relationships. When executed, it produced a system that could not be manually generated or exactly predicted. This expressed a process that was altered to weigh towards a trust of the generative method and a desire for its unexpected results.

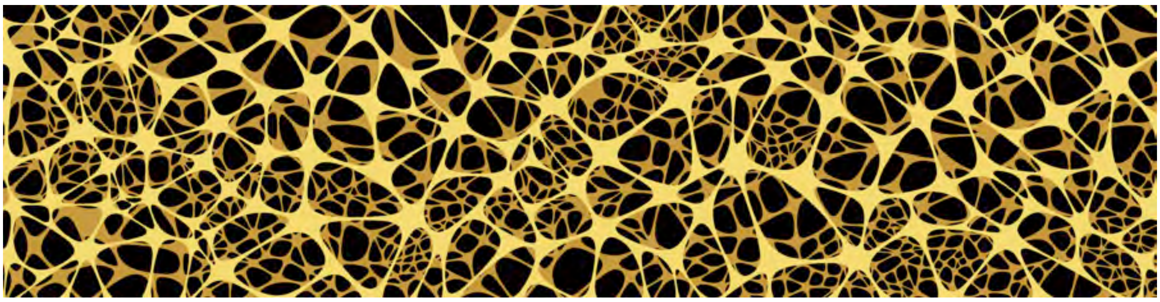

Image 2**: Individual layers to be compressed to create single skin**

4 Parametric Complexity

With the Kinetic Sculpture[6] project, designed by Reed Madden Designs, the role of the technologist was primarily as a problem-solver. The focus of the digital work was to rationalize the design, ensure its buildability, and develop and provide all necessary information for fabrication. The design was simple in concept, where the complexity laid in the nature of the curvature of the forms and the interrelationships between them. It was apparent that pursuing a digital model was the only way to resolve issues of understanding the design at full scale. The sculptors looked directly to the physical to judge and compose the design. Working within a highly digital environment, that way of perceiving design significantly shifted and adapted to a language that dealt with digital geometries and associative parametric models. From the technologist's perspective, a balance had to be struck between satisfying the sculptor's desire for an expressionistic, interpretative sculpture and following the inherent associative geometric rules that the forms clearly represented.

4.1 Project description

The project is a public sculpture for the center of downtown Tiburon in Northern California. The sculptors developed the design to make reference towards the sails of the boats docked nearby and the ocean life itself in the neighboring bay. The sculpture is built of 5 independent metal fins. They are designed so that they nest in a closed position to resemble a shark's dorsal fin in profile and, loosely, in surface curvature. When open, the sculpture resembles five sails catching wind. The sculpture both conceptually and for purposes of fabrication required that the relationships of curvature across the array of sails be clearly geometrically defined and highly controllable.

Image 3**: Completed kinetic metal sculpture**

4.2 Process

The sculptors work focuses on creating site specific, public sculptures. With the Tiburon kinetic sculpture, they found that using digital models was the only way to generate their design with accuracy at full scale. The design pursues the artist's interest in composing the line against the curve. The challenge as they saw it was to not just compose, but to also composite the two into a singular form, the ruled surface. But, as what has always been a limitation, the constraints of the metal material make constructing these forms elusive. The initial impetus was in simply understanding the nature of the forms they proposed. In the artist's eyes, the expression and metaphor of the sculpture was primary. For the technologist, in this case, the definition of the geometric rules and the adherence to those rules was what defined the project.

This system of forms represented a clear definition of a parametric associative model. There was no one fin that represented the ideal profile and shape. It was only in seeing all of the forms that the degrees of curvature and relationships from one to the next could be verified. When hierarchically all values are equal, it presented a problem in determining where to begin. In this case, the elevational study of the fin profiles, individually and as a whole, was the first step at establishing the parametric relationships. What became the solution was defining a type of a curve that was composed of various base geometric elements and blends between them.

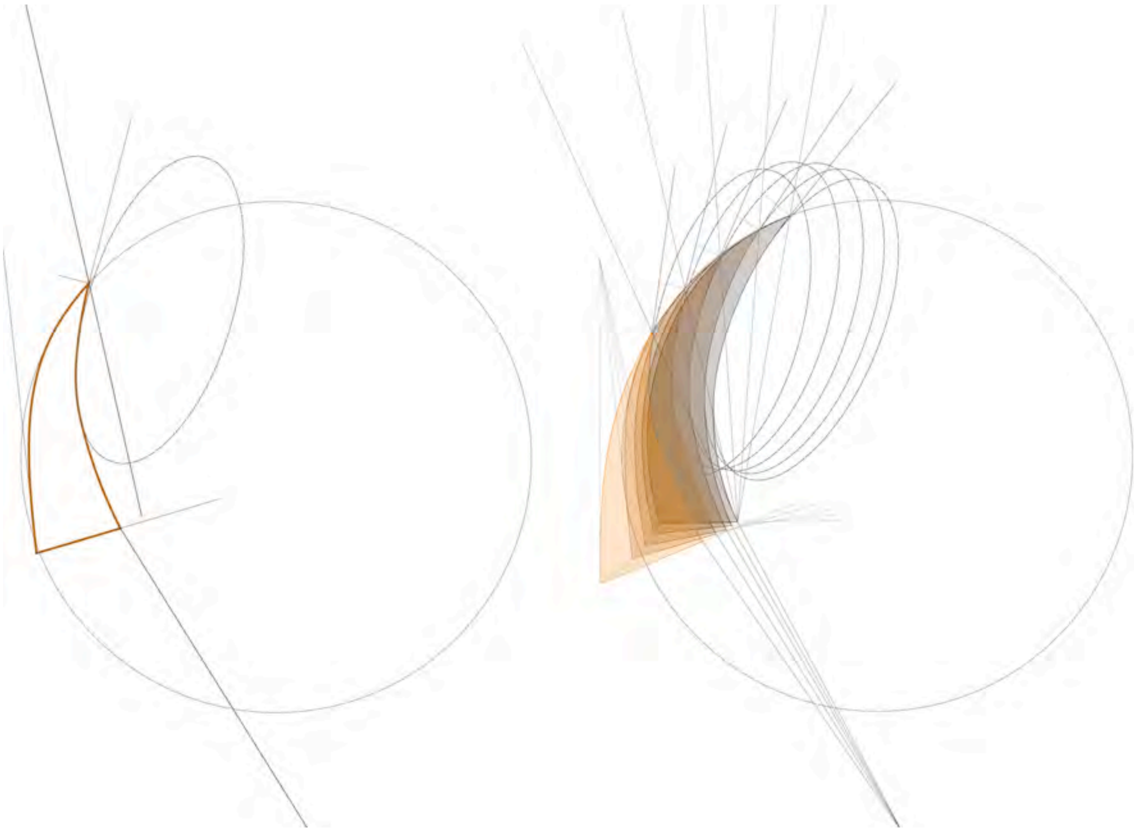

Image 4**: Parametric drawings used to define elevational profile of sails**

The scale and rotation of these base elements were the variables, and the portion of the line that was sampled for the fin was also a shifting parameter. An additional series of curve types was generated to form the three dimensional curvature of the forms. At the same moment of satisfying the associative relationships, the requirement for ruled surfaces had to be met. For the artists, the digital model was both enlightening and frustrating. At one moment, they analyzed the very detailed curvatures, but at another moment they could not enter into the direct manipulation of it, nor look to localize the adjustments, for it would break the associative model. It speaks to the contrast between a desire to be systematic and process driven, or driven by the analysis of the final product. Here the process is trying to mediate both, where criticism of the form challenges the tools of the process. The tools are not informing the design but being refined and further understood to satisfy the ultimate concept of a series of cooperatively curving forms.

5 Conclusion

In the simplest definition of collaboration, all participants have equal interchange of ideas and influence acts in a decentralized manner, rather than hierarchical. Collaboration with an architectural technologist is intended to act in the same manner. In terms of architectural design, this type of specific collaboration does propose a shift, though, where a priority lies in the logic of process and the specificity of the digital tools utilized for design. Collaboration becomes a discussion of design issues and digital methods. With the Jellyfish House, collaboration and process were hierarchical. Communication about digital procedures was minimized. The outcome was affected where all participants of the project were not engaged and sufficiently knowledgeable in the digital tools necessary to produce the design. The modeling technology was necessary as a component of the design. But without proper comprehension of the tools and variables of that technology, that design component could not be fully expressed, engaged, and controlled. With the Airscape Tokyo and Kinetic Sculpture projects process had an inextricable link to the product of the design. Collaboration was in critique of the product and the process. With both projects, there was a pursuit of the architecture, where process was not in depicting the design but in generating digital information that related to fabrication and construction. Airspace Tokyo engaged technology in process to produce computationally-driven, geometrically complex results. The Kinetic Sculpture pursued technology to rationalize the geometric complexity of the forms, while also maintaining their ability to be formed from single sheets of material. In collaboration, there was simultaneity in critiquing process and design, and understanding the direct relationship between them.

Without a clear and even exchange at the levels of process and product, the engagement of the technologist as a contributing designer will be minimized. Any design collaboration will take on this same dynamic. For the technologist, the philosophy and practice has to be balanced between general issues of design and the expertise of digital methods. In collaboration, process is more exposed and therefore the communication must exist at that level. With a constant desire to engage technology to absorb its generative and advanced capabilities, there is a challenge to simultaneously participate in the language of the process and tools, and address the architectural intentions of the design.

6 Notes

[1] Jellyfish House. IwamotoScott Architecture w/ Proces2. 2006. Project commissioned for the “Open House: Architecture and Technology for Intelligent Living” exhibit curated by Vitra Design Museum and Art Center College of Design.

[2] Delaunay is a triangulation method where the minimum angle of all the angles of a triangle is maximized, this tends to prevent “sliver” triangles. This method also forces the triangles to be somewhat equilateral. In Autodesk MAX, Delaunay is used as a subdivision method for NURBS surfaces. It is often selected for the subdivision of surfaces being used for cloth dynamics. The Delaunay triangulation provides for the most accurate results when calculating cloth dynamics.

[3] Voronoi is a tessellation method such that each polygon contains exactly one generating point and every point in a given polygon is closer to its generating point than to any other. Autodesk MAX uses a simulated version of the Voronoi method as a subdivision method with its MeshSmoothing modifier.

[4] GenerativeComponents is a parametric and associative modelling software developed by Robert Aish and Bentley Systems.

[5] Airspace Tokyo. Building design by Studio M, Hajime Masubuchi. Architectural screen design by Thom Faulders with Sean Ahlquist / Proces2. Tokyo, Japan. 2007.

[6] Kinetic Sculpture titled “Coming About”. Reed Madden Designs with Sean Ahlquist / Proces2. Tiburon, California. 2006.

FROM ART TO THE EVERYDAY: ROBIN BOYD AND THE 'WINDOWWALL'

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Abstract

Throughout his career, Australian architect and critic Robin Boyd (1919-1971) explored alternatives for the orthodox elements of architecture. Using the laboratory-scale of the detached house, Boyd would rethink wall, roof, floor and window. He was interested in making such elements serve more than one function. He wanted to rationalise the architectural palette with the hope that his invented elements might develop new formal meaning, and hence potential acceptance at a broader professional and popular level. An early target of Boyd's design research was the combination of window and wall, culminating in 1952-53 with the patented Stegbar 'Windowall', a modular structural window framing system that was to have national application across the full breadth of Australian domestic architecture from the 1950s to the 1970s. Neil Clerehan has observed that, "It was with the Windowall that Boyd, more than any other single architect, gave our suburbs a distinctive look. Even Palladio couldn't do that. The Stegbar victory was his greatest triumph. His Windowalls were an intrinsic look of the fifties" (60).

This paper follows the development of Boyd's window-wall, from his earliest known projects in the late 1930s to unique custom-designed solutions, and in parallel the industrial application of his ideas that would give direction to his own project house designs, and subsequently influence the appearance of the typical suburban home. It will be shown that this process was one of transformation: in a characteristically modernist displacement, Boyd transformed the window of the artist's studio to become a structural glazed frame for the everyday Australian living room (Colquhoun 51).

Keywords: Australian architecture, modernism, Robin Boyd, windows.

1 Introduction: the studio window

In 1938, Robin Boyd, then 19 years old and a student at the Melbourne University Architectural Atelier (MUAA), designed and oversaw the construction of a painting studio for his cousin Arthur Boyd (1920-1999) in the back garden of the Boyds' house in Wahroonga Crescent, Murrumbeena in suburban Melbourne. A feature of the tiny single-storey structure, in which Boyd's cousin could not only paint but live, was the studio window: a canted bank of eight fixed glass panels. This window was not just a practical source of daylight. It was also a symbol of the idea of the artist's studio, the multi-functional light-filled volume that combined living with art. The Boyd studio was thus an echo, albeit a suburban one, not just of the mansard roof garrets of Melbourne's 19th century artists in Collins Street but also of spaces like the light-filled studio designed for Amedée Ozenfant (1886-1966) in Paris (1922-23) by Le Corbusier and Pierre Jeanneret, and which Peter Serenyi and later Kenneth Frampton were to suggest appeared to cater for the 'spiritual needs of the 'artist/monk', as the new ideal, metropolitan man' (Serenyi, Frampton 43). A key feature of the Ozenfant studio was not just its industrial glazed studio windows but also its luminous ceiling lit by two saw-tooth roofs, an idea that would also find its echo in a later Boyd project.

A year later, Boyd's design for a skillion-roofed suburban house (1939), took the idea of the studio apartment as the basis for an ideal house type ("House"). The main window to the double-height living room was another 'studio-window', a large sixteen-panel structural frame infilled with glass. In the space of a year, Boyd had jumped to the scale of the everyday. He had produced a suburbanised Maison Citrohan, a studio as the home for everyman (Etchells).

2 Studio window and glazed stud frame

During World War II and whilst on active service in the Australian Army's Field Survey Corps, Boyd and Kevin Pethebridge's 1944 unplaced entry in the *Sun* Post-war Homes competition was evidence of a new direction for Boyd's design research on the postwar house (The Sun). A key feature of their design for an extendible house was the boxed studio window to the main living room, a memory of Serge Chermayeff's boxed studio window to the dining room of Bentley Wood, Halland, East Sussex (1938). However along the side of the Boyd and Pethebridge design, the windows to the bedrooms comprised structural timber mullions with glazing running up to the underside of the eaves, with fixed vision panels surmounted by banks of glazed louvres that provided ventilation at ceiling level. In this competition design, Boyd was examining the key component of domestic construction in Australia, the timber stud frame, and how it might be able to function not just as structure but also as a window frame. While there would have been local precedent in the modulated all-glass walls of Roy Grounds's Clendon flats, Malvern (1939-40) and Quamby flats, South Yarra (1940-41), it is almost certain that Boyd's interests in minimising architectural elements would have been encouraged by the pragmatic systems building techniques of his wartime experiences in Papua New Guinea (Goad and Willis).

By 1947, in the design of his own home in Riversdale Road, Camberwell, Boyd was to bring these two ideas - the studio window and the glazed stud frame - closer together. Facing a creek gully, the house's long east elevation was glazed by a canted studio window of twenty-four fixed and openable sashes that sloped down and outwards. The intention was to direct the view into the adjacent creek gully ("House near Melbourne", "House at Camberwell"). This giant screen was non-structural. Directly behind it, Boyd exposed the vertical stud frame. It was as if he was deliberately showing the window's role as a non-structural visor. To the one and a half height volume of the house's 'studio' living room, Boyd introduced a much larger floor-to-ceiling studio window as a glazed infill between two brick veneer walls. Boyd's private rumination on studio windows in his own home-laboratory was to be the preface to a very public preoccupation on the role of window joinery in the everyday house.

That same year, in July 1947 Robin Boyd became Director of the RVIA Small Homes Service, a housing bureau that promoted progressive domestic design ideas to the average homeowner, offering architect-designed house plans and specification for £5.00 as part of the profession's postwar effort in responsibly reducing the postwar housing shortage (Goad). Part of Boyd's role as Director was to write about these designs on a weekly basis in *The Age* newspaper. Thus between 1947 and 1953, Boyd would, on numerous occasions, extol the virtues of glazing between structural studwork and infilling with large fixed vision panels and glazed louvres, in effect asserting his thesis of the glazed studio window to the living room (now a full floor to ceiling glass wall) and a series of bedroom windows with glazing between studwork. Boyd was arguing for simplified window frames which an amateur carpenter could assemble on the job, thus reducing the cost of expensive shop joinery (Boyd).

3 Turning to the sun

At the same time and as a sole practitioner, Boyd extended his research on the completely glazed wall in one-off house designs for private clients. The Douglas Gillison house, Balwyn, Victoria (1950-51) was designed on a principal grid of 8' 6" (2590mm) timber posts ("The Life and Good Works"). Between these, glass was held in a wooden frame in which the light members were set diagonally, providing bracing to the skeleton wall. The whole north face of the house with the exception of the first floor study with its Ned Kelly slit window was an emphatic diagram of structure through which the sun was invited to fill the house. The house, with its improbable and inadequate line of projecting shading battens, became a description of stress and support. However this was still not an entirely integrated window-wall despite the structural function of the diagonally glazed frame.

At the Troedel House, Wheeler's Hill (1953-54), Boyd adopted a more thermally sensible approach to a full-height wall of windows. Situated on a sloping site, the plan of the house was a facetted wedge, with a floor-to-ceiling window-wall stepping away from the edge of a terraced verandah that was in effect a double height solar pergola (“House at Wheelers Hill”). All the openable windows (which were also doors) on the facetted glazed wall were on the shorter return sections, while the major windows were fixed glass. Ventilation and vision were kept separate.

In both these houses, the artist's studio window that had once faced away from the sun was now turned towards it, inviting it in. Living was to be done in light. If painting, the act of representation, was to be achieved using reflected light, everyday living was to be undertaken in the full blaze of sunlight.

4 The Stegbar 'Windowall'

In 1953, Boyd achieved his goal of combining window and wall. That year, the Stegbar 'Windowall' was launched. The firm of Stegbar had been founded in Melbourne in 1946 by Brian Stegley (1920-1974) ('Steg-') and George Barrow ('-bar') with the intention of manufacturing clock cases and office furniture. In 1950 Stegbar began making timber windows from their factory on the corner of Bay and Aberdeen Roads in Sandringham. Designed by Robin Boyd, the Stegbar 'Windowall' system revolutionised the firm's economic base. By 1957, the firm had new and larger facilities in Rosalie Street, Springvale (also designed by Boyd) and offices in New South Wales and Queensland. In 1958, Stegbar opened offices in South Australia and the ACT.

In January 1956, *Architecture and Arts* ran a two page article on Stegbar's latest window design (16-17). The window-wall was defined as a structural window that stands the full height from floor to ceiling. The important and differentiating term was the word 'structural' which distinguished the window-wall from the non-structural curtain wall, the glazing system then finding favour in commercial and industrial applications across the globe, and being lionised by architectural commentators, especially examples like the use of Crittalls steel windows as a curtain wall - at Walter Gropius's Dessau Bauhaus (1925) and as a skin to the steel portal frames of Charles and Ray Eames's Case Study House in Pacific Palisades (1949).

While the overall appearance of the Stegbar 'Windowall' was light, the kiln-dried hardwood frames were strong enough to support any roof load likely to be placed on them in typical domestic construction. A key part of the 'Windowall's strength was that the individual framing members (5 1/2" x 1 3/4" - 140mm x 45mm) were continuous in both directions - unbroken mullions and transoms - crossing each other in a copyright halved joint. In other words, it was like a floor to ceiling studio window.

The implication of the Stegbar 'Windowall' was that it was then possible to make all of the external walls of a house from such windowalls, with no additional supports required. The frames could carry a regular plastered ceiling, timber roof framing and terra cotta tiled roof. Stegbar 'Windowalls' were available in three standard series, but one could also custom-design a 'Windowall' with mullions and transoms in any desired positions, thus creating panes of any size of shape. The standard Stegbar 'Windowall' frame had mullions at 3 feet (915mm) centres, thus the 'Windowall' was available in widths of any multiple of 3 feet.

The first of the three standard patterns was the 'SD' type, 8' 6" high (2590mm, then the normal ceiling height in Australian domestic work) with a low transom at 2' 8" (812 mm) and another at 6' 8" (2032 mm). These heights matched the sill and door-head levels in other shorter windows of the same Stegbar 'S' series windows which might be used in ordinary solid walls elsewhere in the same building. The second pattern, the 'W' series, was 8' 6 3/4" (2610 mm) high, and the lower transom was dropped so that the high and low panes were the same size (26 1/2" [673 mm]) and the central pane was 45" (1143 mm) clear. The third pattern was the 'N' series, with two evenly spaced transoms, but only 7' 0 3/4" (2153 mm) high overall, and used mainly where boxed eaves caused the dropping of the window-head.

A key aspect of Boyd's design was that he had deployed the timber stud frame as a self-contained structural device. He had removed every second stud and instead of noggings and diagonal bracing, the continuous horizontal transoms gave the frame its lateral stability and strength. The implication was that the walls could be prefabricated off-site and that the specialist skills (and hence fees) of the window-joiner could be dispensed with. Another aspect of Boyd's window-wall was its division into other elements. The division of the frame respected the idea of the conventional door, and also the balustrade or chair rail. While the intention was to double the function of structure and glazing, the divisions of the frame meant that conventional relationships to the body and to other orthodox elements of architecture were in large part retained.

While other Australian architects like Douglas Snelling, Neville Gruzman, Harry Seidler and Peter Muller were able with handsome budgets to provide huge sheets of plate glass, to make their walls completely disappear and achieve complete transparency, the 'Windowall' through the pragmatics of its making, respected the divisions of scale that one would normally associate with the conventions of the orthodox window-opening and its frame. Indeed it is clear that across a range of domestic designs, Boyd enjoyed the qualities of the frame as an ordering device - as a screen - not as an element that one made disappear. His second house for his family in Walsh Street, South Yarra (1957) was another meditation on the artist's studio/living space volume and accompanying studio-window, but achieved through the expression of a rustic frame and with lead divisions between each glass panel. It was as if Boyd didn't want to relinquish the qualities of human scale implied by the frame, a tacit recognition of the small-scale units that made up the whole, units which could be economically supplied and assembled by hand. It was as Joan Ockman has acutely observed an example where “Modernism, as now reinterpreted largely meant a frame with repetitive components. Flexibility became interchangeability as the ‘modular plan’ replaced the free plan and ‘form followed form’ “(18). Yet despite its implications for mechanized production, Boyd’s application of the frame was one that acknowledged the humanised process of making.

5 Influence and Application

The significance of Boyd's timber windowall was not that he invented the idea, nor that he was the only one to think of the idea. Indeed in Geoffrey Baker's 1948 book, *Windows in Modern Architecture*, there was a separate section on the window-wall described as "an attempt to bring the benefits of standardization and pre-cutting to the sort of window wall which many designers now want" (37). Several examples of timber window-walls were illustrated like Gardner Dailey's Owens House, Sausalito, 1939, Wurster Bernardi & Emmons's Schuckl Canning Co. Building, Sunnyvale, California, 1942, and Franklin, Kump & Falk's Elementary School, Fowler, California, 1938, all examples well known to Australian architects.

What was significant about Boyd's invention for Stegbar was that it was a structural window-wall. It was different from Chicago architect George Fred Keck's use of the modular but non-structural Thermopane windows in his 'solar house' designs during the 1940s like the largely prefabricated Green's Ready-Built house, Rockford, Illinois, 1945 (Boyce). It was a different concept from the generously glazed designs of Northern Californian project house builders, Eichler Homes whose houses between 1949 and 1967 almost without exception adopted the structural post and beam redwood frame with plate glass infills (Adamson and Arbunich; Ditto, Wax, and Stern).

The importance of the Stegbar 'Windowall' was that it was manufactured, mass-produced and marketed by industry and adopted nationally, and that it was used by architects and speculative builders. Instead of having influence through type, plan or form, Boyd influenced an entire generation not just of architects, but builders and homemakers. One of Boyd's immediate applications of the Stegbar 'Windowall' on a broad scale was his 1955 design for the Peninsula House, a project home developed by Contemporary Homes Industries (CHI) and whose north face was constructed completely as a Stegbar 'Windowall'. Importantly, the 'Windowall' was adopted by other project house builders like the Sydney firm Sunline Homes, which was later to become the extremely influential and successful firm of Pettit and Sevitt in 1960 (Temple). In 1965 Merchant Builders in Melbourne also adopted the Stegbar 'Windowall', and by this time it was available in Western Red Cedar. In the work of other architects, the Stegbar 'Windowall' became the main feature of Neil Clerehan's *Age* Dream Home (1955), a public demonstration house. Clerehan, in his own home in Fawkner Street, South Yarra (1957-59) deployed the 'Windowall' as a two-storey self-supporting curtain wall, complete with double-height terylene curtains.

6 Return to the studio

Stegbar as a company went from strength to strength. In 1963, Stegbar added aluminium windows to their market offerings. They had grown to a staff of 400 and the firm was floated as a public company. It was acquired in 1971 by F&T Industries and in 1981, Stegbar was in turn acquired by ACI Australia Limited. Boyd, over the years, had retained a financial interest in the company, collected royalties from his original patent, and continued to experiment with his walls of windows. At the same time the project house market boomed in the late 1960s and his invention changed the look of Australia's suburban homes.

One Boyd design, though, stands out in this period. In many respects, it represents the turning of a full circle to his design research on the window-wall. In 1968, the Featherston-Currey house on The Boulevarde in Ivanhoe was completed. Designed for industrial designers Grant and Mary Featherston, this was Boyd's ideal house ("House, The Boulevarde, Ivanhoe, Victoria", Boyd and Strizic). It not only realised the fanciful and utopian idea of living on platforms in a garden but it was also a living and working environment for the ultimate ideal metropolitan couple. The Featherstons lived in a giant single studio/dining/living space. It was the ultimate warehouse/loft - the artist's studio - and, as had occurred at the studio of Maison Ozenfant, it had an illuminated ceiling, though not of glass but a quilt of Dacron fibreglass. But this time the studio-living room properly faced south, and instead of a custom-designed studio window, the Featherston house had a giant Stegbar 'Windowall'. The pre-cut frame of the everyday living room had returned to its studio roots.

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ARE YOU TALKING TO ME? WHY BIM ALONE IS NOT THE ANSWER

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Abstract

In contemporary building practice, the hegemony of 2D-based design communication is gradually being challenged by the possibilities offered by integrated 3D design environments and digital interfaces. The upcoming application of building information modeling (BIM) offers a way out of the current Babylonian plurality of non-compatible modeling-languages in order to push software developers and users to convert towards one common industry standard for data exchange. It is a clear aim of those propagating the use of BIM to strengthen the interaction of design teams and to assist facilities management through common standards for increased interoperability and data-management from the early design stage to completion and operation of a building. Current BIM capabilities rather seem to lie in the area of design documentation and post-design rationalization than triggering new design solutions. This paper sheds light on the status-quo of BIM and questions how designers can complement the current BIM capabilities to increase design-communication and a more seamless flow of information between various parties in architecture, engineering and construction (AEC).

Keywords: BIM, Parametric Design, Design Heuristics, Transdisciplinary Design.

1 Introduction

Building Information Modelling (BIM) as we know it today has been around in the AEC industry for decades and it has only recently come out of the ‘building science’ closet. After spending years on the back seat of architectural practice, BIM is suddenly resounding throughout the land and one won’t easily find an architecture conference, engineering function or building manager’s journal where the topic is not discussed in one way or the other. This step towards becoming ‘mainstream’ has occurred due to a strong push during recent years from the leading software developers which promote products such as REVIT, TRIFORMA, DIGITAL PROJECTS and ARCHICAD.

Whilst the application of BIM becomes more accepted and widespread throughout the industry, we do find ourselves in the paradox situation that nobody quite seems to agree on how to define BIM anymore. Depending on the sources one will find definitions describing it as method for managing project information where non-geometry attributes get associated with geometrical entities, or definitions which mostly point out its capabilities for cost-control and to facilities-management.

In this paper, the reasons for the current perplexity in defining BIM get analysed and arguments of BIM supporters and antagonists get brought into perspective for a more subtle view on the issue. Further, the author proposes ways out of the deadlock to pour oil on the troubled water surrounding the BIM debate.

2 Background to BIM

Before the currently accepted acronym 'BIM' was coined by Autodesk in the first years of the 21st century, a vast development had taken place resulting in a variety of proposals for object-orientated building design linked through commonly accessible databases. Over the past 35 years various investigations for finding methods and tools for computationally sponsored exchange of building-specific information and multi-disciplinary interoperability has been made in the field of Building Science. The predominant aim of this quest was to find ways to organise data-models which allow for a complete integration of all relevant factors in the building lifecycle. As Eastman points out (Eastman, C. 1999 - Building Product Models), all phases in a building lifecycle starting from a pre-design phase of feasibility studies, then design, construction planning, construction, facility management and operation can get described as one holistic process. (Eastman, 42)

A plurality of approaches for knowledge-based design systems which have dealt with similar issues as the current BIM platform since the late 1970s can be found at Khemlani et al (52). The authors discuss inter alia how STEP, the international *Standard for the Exchange of Product Model Data* (without specific focus on the building sector) provides a basis for the exchange format of BIM models. The International Alliance for Interoperability (IAI) was founded in 1994 and is developing a data-exchange system based on the 'building product model' (Malkawi, A.M. 2005). The data-exchange system consists of a component-based data library with descriptions of building parts and their interrelation in standardised classes – the so called Industry foundation classes (IFC).

In the late 70s and early 80s, at a time pre-dating personal computing, the Cambridge-developed and commercially applied RUCAPS was using very similar methods for connecting building-design information to those currently set for BIM. RUCAPS operated in a partly parametric environment where 2D information was extracted from a 3D model. It allowed multi-user access and did not mimic common drafting processes, but proposed a novel way to generated, distribute, and retrieve building information. The disadvantages of this early 3D system lay in its inflexibility to produce complex geometrical shapes and the high cost and slow speed of the system. (Day – paragraph 11))

Some of the principal ideas from RUCAPS can be found in current BIM software such as Autodesk's REVIT, Bentley's TRIFORMA, ARCHICAD as well as Gehry Tech's DIGITAL PROJECT.

2.1 BIM – many definitions- many interpretations

Due to current marketing-strategies of BIM software providers, it has become difficult to get a distinct picture of the aspects which can be addressed through BIM. These software providers want to make us believe that all aspects of the use of computers in design from early stages to completion and operation can be solved using their specific tool.

When looking at the development of what we currently understand as BIM, there is no indication that it is synonymous for one, all encompassing software solution. One scope for BIM is the seamless integration of information through a standardized format. At the current state of development this implies the capability to bridge the interoperability-gap that exists between distinct software tools. The tasks that are performed in this context vary to a large degree. BIM assists in design documentation, virtual pre-assembly, cost control, construction sequencing and facilities management – just to name a few. Davies argues the notion presented by some providers that BIM has to use 3D building components throughout the whole building-lifecycle is not correct (Davies, paragraph 7). Although BIM might offer possibilities to integrate those, it is traditionally a far more open platform where individual contributors can share information in a standardised format to manage project information.

The point is being made by those propagating the use of BIM that designers can get a better understanding of complex design-issues and resolve them quicker – which – in return – gives them more time to focus on design. If the tools currently supporting BIM rather address issues of virtual pre-assembly, error checking, on-site construction coordination and building maintenance, does the benefit for the user then not mainly lie elsewhere than in design?

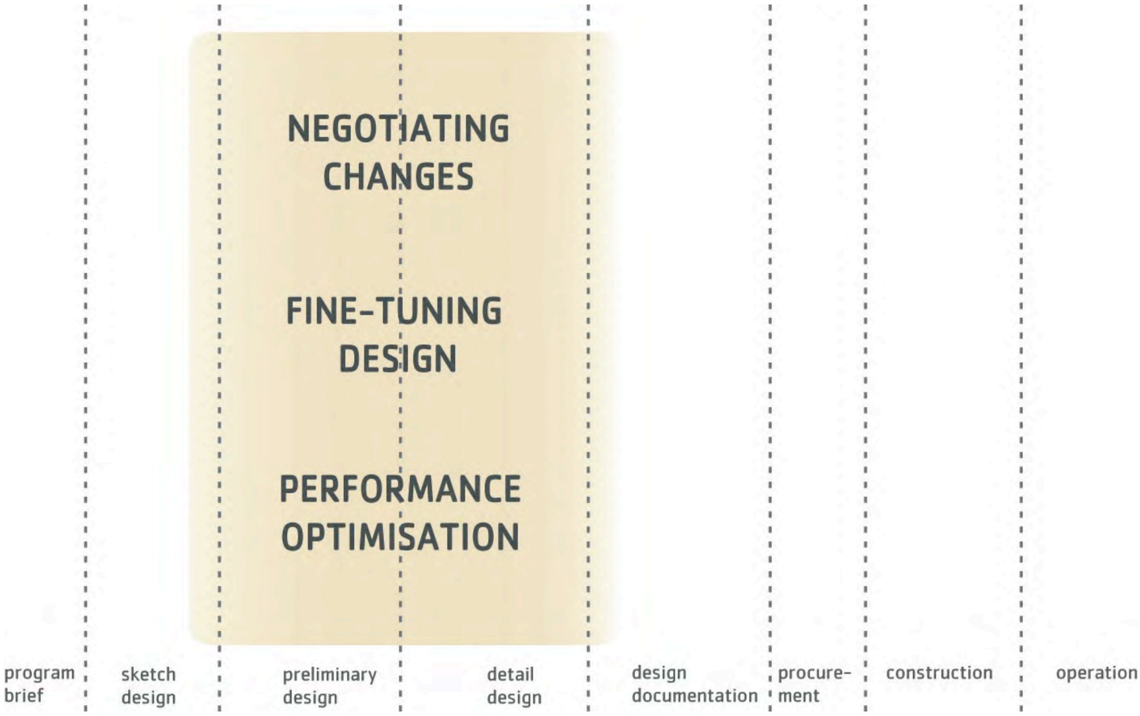

Table 1**: BIM capabilities – strength in documentation, construction an operation**

2.2 Who does the work – who takes the profit?

Those promoting BIM from argue that all involved in a building project will profit from its implementation. The list of possible beneficiaries is extensive and includes clients, architects, engineers, estimators, specifies, contractors, lawyers, sub-contractors, fabricators, code officials and operators – just to name a few (National Institute of Building Science, paragraph 4) . The often un-answered question is the one about who actually produces the BIM model and who controls it. The current notion is that the architect – in his/her traditional role as project-coordinator should be the one to do the work. There does not seem to be a clear indication that this reflects reality on a global level. The distribution of roles is much rather dependant on the level of BIM skills and contractual frameworks in individual countries. A certain reluctance to do the BIM work is apparent amongst architects as they often do not see the advantages it may bring to their work

One reason for this is that architects are by far not the only party who might profit from the creation of a BIM model and it may raise questions in how far it would be their 'job' to produce work which is used for building information management rather than modelling. The work is done by the upstream parties but mainly favors the downstream parties – notably the client, the sub-contractors and the operators. The model becomes a digital asset, but the added value is currently not understood by all parties involved in the BIM process.

We need more transactional compensation models to re-allocate the financial benefits to those who do the work. This issue has been discussed by Aish in reflection on the failure of the above mentioned RUCAPS and the lessons we can learn for the present implementation of BIM (Aish, 2). Once contractual issues about compensation as well as responsibilities and liabilities of individual parties for work undertaken on BIM are agreed on, who is supervising the process of collating all the information that feeds into the integrated model? Ceccato encourages architects to take advantage of the shift which is currently occurring in the building industry to regain lost ground in the design and building process through a redefinition of their professional status as integrators (Ceccato, paragraph 8). The person who is responsible to coordinate the BIM data will have to be able to capture design intent and expert knowledge to encode and incorporate it to the information platform next to the geometry-data which is provided by individual parties.

2.3 Outside pressures - BIM as legal requirement

The US General Services Administration (GSA) has issued a BIM-guideline in late 2006 which introduces their roadmap for a stronger integration of the use of BIM in the US AEC sector in general and the Public Building Service (PBS) in particular. The point is made that the GSA has instantiated a requirement in 2007 which will force all planners to produce BIM models for spatial program validation as an open standard if they apply for funding for their projects (GSA, 14). This is a significant shift for a public client to pro-actively push the industry to use a specific standard – a method which has now also become a legal requirement in Denmark since the beginning of 2007.

The issue of code-compliance might represent a further incentive to design using BIM. 3D integrated models are a far more accurate representation of any building project than the currently used 2D plan material. It is likely that in not too far future, BIM models will become more convincing instruments in communicating design and get it signed off by the authorities

2.4 BIM: A framework for design?

Those in favour of the implementation of BIM advocate its usefulness in bridging design intelligence across disciplines from pre-design to operation. How can this be instantiated? As much as the BIM approach allows for better data-transfer and integration, it currently does not entirely seem to encompass and link into processes that occur in the creative, conceptual design phases.

Lawson argues that the way CAD in general is currently implemented in design, planning and construction, falls short of supporting the design process in favour of assisting in drafting and documentation. The reciprocal feedback processes which occur between pencil and brain during conceptual design have not been mirrored with according CAD tools. Lawson draws a distinction between design as a problem-solving activity and an act where designers apply semantic and episodic knowledge to develop solutions through experiential memory. In case of the latter, designers combine *slow reflection* with the necessity to keep many things in mind at the same time for rapid decision making (Lawson, “Oracles” 389). Current tools often do not allow designers to keep various options open for evaluation simultaneously. What does this mean for BIM?

With current computational capabilities, there is a computational limitation in the design aspects that can be addressed parametrically. The *One Island East* project in Hong Kong developed by *Swire* is one of the first office buildings that have been pre-designed virtually in the parametric BIM software Digital Project (DP) by assembling up to 300.000 building components in one master-file. As much as DP is fully enabling parametric design, it was only used for digital pre-assembly, integration of building components, clash detection, construction sequencing and facilities management. The design was not set up parametrically due to the enormous complexity of handling the amount of detailed building information implicit in 3D design documentation. The more information is added into a BIM model, the less likely one will be able to remain flexible in the creation of alternative versions. This leads to the assumption that with current computational capabilities, a BIM model which includes the necessary information for documentation only makes sense once the basic geometry remains fixed and will not be altered. For design-explorations in the earlier design stages where changes occur due to the input of a variety of reasons, lighter data-sets and models for project-representations are required.

The question thus remains: How far down the track in the design process should we start using BIM? Can one single BIM model assist in the design process from the early stages to operation and demolition?

3 Complementing the BIM process

There is not question about the usefulness of BIM in regard to data-interoperability issues, but rather about the nature of support it can/should offer in the various design stages. In how far is there a limit to what digital representations can do and where human interaction and communication together with new skill sets are required? If dealing with uncertainty is seen as an intrinsic quality for creative processes, how can we avoid that standardised computational frameworks obstruct the design process rather than supporting it? What instruments do we have at hand for the design stages where we are not yet working with detailed descriptions of building objects, but want to evaluate options and keep the design flexible enough for input form design intelligence coming from our partners?

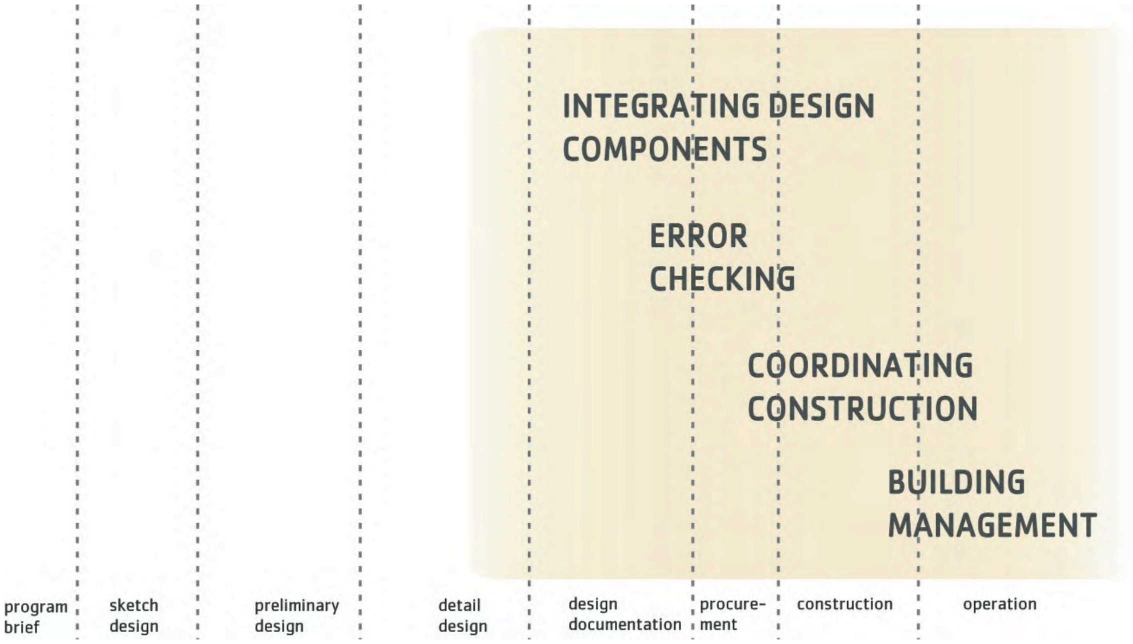

Table 2**: Flexible design in earlier stages, creating versions - evaluating options**

3.1 Analysing the process, finding toolsets for design decision support

We need to complement the possibilities of data-exchange with design methodologies that sponsor knowledge transfer across teams. In particular in the early design stages, where we are dealing with a high degree of uncertainty we require support to define, weight, and prioritise aspects of design in collaborative processes.

Can processes which lead to 'good design' be captured and replicated to create process maps for increased efficiency? After 25 years of in-depth observation of the way designers work Lawson concludes that *a shared view of the design process is more myth than reality.* Lawson further asserts that it is unlikely that efficiency of process would automatically equate with better design (Lawson, "Designers" 258). There exists an apparent antagonism between these comments and the claims most BIM supporters raise. Evidence suggests that under certain conditions, BIM systems can be augmented by manuals that describe and display information for construction of building-projects in the shape of process-maps (Mitchell, Wong, and Plume 321). These Information Delivery Manuals (IDM) have originated in Norway and they serve as framework for multi-disciplinary teams to improve communication amongst various teams in the construction process. IDMs provide assistance for BIM users by using descriptions of building construction processes as well as support for BIM software providers by identifying and describing detailed functional breakdowns of the process to be supported. When developing process models, how can we agree on the importance of each contribution by the individual members of the design team?

Deiman and Plat argue that referencing information about cost-consequences to design-decisions is a key factor for evaluating their importance in succeeding stages. The earlier decisions are made in the design process, the more significant is their impact on the final outcome. Deiman and Plat hence propose applying different levels of granularity of data-representing for building projects by clustering elements into design parts (Deiman and Plat 328). In accordance with this basic concept, the research of Khajehpour and Grierson illustrates an example of evolutionary search algorithms together with Pareto optimisation can assist in finding trade-offs between lifecycle profitability and structural considerations in a high-rise project. Multi-objective design optimisation is carried out in the early design stages by first assembling quantitative data about capital cost, operating cost and income revenue over time.

This gets brought into relation with quantitative data about building typology, structural systems, material usage, transport costs etc. A relational matrix of design aspects influencing cost and revenue considerations is established and consequently a set of alternative designs for the building is created (Khajehpour and Grierson 281). The aim in this multi-objective optimisation process is not to find one optimum solution, but to offer designers an array of designs which represent a good compromise between profitability and structural safety. This high-lightens that there are computational methods that can assist in providing effective decision support for solving complex multi-objective design problems. At the same time, it shows that expert input for prioritising one solution to another is always required and that the computational assistance can offer a greater variety of informed solutions to choose from.

3.2 Stepping outside one's own domain

Once individual users or user groups have developed their own working method they can enter a wider dialogue with others and to take a simple step at a time. In order to work towards integrated practice we require an intensive dialogue with the end parties who receive our information to understand their work methodology, skill sets and the way they interface data (be it for design, analysis or production). This will enable us to 'work backwards' to inform our own design-processes towards integrated practice.

Designers are often not aware of the interfacing potential between the information they produce, and the information that is needed to drive manufacturing processes. It has shown beneficial for designers to be aware of constraints and possibilities of the building-manufacturing industry as early as possible in the planning process. In consideration of project to project specificity, advantages can be gained through designated interconnections with the manufacturers and contractors to gain knowledge about their work-methodologies, their production constraints and their digital interfaces. In some cases, simple custom-made scripts and programming interfaces can create seamless CAD/CAM links from design to production. Only if we demonstrate the benefits of this rationalisation to the client and the quantity surveyor, we can prove that cost can be reduced to increase feasibility.

Alternatives to current tendering processes can assist designers to share the benefits and the risk of their work with the sub-contractors. Tombesi has investigated the 'request for proposal' method as practiced in Frank Gehry's office as a new way of organising tenders for subcontractors (Tombesi 86). When using request for proposal tenders, a 3D information package is distributed amongst competing subcontractors at a stage where no contract is signed yet; no detail drawings are made available to them, but accurate design intent – flexible about engineering strategies.

4 Conclusions

BIM is a useful way of increasing interoperability and pushing the agenda of integrated practice throughout the whole AEC industry. Next to that, its usefulness for the clients and operators of buildings is unquestioned and there are indications that its implementation will increasingly become important as a legal requirement. As designers, we have to scrutinise our design methodology to distinguish where BIM can assist us to do our work more efficiently, but also where it might limit our creativity in the conceptual design process. Only by doing so, we can develop our own specific way of designing with the help of computational processes which are currently not supported by BIM.

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UPSTAIRS/DOWNSTAIRS: INDIA, AUSTRALIA AND THE CHANGING DIVISION OF LABOUR IN 'OFFSHORE' ARCHITECTURAL PRODUCTION AND EDUCATION

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Abstract

As with many other 'industries' routinely engaged in the digital production and exchange of information, global interconnectivity is driving a worldwide relocation of architectural design production and documentation facilities from higher-wage to lower-wage regions. With common professional and linguistic legacies from the colonial past, India is emerging as a key provider to Australia in this emerging market of offshore architectural services. Conversely, India is also one of Australia's most important emerging consumers of architectural education. Until recently, a 'foreign-returned' Indian architect with a degree from an overseas university could anticipate architectural employment in an 'upstairs' position of responsibility and prestige. Overseas qualifications typically entailed overseas work experience as well, and the enhanced professional judgement these implied to perform the higher order 'symbolic analysis' of a designer or project leader. It was the 'downstairs' staff of locally trained drafters and technicians who did the 'routine production' and were paid accordingly. With the rapidly increasing volume and sophistication of 'offshore' architectural work now being 'outsourced' to Indian firms, however, the old 'upstairs-downstairs' division of labour and expertise is no longer clear.

This paper interprets relevant findings from the Indian case study of a larger comparative study of the changing geography of architectural work. Here we question what an Australian architectural degree is actually worth, or should be, to an Indian graduate architect when locally trained architectural technicians based in Delhi, Mumbai, and even provincial Kanpur are routinely working on major projects around the Globe as remote digital collaborators with some of the largest architectural firms in the world.

Keywords: digital outsourcing, offshore architectural services, overseas education, India.

1 Introduction

Recent advances in the digital production, representation and exchange of information are enabling dramatic changes in contemporary architectural design and practice. The evidence of this is already substantial. Most conspicuous is the extraordinary volume, scale and sophistication of architectural projects that are currently under construction in emerging new urban regions and economies of the Globe which, just a few years ago, were regarded as underdeveloped backwaters if they existed at all. Typically designed 'offshore', in many cases by leading corporate and avant-garde architectural firms, the timely production of these developments is enabled technically by the combination of computer-aided drafting and design (CADD) with the broadband interconnectivity of current internet-based information communication technology (ICT). Less conspicuously than the changing flows and concentrations of economic, political, and cultural capital that this new construction so spectacularly represents, these geography-collapsing ICT networks in which it is technically produced are enabling further exchanges of professional and technical knowledge. These flows are dramatically displacing and potentially completely restructuring labour and services in the architectural, engineering, and construction industries worldwide (Tombesi).

With the English language and other professional and institutional legacies of its British colonial past, India is already a key provider in the emerging market of offshore services for the architecture and construction industries of the UK, Canada and the USA, and increasingly Australia as well (Tombesi et al, "Routine Production"). It is no coincidence, perhaps, that India is also one of Australia's most important emerging consumers of architectural education. But what is the actual value of such an overseas architectural education, this paper asks, when even IT-savvy architectural technicians trained in undistinguished technical colleges in provincial India are in demand by fast-growing outsourcing agencies to work for some of the largest architectural and engineering firms in the world on projects ranging from skyscrapers in New York and Shanghai, to shopping malls in Poland, to suburban housing developments in Calgary and Melbourne?

To address this question critically, the operative premises of 'off-shoring' design production must also be cross-examined: How transferable are context-specific architectural knowledges across geographic distances and cultural divides? What types of knowledge and skills do effective distance collaborations of this kind depend on? Does this work require a mastery of increasingly complex building and information systems that extends beyond the purview of basic design production and technical support?

These are some of the key questions we are pursuing in a larger comparative study of Australia's prospects in this fast evolving new geography of 'globalised' architectural work (Scriver et al; Tombesi et al, "Evaluating Industrial Potential"; "Rules of Engagement"; Dave et al; Gardiner et al). The present paper focuses specifically on the division of labour and knowledge in the emerging IT-immersed sub-culture of 'outsourcers' within the contemporary Indian architectural profession.

2 Upstairs downstairs

As recently as the 1980s, the structure and operation of typical medium and large architectural firms in contemporary India could be characterised succinctly as an 'upstairs/downstairs' hierarchy. The 'upstairs' staff was the design professionals – principals, associates and graduate architects as well as student trainees of university-based or affiliated schools of architecture and design – who assumed responsibility for the higher-order intellectual labour of the office, as well as all design credit. Typically educated in English, the 'upstairs' staff readily engaged in the wider international debates of the profession.

The 'downstairs' staff was comprised of the clerical and technical support staff, and the draftsmen (and women) and clerks of works who produced the working drawings and liased with the construction industry and planning authorities. Larger firms often retained their own in-house engineers and quantity surveyors, with responsibility for technical coordination and the management of the documentation and construction phases of the work, but the rest of the 'downstairs' staff often had only vocational schooling. The language of work downstairs was the local vernacular.

The modernist ideologies that still dominate contemporary architectural education and practice privilege the 'atelier' or 'studio' as the ideal-type of architectural practice (Cuff 17-56). On the other hand, the division of professional knowledge and the work of 'symbolic analysis' from the procedural knowledge and labours of 'routine production' is a basic principle of industrial theory that many larger corporate practices, at least, have long exploited (Tombesi et al, “Routine Production”). However, the distinctive social and cultural segregation inherent in the division of labour typical in Indian architectural firms of the second half of the twentieth century also reflected the particular history of the Indian architectural profession with its origins under the former colonial system. To the limited extent that a ‘modern’ profession of architectural practitioners had been enabled to take root in India before the departure of the British in 1947, its organisational norms and practices remained very similar to those of the British Indian Public Works Department system (PWD). Within the engineer-dominated PWD system, in which many of the first generation of the nascent Indian architectural profession was trained, a small elite cadre of British architectural professionals had been assisted by a subordinate cadre of Indian draftsmen and clerks of works. With the departure of the British in 1947, the senior subordinate cadre rose to executive positions of professional authority within the technocratic framework of government service, but institutional inertia resisted deeper structural change.

In the post-independence era this inherited professional/technical division was reinforced by the promotion of general technical education under the ‘modernisation’ ethos of the new Indian Republic. With the emphasis on science and engineering as the primary tools of social and economic development, the comparatively esoteric concerns of ‘Architecture’ as an autonomous professional discipline were championed by the establishment of a handful of elite, self-consciously ‘professional’ schools of architecture and planning. The avant-gardisme propagated by these schools and associated smaller design practices ostensibly contested the technical-service model of practice propagated by the public works system and larger corporate firms. But this effectively reinforced a neo-colonial distinction between a professional class of elite architectural designers and a more humble and numerous class of mere technicians.

3 Downstairs upstairs? An overview of Indian documentation service providers

Over the past two decades, this conventional hierarchy has been radically challenged. Under neo-liberal economic policies that began to be introduced in the mid 1980s, India has re-emerged as one of the most dynamic and innovative ‘localities’ in the global economy today. India’s disproportionate stake in the intellectual capital that underpins the digital infrastructure of this global economy has played a key part in this paradigm shift (Heeks), and IT dependent industries such as Architecture, Engineering and Construction have experienced some of the most dynamic changes. The emergence of the outsourcing sub-industry is one of the most recent developments arising from the more fundamental emergence in this increasingly free-wheeling, unregulated building scene, of a parallel formation of both qualified practitioners and para-professional providers of architectural services working outside the purview of the organised architectural profession. The defining characteristic of this less exclusive, more heterogeneous group is its commercial focus. Qualifications are valued from a strictly pragmatic rather than symbolic point of view, and the major currency in this regard is architectural data processing skills, not least facility with sophisticated CAD packages and other digital tools. (Tombesi et al, “Routine Production”).

How then has this radical and irregular growth of a larger architectural ‘industry’ challenged the established norms and hierarchy of professional practice? Have the ‘downstairs’ technicians simply moved ‘upstairs’? Our research on India’s architectural outsourcing sector is revealing a more complex and ambiguous picture.

Supported by an ARC grant in 2005-2006, a research program was undertaken to better understand the complex interdependencies between technical, professional, and cultural knowledges in the production of architecture through remote collaboration. The core of the project is a series of controlled experiments in documentation collaboration between conventional Australian architectural offices and a range of service documentation providers, from local (Australian) drafting sub-contractors to global (offshore and/or internet-based) outsourcers (Dave et al). The exclusively digital parameters and evidence of these ‘laboratory’ experiments were complemented by field-work in India to investigate the internal organisation and practices, and the actual infrastructure and human-resources on which several of the participating offshore outsourcers in our study and their local competitors relied. Outlined below are some of the key findings of this ongoing research pertinent to our specific concern here with the structure and division of architectural work and knowledge in this fast evolving IT-driven sub-industry.

Few if any architectural outsourcing firms existed in India a decade ago, but growth in this sector has been exponential in the last few years. Typical firms appear to fall into one of a small number of types. On one end of the scale are firms that openly and exclusively provide outsourcing services, employing hundreds of staff. On the other end are start-up operations with just 2-5 employees. Many firms have overseas 'front' offices with actual work being carried out in 'back' offices based in India. One variant of this is the 'captive unit' or wholly owned subsidiary of offshore firms. Another variant depends on free-agents, including Indian students enrolled in post-graduate degrees overseas, who broker connections between those seeking services in overseas markets and providers in India.

Services are provided on a 'project' basis, 'studio-mode' (dedicated staff working as long-term satellite staff of another office) or even 'person nodes' (in which one or more staff are 'attached' to overseas offices). Many firms also operate up to three shifts a day to respond to the volume of work and to align office hours with the different time zones of key client markets around the globe. The locations in India of the actual documentation production offices do not indicate any overarching patterns. Outsourcers are operating in big cities and small, and in every grade of accommodation from corporate office space to veritable sweat-shops.

Not only is the volume of 'offshore' architectural work produced in India increasing rapidly, but the sophistication as well. Technological capabilities and advantageous wage differentials are obvious drivers where, until recently, an experienced draftsperson in India earned approximately one tenth of the average starting salary for an architectural graduate in an Australian firm (Tombesi; APESMA). The typical scope of work begins with basic conversion to CAD of physical hand-drawn or drafted drawings, and the production and development of construction documentation. But 3D building information modelling (BIM) is rapidly becoming the new paradigm for the services offered. With the greater scope for coordination this technology enables, and the expert experience gained through successive jobs for repeat clients the majority of outsourcing firms openly aspire to play a more comprehensive role in the production of their client's projects. But, even where greater 'design' related scope of work is not the aim, it is still widely acknowledged that mere drafting technicians are not up to the job alone, as this requires a professional's sense of the complexity of criteria and details that need to be addressed and coordinated. Firms are therefore increasingly keen to recruit and retain more senior, professionally qualified staff, ideally with relevant overseas experience as well. There is also considerable awareness of the need for expert knowledge acquisition and development and through on-going staff training as a core priority of the business. India still works a six-day week, and Saturdays are the days on which employees are paid to learn more about the technologies they are using, and the technicalities and cultural differences of their current projects. In a fast changing industry, such staff development is also calculated to inspire loyalty through a sense of growth and maturation with the firm.

To summarise this very cursory description of relevant findings from our fieldwork, three key points can be emphasised: There is (1) ample evidence of rapid growth in both demand for and supply of offshore architectural services, in a range of different modalities; (2) evidence of rising expectations for greater scope of work and sophistication; and (3) a recognised need to pro-actively acquire a higher order of both technical and professional knowledge.

The latter point in particular is corroborated by the preliminary findings of our controlled collaboration experiments in which the paramount significance of the internal sub-cultural knowledges and practices particular to the specific firms engaged in such collaborative relationships has become very apparent (Gardiner et al.). If the outsourcers are to fully grasp the character and the details of the design work they are engaged to produce, and increasingly to assist in the detailed development of the designs as well, the commissioning firms need to be better attuned critically to their own formal and practical idiosyncrasies and how these may be understood and communicated. Thus, the possibility of developing and sustaining productive distance relationships does not depend on common norms and standards alone, but a common awareness of and engagement with complex contextual knowledges on both sides.

This key point has certainly not eluded the outsourcing industry and is the conscious aim of developing dedicated work teams as 'remote studios' for established offshore clients. As one of the industry leaders argues, "offshoring actually forces their junior staff [on both sides of the collaboration] to become technical and process experts, demanding both the knowledge of design and construction detailing, and also management skills as well, all of which benefit individual firms' employees" (Jansen). But beyond the particular vocational/technical and professional criteria of the work itself, access to additional contextual knowledge of the socio-cultural kind is a probable further success factor in such distance collaboration. The phenomenal success of the largest India-based outsourcing firm is a case in point. Whilst a champion of the 'remote studio' model, the exceptional growth of this firm of 300+ employees also appears to derive from intimate 'insider-knowledge' of the cultures of practice on both sides of the business relationship. The firm was founded in the late 1990s by a young expatriate American architect, now settled in Delhi. Following architectural studies at Yale and Cambridge, extensive post-professional studies in China and India as a Fullbright scholar, and a period of overseas work for one of the largest corporate firms in the USA, marriage to the daughter of an influential architectural educator on the Indian scene brought him back to Delhi to establish his own outsourcing firm. Together with a carefully coached team of senior managers recruited from the handful of elite Indian schools of architecture, the firm presents a powerful and persuasive ethos of professional command informed by an understanding of the values and practices sustained in the sub-cultures of elite architectural education in both India and the American Ivey League.

4 Conclusion

To conclude, let us return then to the question of architectural education latent in the preceding observation, and what we suggest are some of the possible implications of these ‘offshore’ developments in technologically globalised architectural production for architectural learning today.

In a salient essay, the celebrated Indian architect, Charles Correa (445-56), invokes a well-known parable from Indian mythology to serve an argument about architectural education. The story concerns an untouchable slave boy, Ekalavya, who so passionately venerates the mastery of a great Brahmin archer, from the necessary distance prescribed by his lowly social station, that he virtually masters the art himself. But the boy’s cruel fate for this miraculous conceit is to sever his thumb so he can never draw a bow again. Correa’s point is that architecture can almost certainly be ‘learned’ mimetically, whether or not it can be ‘taught’ effectively. And, learning about the craft and intrinsic cohesion of the discipline is perhaps no more felicitously gained, he argues, than through intensive immersion in the work of other accomplished designers – not least through the devoted, even slavish copying of the ‘masterclass’ studio (or, we might add, the ‘remote studio’ services typically offered by offshore documentation firms). But to become a mature and original designer in one’s own right, Correa counters, the delusion of mastery through mimicry must necessarily be challenged, in any good architectural education, with a healthy balance of critical ‘distancing’.

Written in the mid 1990s for a collective volume on ‘the education of the architect’ put together by faculty and affiliates of MIT (where Correa teaches and had, himself, been an international graduate student in the early 1950s), Correa’s essay articulated the distancing function of the theoretically and critically rich curricula that such elite schools were celebrated for. This was the necessary counterpoint to the charismatic immersion of the master-class studios that they were equally well-placed to provide and which students with the requisite brilliance (or finances) flocked from every corner of the planet to experience. But Correa was also certainly conscious of passionate debates at the time about MIT’s radical commitment under its new ex-pat Australian Dean of Architecture, Bill Mitchell, to total digital immersion in the new paradigm of the ‘paperless studio’. One could therefore read Correa’s conventional wisdom about complementarity and balance in the substance of an education, in a slightly different light. The seduction of virtual mastery through digital technique had all the more to be countered by critical inquiry, humility and introspection about the just balance between the visual and the verbal in architectural learning; the technical and the ethical.

Over a decade later, the digital tools and templates we use to craft the global architecture of today are as ubiquitous as the virtual realities they are prone to produce. The typical Indian or Chinese international student arrives to study architecture at an Australasian university with IT user skills that are equivalent or often superior to those of their Australasian educated classmates. Surely, then, it is the ‘distancing’ – geographic, cultural and above all ‘critical’ – that such a student experiences when they actually travel overseas in which the real pedagogical value of that investment resides.

In the competitive scramble for international student recruitment and retention, Australasian schools of architecture should take note: it is not generic vocational training that is wanted. As Adrian Snodgrass (35-43) has cautioned, this assumption is not only patently neo-colonial, but naïve. What we need to initiate in our increasingly international studios and classrooms is a dialogue between future ‘collaborators’ in an emerging global exchange of expert services and knowledge; between different professional sub-cultures of critical practitioners who will need to be equally reflexive about their own practices and locality as they are acquisitive (and hopefully inquisitive too) about the opportunities of the global.

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CODE TO CRAFT – BEYOND THE VOXEL

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Abstract

The digital nature of post-industrial societies has profound implications for architectural design, documentation and construction. Digital tools and technologies bridge the representational divide between conception and realization, empowering architects to regain control of the design, fabrication and assemblage processes. This paper will discuss ideas and concepts to facilitate the fabrication of non-standard, context-specific, geometrically complex architecture and components. Two case studies exploring digital fabrication and metal casting will be described alongside implications for the fields of architectural design and construction.

Keywords: architecture, craft, craftsmanship, component manufacturing, computer aided manufacturing, digital design, jewelry, metal casting, rapid prototyping.

1 Introduction

Digital tools are prevalent in many aspects of contemporary global culture, streamlining and consolidating multifaceted systems and automating repetitious tasks. They are increasingly instrumental for developing complex and holistic solutions to complicated problems. These technologies have the potential to extend human knowledge and the ‘vocabulary’ we use to engage and express ourselves.

The advent of CAD (computer-aided design) and CAM (computer-aided manufacturing) has transformed the paradigm traditionally associated with design, fabrication and construction. CAD/CAM tools enable the direct fabrication of a virtual 3D model using a diverse range of materials and techniques. As such, these technologies bridge a representational divide between conception, design and realization. Highly integrated in the fields of aerospace, automotive, industrial and nautical design, the use of CAD/CAM has only recently prompted interest from the building industry and allied fields of architecture and engineering. These professions are poised for change as they become empowered through a nascent medium where representation is synonymous with the information needed for data-driven fabrication.

The integration of digital design tools in teaching, learning and practice over the past decade has rendered CAD obligatory as a drafting aid in much of the architecture and engineering industries. Recently, increased computing power has enabled CAD tools to mature and suggest possibilities far beyond their origins. Those at the forefront of research-based architecture practice have recognized the potentials of appropriating an array of computation and fabrication strategies to extend design, manufacturing and construction capabilities.

Complex forms are increasingly frequent in the contemporary architectural lexicon and these necessitate novel and innovative means of communication. Concurrently, commercially available and emerging CAM technologies facilitate new geometric potentials and bypass the need for traditional 2D drawings to specify 3D relationships, dimensions and other vital fabrication information. This digital convergence of representation and production embodies one of the most important opportunities and challenges facing the contemporary architecture industry.

2 Beyond Aggregates

As data driven CAM technologies increase in scale they can be used to fabricate components suitable for building and construction. Schodek outlines a host of architects and projects that have made headway into automated fabrication and rapid construction techniques for geometrically complex non-standard architecture. It is interesting to observe however, that the majority of work thus far considered in these terms has been surface-oriented with structural systems manifest as sampled 2.5D instances of a particular 3D 'master geometry'. Achieving a precise (re)production of complex digital form has consistently posed fabrication challenges. Generally, so-called smooth or non-planar geometries have been accomplished with a combination of CNC (Computer Numerically Controlled) milling and casting/forming (glass, composites, plastics, concrete, metal etc) but have remained in the domain of surface and/or surface treatment. Bernhard Franken's BMW Deutschland Pavilion built for the Frankfurt motor show in 1999 exhibits two of the dominant approaches to the construction of non-standard architecture. 305 doubly curved cast Plexiglas panels enclose an aggregate system of interlocking planar sections that define the structure and interior. In his essay *Blurring the Lines*, Andre Chaszar queries a pivotal characteristic of contemporary and emerging architectural design, fabrication and construction;

"Will CAM eventually be able to produce fully 3D forms in building scale elements or will complex forms continue to be made from 2D elements assembled into 3D aggregates?" (14)

This is an important question. It suggests thinking beyond surface to increasingly efficient and context-specific systems that suitably compliment digitally generated architectural forms. In an interview with Pyotr Kudryavstev, Franken acknowledges this necessity stating that many contemporary architects "are interested mostly in the external characteristics of a building, its surface … These days, architecture is seen merely as designing a sort of clothing for buildings." Currently, industrial processes for realizing "fully 3D" complex objects fall within the broad genres of additive and subtractive fabrication. These tools represent the framework for an almost limitless palette of geometries and support the quest to unify surface, structure and ornament. Due to the ongoing development of new materials and larger scale fabrication platforms they are increasingly applicable in the fabrication of non-standard architecture and components. An emerging avenue of particular interest is rapid manufacturing, the direct fabrication of functional end-use parts from 3D model data. Viable at the scale of hardware and industrial design, the building industry awaits the development of sufficiently large platforms where freeform processes such as laser sintering or layer deposition can be used to directly fabricate full-scale building components. An example is Concrete Contour Crafting, a mega-scale construction technique being developed by Behrokh Khoshnevis at the Department of Industrial and Systems Engineering, University of Southern California. Using a layer deposition method familiar to the rapid prototyping industries, contour crafting has the potential to automate the construction of whole composite structures. A building or colony of buildings each with a different design may be constructed in a single run. Embedded in each structure all internal components such as piping, electrical conductors, and reinforcement modules. (302) This technology suggests future potential for the large-scale rapid construction of non-standard, geometrically complex architecture and indeed "fully 3D forms in building scale elements".

Direct rapid manufacturing at building scale is still in its infancy, however it is possible to indirectly manufacture "fully 3D" architectural components using a combination of digital and traditional means. Commercially available Solid Freeform Fabrication (SFF) and CNC manufacturing can be used to rapidly create molds, patterns and tools for fabrication processes such as casting. Although build chambers are currently limited, large and complex components can be subdivided and assembled in sections. Dr. Kevin Rotheroe has initiated research into this method of fabrication in the architectural context. His Freeform Tubes use CNC milled foam as investments for casting non-standard, structural steel components. Although enabling a degree of geometric flexibility and demonstrating a promising methodology, Freeform Tubes have not harnessed the full potentials and context specificity afforded by these technologies in order to compliment and enrich contemporary digitally generated architectural forms.

3 Case Study

3.1 Genome Jewelry – integrating digital fabrication

The Genome jewelry collection demonstrates some of the benefits that can be gained by integrating current and emerging digital technologies with traditional metal 'investment' casting. In particular, the appropriation of computation, design and fabrication strategies across scales and between disciplines.

Elastic membranes exhibit elegant and efficient solutions to spatial and structural design. These 'minimal surfaces' are curiosities that have intrigued mathematicians and designers alike and are recognized for their abilities to rationalize highly complex boundary conditions. The pioneering work of Frei Otto, Sergio Musmeci and more recently that of Ingenhoven Overduik & Associates, UN Studio and Minifie Nixon Architecture exemplify the use of these surfaces in building design and construction. Genome jewelry and its associated research began as an investigation into the use of digitally generated minimal surfaces as an architectural design tool.

The Surface Evolver written by Professor Kenneth Brakke (Department of Mathematical Sciences, Susquehanna University) is a digital tool that emulates the mathematics and behavior of minimal surfaces. This software enables the generation of unique complex forms and geometries across a variety of scales. Using Surface Evolver alongside a combination of 3D modeling packages, the Genome collection has been meticulously crafted as a comprehensive data set containing all necessary fabrication information. A high-resolution SFF system was used to build the virtual model as a wax object. The 'printed' master wax then translated into precious metals using a common method of investment casting. The industry contacts involved in the process are invigorated by a fresh complexity and the challenge it represents to traditional methods of manufacturing. The information exchange throughout this research has prompted the casting firm Lenrose to purchase the specific high-resolution SFF system used for Genome jewelry. Due to the precision of the casting technique, artifacts from the fabrication process can be seen as contours on the surface of the objects. The fabrication of the final sterling silver and gold pieces has been adjusted to express permutations of surface articulation and patterning that illustrate the numerous potentials, variables and unexpected outcomes implicit to digital design and fabrication strategies.

Digital environments enable the concurrent generation of design and manufacturing information. The complex, intricate and specific geometries explored in the Genome collection were manufactured without the use of 2D information. The final forms, a physical (re)production of precisely crafted 3D data. Beyond the implications of liberating design, digital tools and technologies question the very nature of representation and construction. This research resonates with current and future potentials for the architecture, engineering and construction industries.

Prior to the late nineteenth century, the primary metal used in construction was iron. The flexibility and strength of cast iron freed designers to create new structural forms impossible in stone. Despite its innovation and potential, the tradition of casting metal structural elements with complex geometries has struggled during recent history. The mass-production of rolled and extruded steel from the late nineteenth century has ultimately led to the standardization of construction methods. Twentieth century industry has developed more efficient casting techniques and better-suited construction materials, however the difficulty and primary expenses involved in casting processes have always been the production of tools, patterns and molds. Casting has therefore developed into a specialized craft primarily used for its economy of scale and suitability to mass-production. Rotheroe's research shows that digital fabrication technologies provide a vital framework to alleviate some of these limitations, engaging concepts of mass-customization and enabling the economic manufacture of unique non-standard casting tools.

By appropriating, mastering and integrating digital fabrication with design and manufacturing strategies across scales and between disciplines, Genome jewelry challenges traditional notions of craftsmanship and successfully demonstrates a specific contemporary process with potentials at a variety of scales. The Genome designs debuted in 2^3 @ Sherman Galleries Sydney 2006 and have since been exhibited at the Kunst Museum Germany, 2nd Architecture Biennale Beijing and New Craft Future Voices Conference Scotland.

Picture 1: **Genome – Not ring 2006**

4 Case Study

4.1 Evolutionary Plasticity – context-specific structures in architecture

When modern man builds large load-bearing structures, he uses dense solids; steel, concrete, glass. When nature does the same, she generally uses cellular materials; wood, bone, coral. There must be good reasons for it. Prof. M. F. Ashby, University of Cambridge

Nature always achieves its objectives economically, with the minimum energy, conserves its resources and completely recycles its waste. http://www.daimlerchrysler.com/

The success of the Genome jewelry investigation has prompted further exploration into digital means of design and fabrication at larger scales. Evolutionary Plasticity is being undertaken as research into the suitability of SFF and CNC technologies as indirect manufacturing tools for large-scale components that can be used in the architecture, engineering and construction industries. Specifically this study looks at combining traditional metal casting methods with contemporary digital fabrication to enable the economic production of molds, tools and patterns for the indirect manufacture of non-standard, geometrically complex architectural components. It is expected this production methodology will be widely applicable to the architecture and construction industries by facilitating "fully 3D forms in building scale elements." To test this idea, a computational process has been guided to generate optimized, context-specific structural forms that challenge traditional modes of fabrication.

Naturally occurring structures such as trees, bone, coral, sponge, foams and bio-mineralized protist shells exhibit flamboyant geometries that simultaneously negotiate several environmental conditions with minimal energy and material consumption. This negotiation of contextual factors achieves a near uniform stress distribution throughout the structure. The *Axiom of Uniform Stress* is a phrase coined by theoretical physicist, Professor Claus Mattheck to describe the adaptive growth strategy of naturally occurring self-optimizing structures. Trees have the ability to add material in order to compensate for differentiated environmental stresses. Bones can further restructure material deposits to accommodate temporal changes to their environment. Contemporary computation techniques such as Bi-directional Evolutionary Structural Optimization (BESO), the similar Extended Evolutionary Structural Optimization (EESO) and Soft-Kill Option (SKO) are tools for removing low stress regions and adding material to high stress areas of a 3D digital model under specified loading conditions including consideration of scale, topology and material properties. The BESO algorithm is written by Dr. Xiadong Huang from the Innovative Structures Group at RMIT University and extends the concept of Evolutionary Structural Optimization (ESO) initially presented by Professors Mike Xie and Grant Stevens in 1992 at the International Conference on Computational Engineering Science in Hong Kong. BESO iterates a virtual model toward uniform stress. The framework for the original BESO model is a set of basic parameters distilled from context analysis. These manifest as preliminary geometry, domain scale, load cases, boundary conditions and other design properties such as fixed areas. Adjusting and restructuring material distribution can achieve reduced consumption and increased overall strength-to-weight ratio. This process can be applied at numerous scales and enables the evolution of optimized macrostructures, substructures and microstructures suited to lightweight context-specific building components. The resulting geometries exhibit an elegant combination of function, form and efficiency

The design context for Evolutionary Plasticity is a popular local music venue where an obtuse concrete column interferes with privileged views toward the performance stage. Removal altogether is prohibitively expensive. Replacing it with an optimized porous structure could ease much of the visual interference and provide a functional, intriguing and interactive replacement.

At this point the objects pictured are conceptual, demonstrating three possibilities for engaging the BESO algorithm to generate optimized structural systems. A contextual survey is necessary to finalize the exact computational parameters to ensure the desired design outcomes are attained. Illustrated are potential macro, sub and micro-optimization schemas that can be applied to achieve enhanced strength to weight ratio components that combine a material elegance with functional and structural logic. The macrostructure accomplishes a seamless junction with planar surfaces and illustrates a way of integrating standardized structural systems. The resulting geometry of the substructure optimization acts to enhance rigidity similar to the internal structure of bones. The internal bracing becomes dense in areas of high load transference, adding interest and differentiation to an otherwise smooth form. This optimization schema can be used to create integrated reinforcement and formwork for complex cast composites as it generates hollow sections. The filigree microstructure shows a further level of optimization at the level of surface. For current purposes the structural logic has been appropriated from the deep-sea sponge *Euplectella aspergillum* also known as the Venus flower basket. This sponge is made of very fine silica material and though inherently brittle, has a particularly robust structure due to its uniquely integrated cross-bracing system. Nature's structural systems demonstrate the principle of lean construction, using minimal energy and material to function optimally. The building and design industries must capitalize on emerging digital technologies that can be integrated to achieve leaner construction methods. Beyond minimizing energy and material consumption, digital tools can be utilized to dramatically streamline the construction process reducing waste, assembly time and on-site labor.

The resulting complexity of evolutionary-based form finding amplifies the need for new and innovative means of fabrication. The level of detail attained in the microstructure optimization is currently only achievable in functioning architectural elements by employing an analogous fabrication process to the one used in the Genome jewelry research. As the examples show, achieving highly optimized architectural componentry is possible by integrating digital technologies with traditional freeform manufacturing processes such as casting. Similar to the

Genome jewelry, the plaster models pictured have been directly fabricated from a virtual 3D model using the Z-Corp Spectrum, a typical SFF system. The Z-Corp system also supports a proprietary starch material engineered for the investment casting process. It is expected that subdividing the final object will enable a full-scale pattern to be produced via this method. This pattern could then be used as the investment for casting a "fully 3D" building scale component

Picture 2: **Evolutionary Plasticity – concept models and example diagrams illustrating the removal of low stress regions using Evolutionary Structural Optimization (Xie & Steven)**

The next stage of Evolutionary Plasticity looks at viable methods of integrating specific digital fabrication and metal casting technologies. Of particular interest are investment, sand and 'lost foam' casting. Their differences are marked and range from size and weight limitations to part complexity constraints. The most promising and recent method is 'lost foam', a healthy mix of sand and investment casting. A sacrificial pattern generally made of polystyrene is embedded in sand with feeder channels attached. Molten metal is poured directly into the feeders, vaporizing the foam as it takes shape. This casting method can be used for components up to 50 tons and imposes little limit on form or complexity.

4.1.1 A note on aesthetics:

The iterative reduction of irrelevant material using evolutionary-based computational processes returns architecture to its modernist musings. By distilling objects according to functionalist principles are we not effectively practicing modernist theory in an evolutionary fashion? Is it not ironic that the resulting forms are exceptionally flamboyant, challenging traditional methods of fabrication and the industrialist ideology of mass-production? Fortunately and excitingly, the actualization of “fully 3D” non-standard, context-specific, optimized strength-to-weight ratio components is a viable prospect in post-industrial digital societies.

5 Conclusion

The digital revolution has heavily impacted architectural thought, research and practice. The contemporary vocabulary of digitally based architecture and practice emerged during the mid-nineties and heralded a new era of forms and form finding. This work challenged the profession, questioning traditional notions of design, manufacturing and construction. Its legacy is fundamental to the development of a new cultural aesthetic. As suggested by Chaszar, it is time to look beyond the surface of architecture to increasingly efficient and context-specific “fully 3D” structural systems that suitably compliment digitally generated architectural forms. The coming generation of architects are increasingly conversant in digital design tools, however a knowledge gap emerges when considering fabrication techniques for complex geometries. The convergence of representation and production information in the digital paradigm signifies a crucial opportunity for architecture. Information-driven modeling enables associative and/or explicit 3-Dimensional models with embedded data sets that can drive computer aided manufacturing tools. As illustrated by the included case studies, active exploration and understanding of available and emerging technologies coupled with an intimate, first-hand knowledge of tools and materials evolves the role of the architect as 2D documentation providore toward the notion of Master data craftsman, facilitator of the design, fabrication and construction processes.

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NEW PLACE DESIGNS WITH EMERGING TECHNOLOGIES

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Abstract

The emergence of digital and computing technologies is arguably the force of the century for innovation in all domains. In design, researchers and practitioners have shown an increasing interest in predicting and examining the effect of these technologies in transforming our everyday life and surroundings. Built environments as an essential part of our holistic living environment have played an important role in this revolutionary process. While many have laid out the vision, we are now looking for the integration and extension of this vision with respect to our traditional notions of place. Rather than seeing the future of built environments as a more confusing array of computers and cables, this paper presents three different types of digital and computing technologies and discusses their applications in defining new place designs where the digital and computing technologies become design elements suggesting exciting new resources and languages for exploring built environment designs. For design education, the further understanding and application of these new technologies in design will provide opportunities as well as challenges for future teaching curriculum. The integration of teaching these technologies as new subject areas will prepare the future generations of designers to develop the understanding and skills of designing with and for the new technologies.

Keywords: Built environment design; digital media; cyberspace; responsive environments.

1 Introduction

In the 21st century, our living is inseparable from digital and computing technologies. In design, researchers and practitioners have shown an increasing interest in predicting and examining the effect of these technologies in transforming our everyday life and surroundings, notably in William J. Mitchell's epic trilogy: *City of Bits* (1995), *e-topia* (1999) and *Me++* (2003). Built environments as an essential part of our holistic living environment has played an important role in this revolutionary process. While many have laid out the vision, we are now looking for the integration and extension of this vision with respect to our traditional notions of place. Rather than seeing the future of built environments as a more confusing array of computers and cables, this paper presents three different types of digital and computing technologies and discusses their applications in defining new place designs where the digital and computing technologies become design elements suggesting exciting new resources and languages for exploring built environment designs. We perceive built environments as a new kind of (1) media place; (2) augmented reality place; and (3) curious responsive place.

For design education, as the digital and computing technologies are gradually redefining and reshaping the environments we inhabit, the further understanding and application of these new technologies in design will provide opportunities as well as challenges for future teaching curriculum. The integration of these technologies as new subject areas will prepare the future generations of designers to develop the understanding and skills of designing with and for the new technologies.

2 Built Environments as a New Kind of Media Place

Media, and now digital media are traditionally understood as information about some aspect of the world or about the procedures involved within a specific organization. The key concept of this traditional understanding is that media is about something else and separate from the thing it describes. Digital media being "digital" is often understood as being opposed to something that is "physical". We challenge this idea with a concept of place in which the "digital" is merged with the "physical": digital media play a role in defining the space in which we inhabit by integrating physical objects and place making elements such as walls and doors with digital information visualization and sonification.

2.1 "Stepping out" of Computer Workstations

Imagine the built environments become the interface to communicating remotely with friends, accessing information, executing computer programs, and collaborating on projects, without long hours of sitting and staring in front of computer screens. With the advancement of mobile, ubiquitous and tangible computing, digital information is able to "step out" of the traditional workstations and even to be scattered around us.

New information visualization techniques have enabled time-varying commercial datasets to be visualized and analyzed as spatial elements rather than conventional bars and charts. A person can become fully immersed in the dataset by wearing a head-mounted display device and, as such, the process of data analysis becomes the experience of space exploration. Such a visualization system has been applied to stock market quote price datasets (Vande Moere, 2004) and specific knowledge management datasets within a global engineering consultancy firm (Vande Moere et al, 2004).

Smart objects like Ambient Orb[1] and Nabaztag Smart Rabbit[2] can bring so-called "ambient information" into built environments. The Ambient Orb, for example, glows in different colors to notify you about the health of your stock portfolio, the changes of weather or the presence of your online contacts. Nabaztag Smart Rabbits will not only glow with different color patterns, but "talk", "sing" and even "wiggle ears" to keep you apprised about different information.

To take this smart object idea further, researchers at the MIT Media Lab developed a device that can turn a physical object into an interface to digital information (Carvey et al, 2006). The traditional portals to digital information have been fixed on computer workstations. As a result, our interactions with digital information have been reduced down to certain direct operations on these workstations regardless the meaning and context of the information. The key idea of this research is to break free the limitations imposed by the workstation concept and to propose new ways of interacting with digital information. For example, as demonstrated in this project, any object in a physical environment can become the interface to open a specific computer file, to modify a digital document, to send an email, or to execute a computer application. This flexible association of digital information and everyday physical objects further blurs the boundary between the physical world and the digital world.

As contemporary living demands increasing levels of computer skills from people, there are general concerns regarding the effort and sometimes even stress on the general public in order to cope with the rapid development of digital and computing technologies. To address these concerns, researchers are developing multi-modal interfaces aiming to provide computing technologies that are more intuitive and user-friendly. These interfaces allow people to interact with digital information through means that we have well mastered, for example, gestures, speech, and the manipulation of tangible objects in place of the current interactions through mouse and keyboard. Developing tangible user interfaces - physically touching, grasping, pointing and dragging physical objects on a digital workbench - is one possible way forward. Figure 1 shows a digital workbench integrated with table-size touch screen and augmented reality technologies, for design and collaboration with digital models (Dong et al, 2006; Maher and Kim, 2006).

Figure 1**: A digital workbench for design and collaboration**

2.2 Digital Media as New Design Elements for Built Environments

With digital media being able to “step out” of computer workstations, the traditional separation of the objects that display digital information and the elements that make up the design of built environments will be eliminated. In the future, these two will be seamlessly merged.

One of the early attempts to bind digital media with design elements was media façade; a technique that has been widely embraced by contemporary architects and artists. Media façades used in architecture and art installations can be seen in the Kunsthaus Graz[3], the Blinkenlights project for Haus des Lehrers office building at Berlin Alexanderplatz[4], and Monuments of Switzerland art installation on giant cooling towers.

Similar concepts have been developed for interior design elements. Activity Wallpaper[5], for example, provides an ambient display, which can visualize and respond to indoor activities such as the changes of crowds and noise levels. Not So White Walls[6] can display a person’s email, SMS and webcam images. In Weather Patterns[7] (Figure 8), a permanent installation at the York Art Gallery, UK, the windows become the devices for visualizing the changing weather patterns.

Technologies enabling these new design elements to be interactive have further enhanced the experiences from media place. For example, the SmartSlab[8] and Lightspace[9] technologies provide interactive display technology within a vertical or horizontal solid structure that can be used as walls or floors that respond to the presence and movement of the inhabitants. Different design elements of built environments now can also have Radio Frequency Identification (RFID) tags for automatic location and cataloguing of information about the place. The Media House Project (Guallart, 2004) pushes the media place concept to the extreme by literally constructing a “computer” using building elements. The project implemented a prototype of a media place filled with digital information where “house is the computer and its structure”.

3 Built Environment as a New Kind of Augmented Reality Place

Cyberspace, as first introduced in the science fiction novel *Neuromancer* (Gibson, 1984), has become accessible in the past two decades through the world wide web. It has gradually become an important part of the holistic living environments we inhabit supporting everyday economic, cultural, educational and other human activities. Cyberspace distinguishes itself from other networked technologies by having place characteristics. It is not just another communication tool but the “ultimate destination” where we shop, are entertained and get educated (Kalay and Marx, 2001).

3.1 Cyberspace

The development of built environments used to mean its physical expansion - larger space and added extension. With the evolution of cyberspace technologies as well as the booming of online community and activities: e-business, e-learning and e-entertainment, the future will see an increasing use of cyberspace as an important extension of our physical world. We will be spending increasing amount of time in cyberspace. Therefore, designing cyberspace will potentially become an important design topic, which deserves better understanding and in-depth exploration.

Asymptote principle architect Hani Rashid[10] designed the virtual trading floor for the New York Stock Exchange (NYSE). The design incorporates and visualizes the virtual booths as well as interactive graphs within the virtual place, which simulates but, more importantly, extends, the physical trading floor.

One important characteristic of the contemporary world is the ability to be distributed. Societies, corporations and individuals are remotely linked together with the support of telecommunications. While the use of teleconferencing and videoconferencing facilities allow you to reach for collaborators in different geographical locations, Cyberspace extends our built environments into the virtual realm with augmented place and augmented presence.

In a series of joint studies, researchers at the University of Sydney and architects at Woods Bagot, have looked at the prospects of using cyberspace to augment architectural design offices for remote team collaboration (Rosenman et al, 2005). Figure 2 shows architects working together in a range of remote collaborative situations in a 3D virtual world.

Figure 2**: Remote team collaboration using cyberspace**

3.2 3D Electronic Institutions

After the fear engendered by the September 11 attacks and the questions surrounding the value of centralized business districts (such as downtown Manhattan[11]), experts from the domains of sociology, business and design have been seeking alternatives to such central business districts and considering the question: Will virtual organizations be "the next big thing"?

The places in cyberspace may be virtual, but the community and the economy in cyberspace are real and are growing rapidly. For example, virtual worlds like Second Life[12] (Figures 3) have attracted millions of members. The virtual organizations range from property investment, travel agencies, entertainment industries to academic and research institutes. Communities in Second Life even use their own currency, which is exchangeable with US dollars, and maintains their own stock market.

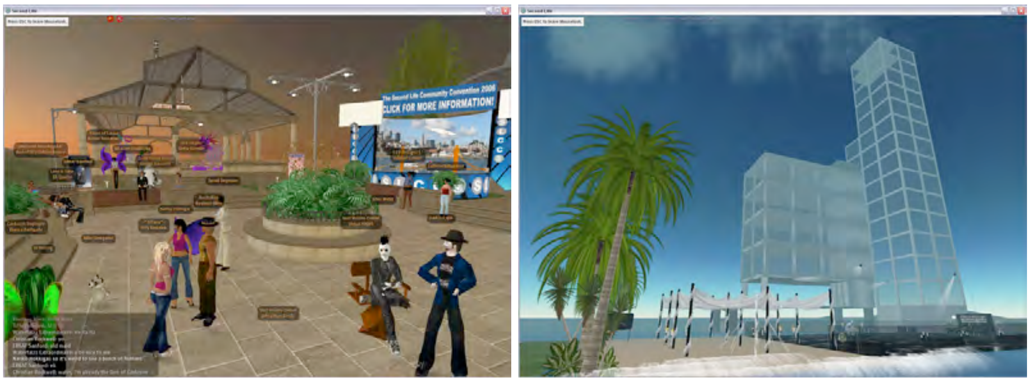

Figure 3**: Community members gather for a Second Life convention (L), A newly built virtual office building for rent (R)**[13]

To better support virtual organizations in cyberspace and, working together with computer scientists from the University of Technology, Sydney (UTS), we have developed the concept of 3D electronic institutions (Bogdanovych et al, 2007). The key advantage of 3D electronic institutions is the existence of a 3D virtual world with an underlying computer agent framework that ensures secure online activities and reinforces organizational structures. The 3D virtual world is automatically designed and redesigned, as needed, using a design grammar (Gu and Maher, 2005), providing an adaptable virtual world for the electronic institutions.

4 Built Environments as a New Kind of Curious Responsive Place

Built environments are traditionally perceived as a passive environment that requires direct modification in order to respond to changes or user needs. However, with sensor and effector technologies, and the development in artificial intelligence, it is possible to create environments that can respond to changes and user needs without direct modification. This section presents these ideas in two phases: “responsive environments” that have a fixed response to their inhabitants, and “curious places” that are interested in reasoning about changes in the use of the places.

4.1 Responsive Environments

Imagine that the lighting, temperature and the layout of the environments you inhabit automatically adjust according to your presence; the relevant resources and applications selectively cluster and present themselves according to your living/working mode; your personal environment emits ambient information for your interest. Phenomena like these will significantly affect the way we perceive, design and inhabit built environments.

Built environments are generally passive. But, when integrated with new technologies like (1) sensory devices that can be spatially and socially triggered; (2) video tracking and data capture devices; (3) pervasive mobile computing devices; as well as (4) ambient visual and auditory displays, built environments will be able to actively interact with their inhabitants. Those new objects and design elements introduced in section 2 are in fact example applications of such technologies, and will contribute to the making of responsive environments. With the further development of responsive place making, it is possible to upgrade buildings like Jean Nouvel’s[14] L'Institut du Monde Arabe to enable auto-adjustments of the diaphragms on its façade to allow dynamic control of the sunlight penetration into the interior, without specific manual operations.

4.2 Curious Places

Responsive environments are indeed intelligent environments. However, some researchers are interested in pushing the level of intelligence further. With the integration of intelligent agent technologies and learning algorithms, built environments can become curious by taking an interest in the inhabitants, learning about their behavioural patterns and trying to provide better services.

In the context of computing, agents are intentional systems that operate independently and rationally, seeking to achieve goals by interacting with their environments (Wooldridge and Jennings, 1995). While agent-based computing started in the 1970s, recently the concept of agents has become important for computing applications, drawing on ideas from artificial intelligence and artificial life.

A possible application of curious places is the development of built environments as intelligent assistants. For example, in an office environment, the environment is able to learn about the behavioural patterns of employees and their project work flows; then (on a grander scale) dynamically coordinate public and shared spaces for communal uses; or (on a more intimate scale) personalize individual work environments, customise working platforms and datasets, or even simulate and automate selected work tasks.

In the Key Centre of Design Computing and Cognition, a long-term research project titled “Curious Room” develops a motivated learning agent, which learns actively from its environments through intrinsic rewards (Saunders et al, 2007). The agent is capable of operating in “the Sentient”, a sensate room incorporated with pressure-sensitive pads for tracking the presence and locations of people in the room (Figure 4). Our current case study shows that the agent is able to learn about the moving patterns of people in the room and actively composes and shows visual displays according to its learning outcomes.

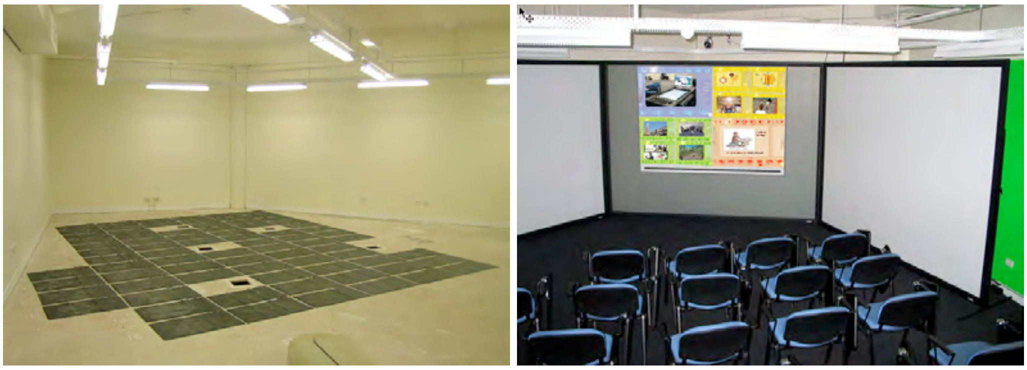

Figure 4**: The pressure sensitive pads placed underneath the carpet (L), “The Sentient” with completed flooring (R)**

The further development of this research will see the motivated learning agent taking more proactive actions in adjusting the environmental conditions of the room and assisting meeting/seminar setups and configurations.

5 Conclusion

As presented in this paper, the emerging digital and computing technologies as new design elements for making media places, augmented reality places and curious responsive places have illuminated interesting ideas and potentials for built environment designs. They suggest exciting new design resources and languages for exploring future alternatives. These three kinds of new places and the emerging technologies applied for designing them can serve as a starting point for further research, practice and validation of using digital and computing technologies in built environment designs.

For design education, as new digital and computing technologies emerge, the further understanding and application of these technologies in built environment designs will enrich and innovate the current teaching curriculum. One important step to such pedagogical innovation is to develop the conceptual shift regarding the roles of digital and computing technologies in design. Within many architecture and design schools, digital and computing technologies are traditionally perceived and mainly used as CAD tools for design presentations and documentations. The teaching of these technologies often separates from the teaching of design. It is important to recognise and understand the roles of digital and computing technologies in design as well as to foresee their full potentials beyond design presentations and documentations. As shown in this paper, the contemporary and future built environment designs are closely connected with and may even be driven by these new technologies. They can have significant impacts redefining and reshaping built environment designs. We are currently experimenting on the teaching of these new technologies as design subjects and planing on their integrations into the current architecture and design teaching curriculum. For example, unlike many other architecture and design schools where cyberspace technologies such as 3D virtual worlds are perceived and taught as a CAD tool for modelling and collaboration, we build on the understanding of 3D virtual worlds as the extension of our physical environments where people can inhabit and participate in a wide variety of activities, and teach designing 3D virtual worlds as a design subject that considers 3D virtual worlds as a different kind of environment design other than a technical tool for supporting design simulation and collaboration (Gu et al, 2007). Our approach that regards 3D virtual worlds as a design discipline adds new dimensions to the development of cyberspace for built environment designs. The teaching of digital and computing technologies as design subjects will prepare future generations of designers to develop the understanding and skills of designing with and for the new technologies. The emergence and further integration of these subjects with the current teaching curriculum will suggest new opportunities and challenges for architecture and design education.

6 Acknowledgements

The authors would like to thank Dr. Andrew Vande Moere for his lectures on information visualization research and technologies and specifically his introduction to the following information visualization projects: Monuments of Switzerland; Activity Wallpaper; Not So White Walls; and Weather Patterns.

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7 Notes

[1] http://www.ambientdevices.com

[2] http://www.nabaztag.com

[3] http://www.bix.at

[4] http://www.blinkenlights.de

[5] http://www.viktoria.se/fal/projects/infoart

[6] http://people.interaction-ivrea.it/d.buzzini

[7] http://loop.ph/twiki/bin/view/Loop/WeatherPatterns

[8] http://www.smartslab.co.uk

[9] http://www.lightspacecorp.com

[10] http://www.asymptote.net

[11] http://www.evolvenewyork.org

[12] http://www.secondlife.com

[13] Places in Second Life by its virtual community designers, powered by Linden Research, Inc.

[14] http://www.jeannouvel.com

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‘REPORTS GIVEN BY IMAGES’ – FILM AS A CRITICAL MEDIUM FOR ARCHITECTURAL INTERIORITY

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Abstract

"Reality has always been interpreted through the reports given by images" (Sontag 153).

The computer has fast eclipsed manual drawing as the prime source of architectural representation in architectural schools. Studios are relinquishing drawing boards, and students spend long hours in dark computer laboratories, alienated from light and the awareness of passing time. While digital media have opened up new possibilities of experiential, real-time and interactive forms, its new animated form is distinct from the tradition of established moving image narratives, such as film.

The narrative traditions, privileged in conventional computer architecture, frequently render the interior lifeless, objective and emotionally distant. They deny the point of occupation where architectural "circulation" becomes interior design's "lifestyle," and where architectural "durability" is challenged by the surface alterations and changes inflicted by habitation. This is also the point where the volatility of time (as fashion, and the consequences of moving through and living in space) impacts. Time and change are concerns for fashion-conscious interiors rather than for the timelessness stereotypically associated with architecture. It is this particular affinity with time (deformation, wear, fashion) which suggests a critical need for representations of the interior of architecture to assertively engage with time-based and strategically subjective representational media. The paper hence argues a need to assertively deploy film as a representational strategy which actively engages the less measurable aspects of habitation.

1 Introduction

Giuliana Bruno proposes film as having a "mental itinerary that, finally, makes film the art that is closest to architecture" (24). She argues that "[t]o join the paths of research on architecture and cinema, not optically but haptically, is to corrode oppositions such as immobility-mobility, inside-outside, private-public, dwelling-travel" (24). She sees this space of imagination as an inner landscape, "a trace of inner differences as well as cross-cultural travel" (24).

Bruno's discussion of architecture and film emphasises an interior mental quality. This paper argues that interior architecture, that which engages the inside of buildings as site of habitation, privacy, controlled shelter, vulnerable materiality, and pleasure in the short spans of time (fashion, habitation, movement through space, the fading caused by exterior sunlight), is a built environment which has a "natural" affinity to film. It locates the idea of the interior as one of submergence and engagement, as distinct from the exterior as built object, and argues these different conditions thrive more readily on different representational forms. It argues that a representational form which actively engages with the subjective, less measureable aspects of habitation, is a current lack in our representational repertoire, and that such a representational form is critical for the interior of architecture.

2 Interior Architecture: Interior Design

Braham, and numerous others, have noted "the strong separation between architecture and interior design" (5). Historically, interior design has been associated with the frivolous, the feminine, the fashionable, the insubstantial and the popular. As Braham states: "those elements that are strong and long-lasting ... are considered masculine and architectural, while those that are short-lived due to wear or fashion ... are assigned to the feminine discipline of interior design" (10). In Bouman's words: "the static nature of architecture, [is] bound up ... with concepts like foundations, durability, inertia and tradition" (64). Issues of interior detail, texture, surface and materiality more constantly occur at a finer scale for interior design than architecture, particularly in student work. The interior as an inside space is subject to mechanisms of control, enabling the ability to transform the exterior environment into an inside able to be manipulated through windows, airconditioning, lighting, and locks on doors, determining its warmth, dryness, appeal for occupation and social climate.

As a discipline, interior design is historically associated with the unregulated amateur or dilettante; the interior designer, or the decorating, or D.I.Y.-ing, inhabitant. It is hence more aligned to the idea of the interior as an explicitly lived and changing space. Interior design's "amateurism" is a trait of its accessibility – "any one" can engage in it. Architecture's knowledge is conventionally considered to be more sacrosanct, and is attained via systems of apprenticeship and university qualification, is often legally regulated and defined. This is conventionally seen to be at odds with informal and unqualified design engagements, stereotyped in the reputed difficulties architects have "When clients move in, inhabit the interior, and start to furnish the house" (Treadwell 286). These "difficulties" are largely within the realm of the interior, as the architectural exterior is much more resistant to change, physically, financially and legally.

It is at the point of occupation that architectural "circulation" becomes interior design's "lifestyle" represented by the surface alterations and changes due to habitation. This is the point where the vulnerability of interior fabrics to the effects of time (as life, fashion, and the wearing consequences of moving through and living in space) occurs. This particular affinity with or engagement with a smaller scale of change and of time suggests a critical need for interior architecture to assertively engage with time-based representational media. The computer and film most immediately propose themselves.

3 Computer Animation

Film and computer animation are the most well-known and accessible time-based representational media. Computer animation of architecture has been typified by penz as the "fly-through" (or "fly-by"), and the "walk-through." The "fly-by" is stereotyped as an architectural "boy's toy" where "[m]any animations resort to the techniques of the fly-through in long continuous takes, often plunging at great speed from blue skies to empty streets and to finally penetrate buildings (still at great speed) at the nth floor level" (Penz 106). These seems alien in their distancing strategies of speed and the objectification of building. They often appeal to the exterior, rather than interior representations of architecture, flying around the building to the heavy and unrelenting beat of dance music. Such representations are about speed, objectification and a fleeting, adrenalin-charged architectural engagement. They are a denial of lingering, dwelling or living. This is tourism on a tight schedule, from a speeding airforce jet, and for, it seems, a very specific age and gendered group. This is architecture as industrial design object.

The other extreme in computer animation is the leisurely-paced "walk-through" is more conventionally interested in the interior than the "fly-through." The lineage of the "walk-through" is, at least in part, derived from desire for a virtual guarantee of post-construction architecture, pre-construction. The walk-through is both a substitute "open home," and a device to rearrange the timeline of construction, selling and buying. It is driven by a developer's desire to accelerate, and hence reorder and abbreviate, time, *and* a formulation of developer priorities in architectural relations, devoid of an immediate identification with living and habitation. This lineage enforces the walk-through's rigid narrative of inspection and description which employs a tightly followed, plan-driven circulation of the interior, aiming to provide a sense of even completeness and coherency where everything is seen, giving the viewer a laborious sense of "how spaces relate to one another" (Shaw). This clinging to the logic of the plan also prevents strangers (a visitor, a foreigner, a tourist) becoming lost or disorientated in this usually sterile (often domestic) virtual space. The "walk-through" is a pre-occupation of the uninhabited interior (McCarthy 91-93). It is a sterile display of architecture, typically accompanied by synthetic, elevator music. It turns architecture into a formal, processional experience, a "lifeless computer animation" (Penz 110). This pre-occupation is not a sentimental expectation of habitation as a familiar or an intimate condition. Instead, the experience of the walk-through progresses with the emotional detachments of the property developer's eye which is interested in market value, financial returns and in maximum rentable floor area. These narrative strategies are hence about describing the physical and material manifestation of the interior, and about interiors as vacant and available for occupation. They echo the landscape painting technologies of the nineteenth-century when strategic deployment of pictorial genré, such as the Sublime, conveyed the vacancy (and availability) of land in support of the processes of colonialisation (Ryan 115-117; Pound 19-21).

Unlike computer games, music videos, advertisements, and film, the walk-through is seemingly devoid of emotional investment. The two extremes - of the fly-by and the walk through - are representational forms which privilege architecture as object or as measureable and quantifiable space container. They are without the narrative strategies used in gaming, music videos, advertising and films which make the viewer partial to the habitation of these virtual spaces (through, for example, identification with protagonists, or through aesthetic pleasure). Their apparent objectivity denies a habitation which is about social living, favouring an isolated and mechanised occupation of space. This is a rendering of the interior which is not typically amenable to being a space able to be identified with one's future habitation as a lived phenomenon. As Penz notes: "CAD animations need to be narrated, populated and emotionally expressive" (Penz 111). Representational forms more explicitly imbued with narrative strategies would enable more complex explorations of subjective habitation and temporal change in architecture.

4 Film

Film locates the viewer with an invested and manipulated interest. Its representation of interior spaces is partial, fragmented and shaped by the agenda, plot, and spatial narratives of film, rather than the administrative building plan. While some genre make more obvious connections to such statements, many films testing conventional narrative structures construct potent spatial narratives which productively explore interior architecture (e.g. films directed by David Lynch, Matthew Barney). Narrative films most obviously present exchanges between character and setting. The camera is selective and constructs the biased habitat of, for example, the homeowner, the family, the lover, the murderer, the tenant, the thief and the child. The agency and deliberate design of filmic architectural interiors are sutured to the personal agenda of characters with whom the cinema audience identifies, enabling the spaces occupied by these characters to be conceived as conceptually habitable. As Schaal notes: "Film architecture is an architecture of meaning. There is nothing in the frame that is not important and does not have something to say" (16). This construction of space is driven by narrative, plot, and character; filmic perversions of attributes of living and habitation, aspects which are stressed in the production of interior architecture, which have spawned the idea that the interior reflects the character of its occupant, a notion also exploited by film.

The idea of the interior mirroring the occupant has been present in various forms in relation to the architectural interior. Examples include the trend of women of the Aesthetic Movement and the pre-Raphaelites to wear "loose, draping gowns, equating personal adornment with the simpler forms of their new residential interiors" allowed woman's bodies to "fit into their designed surroundings" (McLeod 51, 55). This was not simply a subserviance of the female body to the schema of interior décor, but a more complex oscillating of foreground and background in the casting the female inhabitant and the surfaces of her domestic interior as mutually dependent for significance (McLeod 54-55, 57; Wigley 68, 74, 76). As Ionides notes: "To many women the colour of their rooms is only a background for themselves, and since complexion, dress, etc., are considered first with them, the rooms must suit." (73). The matching of clothing to interior surfaces not only matched the female body to décor, but also located the interior surface as susceptible to change. Rosa notes a similar alignment in recent

Hollywood films where modern domestic architecture "has become identified almost exclusively with characters who are evil, unstable, obsessive and driven by pleasures of the flesh" (159). He initially traces a tendency in the past practice in film architecture of distinguishing the apartment (young, naive) and the penthouse (wealthy, older, unsentimental, almost never married eccentrics). Modernist houses as "highly seductive sites of crime and deception" are contrasted with conservative/traditional houses and their characters which represent a domestic ideal (Rosa 164).

These injections of "living" narrate occupation into a programme of temporal change, and adaption for architecture, as interior design inflicts narrative through a compulsion of living. As Schwarzer notes of film architecture: "Architecture both contributes to the events taking place among actors and acts independently with other objects in motion and in space. Architecture is protagonist and antagonist, nucleus for the slow collapse of perception into a space between the actors' lines, a visual language with a power all its own." In its disciplinary sense, interior design practice is an activation of interior space as an interactive and narrativised medium. In this sense, film refigures all architecture in terms of conventional interior design concerns. It thus reconstructs and prioritises architecture in terms of time and interacting surface, rather than simply in terms of conventional understandings of space. Architecture in film *is* interior design. As Schaal notes "Film architecture – interiors and exteriors – is always architecture that has been depicted, photographed, turned into an image. It embraces the actors and scenes like an air-space that has become visible, like a built coat, a petrified robe, a stage set. Its presence defines the setting, the social position of the characters and their inner mood" (16).

Filmic representations of architecture thus produce a time-dependent narrative rather than geospatial contiguity and progression, and in doing so film "documents" the fictive architecture of the interior architectural narrative and separates and distils the geometric logic of plan and architectural form from experiential and ephemeral manifestations. This reconstruction of spatial architecture as temporal, highlights that the significance of discrete and specific architectural spaces is not simply able to be revisited as if they are the same narrative space. Temporal agenda in film redecorate the significance of space in terms of filmic priorities (plot, character, theme). Repetition of filmic space in time, or the temporal adjacency of physically distant spaces (in the film, or as physically built), refigure, manipulate and re-present physical and conventional understandings of architecture. Characterisation, through subjective point of view, also damages assumptions of architecture as consistent, reliable and stable. A child's filmic point of view reveals the volatility perception gives to architecture when contrasted with that of a filmic adult. Architecture becomes interiorised as transient and ephemeral through the disparities of the different points of view of the perceived architectures of floors, walls and ceilings, and demonstrates the different relations and interactions different occupants' experience in the same interior space.

In addition, film, as a representational form, leans towards representing theoretical notions tied to interiority. Critical issues for interior design (such as: habitation, movement, surface, temporality and its disjunction), are wedded to this media which insists on a partiality of representation mimicking the physical constraints of viewing within an enclosed space. Unlike architectural drawings, which often aim to construct an omnipresent eye, film traditionally approximates the subjective and volatile view of the inhabitant. Film also insists on the conversion of the third dimension into time. Space is the third dimension which the film screen flatly refuses, supplying only a serialising two dimensionality as an illusion of three dimensionality, substituting space with time; a four dimensional experience which skips the third dimension. The exchange of time for space shifts the spatial understanding of the interior to having a temporal obligation, a phenomenon which means the camera produces its specific occupation of space through a temporal stitching of two dimensional images: "Space then becomes the animation of these places through the motion of the moving body" (Powell 208). Interior spaces become woven as a fabric of storytelling, and are dependent on the assumption that occupants of plots are also occupants of interior architecture. The film must hence engage with issues of its own media's conventions of representation to unsettle, or disturb these sets of associations with domestic interiority.

Film is a medium which hence understands space as primarily to be an engagement with habitation, while privileging surface and time. As Bruno notes: "She who wanders through a building or a site acts precisely like a film spectator absorbing and connecting visual spaces. The changing position of a body in space creates both architectural and cinematic grounds" (23). This is a complex model of occupation, one both inclusive of, and additional to, pragmatic function. It highlights the possibility of humanity as critical to spatial construction and makes explicit the partial understanding of designed space - the lack of control over the interior, for example, after design and construction. It posits interior design as having an investment in the production of unpredictable narrative, not simply to generate space so much as to test the interior which needs negotiate and be altered by it. Film is a medium with a representational tradition which is driven by and assumes change and alteration.

Such a strategy might not be limited to film, but film is a medium which, while it has engaged many architects, is yet to be deployed fully as an important representational force within the architectural education, in particular in reconsidering the potential of the field of interior architecture. Even the most conventional Hollywood films present a radicalisation and theoretical representation of interior architecture as partial, multi-scaled and associated with habitation, and human identity. These are aspects which are not often made explicit in conventional or professional architectural representational forms.

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THE EXPRESSIVE CAPACITY OF THE TIMBER FRAME

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Abstract

Assembling for the first time a braced, timber frame as a freestanding structure, where no piece could be taken away without collapsing it, was surely a 'eureka' moment in architecture. The expressive potential of the timber frame can be argued to have led both to its development as well as to its later transfer and transformation.

It is the intention of this paper to present the braced frame of the medieval stave-church as the opportunity for expressing Christian 'church-like' qualities in pagan Norway – a part transformation in timber-rich Norway from the established practise of constructing stone churches in the south.

Six centuries later ecclesiologists sought medieval examples for the construction of wooden churches in colonial diocese - such as those in Canada and New Zealand where timber was plentiful. Several mid-C19th publications, such as The Reverend William Scott's paper "On Wooden Churches", raised awareness among ecclesiologists of the potential of medieval Scandinavian examples to contribute to the transformation of the wooden church in the colonies by transferring 'church-like' qualities to the utilitarian 'god box'.

The C19th wooden churches by R.G. Suter in Queensland are innovative examples of an ecclesiastical architecture in timber that takes advantage of the expressive potential of exposing the frame and the use of 'outside studding'.

There are direct transfers of these earlier techniques and technologies through the use of 'outside studding' and the exposed timber frame in the work of Andresen O'Gorman Architects. In this contemporary architectural practice techniques and technologies are transferred as much for the frame's expressive potential as for the pragmatic use of a renewable resource. Mooloomba House will be used as an example to identify conceptual ideas expressed through the timber frame rather than an explanation of the architectural project as a whole.

1 Introduction

It is the intention of this paper to show that a construction technique which permits the structure of a braced, timber frame to be made visible - revealing its parts as contributing to the whole - yields expressive potential and opportunities for transfer and transformation of intentions in architecture. Visibility of the timber frame reveals for example the verticality of uprights (contributing direction, proportion, rhythm etc) and network of lineal timber members for example in a wall plane or as a spatial matrix (contributing degrees of enclosure, hierarchy, proportion etc). These properties also reveal a capacity for expressing formal and spatial character. And, whilst present in frame structures of other materials, properties of the timber frame offer great dimensional range (matchstick to log) and discernable material composition (fibres, knots) that further increase its expressive capacity.

Visibility of the timber frame is significant whether exposed on the interior, exterior or simultaneously on both sides of a structure. In the case of the medieval Norwegian basilica stave-church at Heddal the braced, timber frame is visible on the interior (floor, walls and openwork roof) with primary framing components also visible on the exterior walls. In the 19th-century church at Lutwyche by R.G. Suter the timber frame is exposed on the exterior (walls) and interior (openwork roof). In the contemporary Mooloomba House the timber frame is made visible on the interior and exterior (walls and roof).

In these three examples the conventional timber construction was transformed – initially by freeing the timber from the ground for the advantages of the 'above-ground', three dimensional, braced frame and then by exposing the timber frame with its matrix of members for the advantage of its expressive capacity.

2 Timber frames in the Norwegian stave-church

Development of the braced, timber frame of the medieval, Norwegian stave-church was stimulated by the desire to express Gothic ideals through interior and exterior verticality and allusion to 'heavenly mansions' in clustered gables on the exterior. Its fullest expression can be found in the basilica stave-church built during the 12th and 13th-centuries (Gjone D5).

Of the estimated 750 stave-churches built in Norway over a five hundred year period from the late 10th to the early 16th-centuries (Gjone D2) only twenty-seven have survived (Bugge and Norberg-Schulz 23) - their destruction largely brought about by social upheaval and neglect stave-churches ceased to be constructed in Norway after the Reformation when churches builders turned to horizontal log construction (Gjone D12).

North of the Alps, timber churches were once widely spread across Europe from the earliest times. In general terms, two principal timber construction techniques were geographically distributed; with horizontally laid log construction in eastern Europe and vertical stave construction in western and northern Europe (Gjone D1).

Only remnants of stave-churches built prior to mid-11th-century have been found; namely at the church at Greenstead, Essex, England and the church of St Maria Minor in Lund, Sweden both built around the year 1000 and at Hemse Church in Gotland built during the first half of the 11th-century Gjone D2). The earliest church remnants reveal a timber construction of palisade walls, vulnerable to decay, made of oak timbers raised vertically, each connected by a loose filet and with posts set directly into the earth (Gjone D2).

Central to the successful construction of the 12th and early 13th-century Norwegian basilica-type stave-church was the innovative, braced, timber frame supported above ground on four stone foundations. Structurally this was a radical transformation of the earlier construction where the timber posts were set into the ground. Freeing the timber entirely from the earth required the structure to be both conceived of, and built, as an integrated, freestanding, braced frame (Gjone D2).

In the Norwegian stave-church the frame is of fir and is typically exposed both on the outside and inside of the building. Buildings in the main group of stave-churches are characterized by a structural "system of free-standing inner posts, which define a lofty central space. The weight of the building rests on four points only: a rectangular frame under the floor is supported on four large stones placed where the beams cross each other." (Bugge and Norberg-Schulz 23).

The Norwegian basilica stave-church exterior and interior, despite its relatively modest dimensions to our eyes, would have appeared extraordinarily high and mysterious to congregations of the Middle Ages. The unpainted stave-church interior with its tall, dark forest of posts is spot-lit only by small, round openings set high in the upper walls. Its enclosing walls are cast in shadows dissolving the space into darkness intensifying its spatial mystery. The verticality of the interior space is further dramatized by the close presence of the timber masts that fill the interior as if the space itself were carved out of the wood to dissipate mass.

Christian Norberg-Schultz describes how the timber post becomes an extension of the energy of the frame as opposed to the static resistance to the forces of gravity reflected by the stone column (8). The braced timber frame, as opposed to the horizontal log construction, provided Norwegian church builders with a technology that could support the ambition of the age "to dissolve architecture from the substantial to the insubstantial..." (Summerson10).

Exposing the timber frame on the church interior allows each of the timber fir wood members to be recognized both as separate elements and simultaneously as one of a host of integral parts of a structure contributing to the realization of a vision where there is a unity in the overall construction. The exposed frame offers the architecture both a symbol of and the presence of visual harmony.

In southern Europe from about 1225 onward Gothic aedicular architecture was stressed and exaggerated principally by the liberal use of gables (Summerson18). In the fully developed stave church, such as the church at Heddal, the form with its cluster of roofs is further elaborated by the inclusion of additional gables, crosses and dragonheads. At Heddal the composite roof, top-heavy with gables, appears to hover over the ambulatory arcade with the gables appearing from afar as though "suspended from the clouds and have just been drawn into place by flying monsters…" (Summerson 21).

The influence on the Norwegian stave-church of the masonry architecture of southern Europe can also be seen in the transfer and transformation of elements such as the 'dwarf arcade' and the apse. Curved elements were alien to the constructional logic of timber construction and were difficult to transfer to wooden churches. To achieve the curved forms horizontal members for the curved walls of the apse, upper roofs and turret for example required curve-grown timbers to be specially sourced and worked (Gjone D7).

3 Timber frames in the nineteenth century Anglican churches

Six centuries later, exposing the timber frame on the exterior walls of the 19th-century Anglican church was intended to express the church-like qualities of medieval architecture (Scott 19). These qualities were proposed to be transferred from medieval church building and medieval English, half-timbering technology (Scott 23).

Although the preferred material for 19th–century Anglican church walls was stone masonry a lack of funds and speed of settlement, led to the widespread erection of shed-like, wooden churches particularly in colonies where timber was readily available and masonry skills were scarce.

In 1849, the Ecclesiologist published Rev. William Scott's paper, "On Wooden Churches", praising wood as material for church construction and tracing its ancient origins and transformations. Scott argued that the "colonnade and pediment, however gorgeous, is nothing elementarily, as has been often shown, but a row of wooden posts thrust into the earth, with a roof of timber logs triangularly imposed upon them," and, "then in every church, however gorgeous, we may still recognize the original wooden idea, which was the primary one." (15).

Whilst the Ecclesiologists had a clear preference for stone churches that conformed "with what they called the 'middle-pointed' phase of English Gothic" – i.e. about 1320-1350 (Summerson164) the mid-19th- century surge in the number of colonial Anglican diocese and parish churches throughout the world increased the efforts of the Ecclesiologists to find designs that could address the problems of church design for non-English conditions such as a tropical or freezing climates, where there was readily-available timber (Scott 23).

With the urgency to house expanding congregations colonial parish churches were speedily erected in timber. These were often built as a cheap and temporary 'god box' – an unornamented, stud-framed shed with a single, gabled roof - far from one of the "graceful, reserved essays on the approved 14th- century theme" (Summerson164).

The desire by the Ecclesiologists to find suitable models for timber churches included a search for medieval precedents. Scott's paper lists the features of the Middle Pointed Gothic church and proposes that: "For all the essential parts of a church we have actual examples in wood." (19). The medieval precedents Scott identifies for timber walls are "the two churches of Greenstead and Nether Peover together with the strange Norwegian fabric" (19). The technique for constructing the half-timbered wall, such as at Nether Peover, was to erect the timber framework with posts, beams and diagonal bracing and to fill spaces in between with plaster. Because half-timbered walls constructed in frost prone areas of North America tended to deteriorate as the plaster cracked Scott proposed church walls be built entirely of wood like the proto-stave-church at Greenstead (Scott 23).

Scott's descriptions of the medieval Norwegian stave-church closely follow those of the paper titled "Primitive Churches of Norway" printed a few years earlier in Weale's Quarterly Papers (which also printed a review including stave-churches in 1844). Having described the Norwegian stave-church Scott proceeds to recommend features of the stave-church for the design of the late 19th-century wooden church with the following reservation about the stave-church clerestories: "They interfere, I think, with that subdued humility, that retiring and unpretending dignity which ought to characterize a wooden church."(25).

Scott describes the contemporary wooden churches in the "North American provinces" as exemplifying "almost every error which is possible to make in such a building." (20) and divides the churches into two construction types; the frame church and the log church (20). "It is obvious" he writes, "that the prevalence of flat horizontal lines in both the frame church and the log church is fatal to the great principle of Christian architecture, its verticality." (23).

Around the same time as these discussions about medieval precedents for colonial timber churches were being printed in England, Bishop Selwyn in New Zealand was building the chapel at St John's College, Tamaki, consecrated 1847 and attributed to architect, Frederick Thatcher. The chapel, with its hipped and gabled roofs, has walls with an exposed structural frame patterned by horizontal and vertical members with curved timber braces and the vertical planks fixed to the inner face of the frame. To accentuate the expression of the structure as a skeletal frame the vertical timber boards were originally treated only with a clear linseed oil in contrast to the frame that was rendered darker by oil tinted with umber (Mane-Wheoki 79.)

Whilst it is possible that the adoption of the exposed frame derives from half-timbered domestic architecture in England or the pattern book of 'picturesque design' *Village Architecture,* as proposed by Mane-Wheoki (78), the impetus is fundamentally a desire to exploit the expressive capacity of the construction for its architectural potential to revive medieval precedent.

One of the more architecturally expressive re-interpretations of the stud wall as "outside studding" was adopted in 1865 by the architect, Richard George Suter soon after his arrival in Queensland where he is credited with being the first to use the technique (Watson 28).

Suter's first church design in Queensland, St Andrew's Church at Lutwyche (dedicated November, 1866), was published in the *Illustrated London News* 4th May 1867. Here the single thickness wall, sanctioned by a relatively mild climate, was constructed of diagonally laid tongue and groove boards in a light coloured finish with dark stained hardwood frame of vertical and horizontal framing members with diagonal bracing.

Suter's use of the exposed frame for expressing Gothic Revival ideals in timber church architecture are highly likely to have been influenced by the Selwyn churches discussed in the ecclesiologist and familiar to his brother A.B. Suter consecrated Bishop of Nelson in August 1866.

4 Timber frames in the architecture of Andresen O'Gorman

Curiously the exposed timber frame has not become widely used for contemporary interpretation, but one that Andresen O'Gorman Architects developed in their architecture. The practice has from time to time been asked if their projects are influenced by traditional Japanese architecture, Norwegian stave-churches or perhaps Suter's Queensland work. Whilst research interests and background clearly play their part the architects propose that a superficial, visual resemblance can be generated by the shared technology of the exposed timber frame.

In the architecture of Andresen O'Gorman the primary frame of many of the buildings is constructed from Australian hardwood, a common, regional building material. Eucalyptus and its material properties have in turn prompted architectural intentions – particularly those ideas that explore the expressive capacity of construction and the potential for interaction with the natural environment.

Malouf describes the timber houses in Brisbane as: "Open wooden affairs, they seem often like elaborated tree-houses, great grown-up cubby-houses hanging precariously above ground" (261). The experiential qualities, the material and the diagram of the simple Queenslander house, with its set of rooms surrounded by a fringe of timber posts forming thresholds to the landscape, offers potential for variety and interpretation and is a recurring reference in the work of Andresen O'Gorman.

Another reference relates to the idea of *'harmonia'* the word for harmony that in Ancient Greek simultaneously means two things: One meaning is what we generally understand harmony to be, an arrangement of related elements such as colours, proportions and sounds that make a pleasing pattern (Fletcher 9). Its other meaning is a three-dimensional frame of timber, in joinery or fine carpentry, like the frame of a table "such that to take one member away would cause the whole to collapse." (Fletcher 9). This meaning predates the former and probably goes back to Neolithic times. It is a beautiful, physical symbol of the later more abstract meaning. No doubt the 'captured' space that offers a place within the frame presents a powerful phenomenon to the human psyche, but it also hints at the reverence in which the ancients held the conceptual solution where the interconnection of parts made a total unit. The later, Homeric, meaning of the word '*harmonia*' is given as; 'that which binds together as a unity' (Guthrie 220). Again, the meaning can be either physical or abstract and demonstrates the significance to the ancients of ideas and concepts which they saw as mutually interpretative to both.

Maria Karvouni accents a similar theme in her essay "*Demas*: The Human Body as a Tectonic Concept". She explains how the Ancient Greek word for buildings, '*demos'*, was the historical derivative of '*demas*' which means; 'the human mind and body as a unity' (111).

In Greek architecture '*harmonia',* the binding together of the whole, was sought simultaneously in the physical jointing of the parts of the building as well as the interlocked proportional systems – the binding lines of geometry (Karvouni 112). Karvouni raises many interesting matters and two of these offer important distinctions. Firstly that it is in the hard material (the stuff of building as opposed to the soft shaping of paint or clay) that '*demas'* was found (Karvouni 106). Secondly, the building, through its tectonic concept, was seen to embody and integrate qualities of life and nature through the relationship between physical commodities (Karvouni 118).

The work of Andresen O'Gorman has been informed by eucalyptus timber and its role in Australian architecture. The Australian timber stud frame is a derivative of the British version developed for use with northern hemisphere, mainly Norwegian, softwoods (Bell 84). Imported into Australia and adapted for use with low-grade hardwoods, this framing technique gained popularity in Queensland after the Second World War particularly for use with plantation softwoods.

The timber stud frame system is based on non-durable timbers being protected inside sheeted walls of durable or finishing sheet materials. The visual expression in a building therefore is of the sheeting and not the tectonic form - such as the frame itself. The continued use of this convention has masked opportunities offered by the more durable, local, eucalyptus timbers. This framing technique also limited the architectural opportunities for developing abstract expression and poetical concerns for 'place'.

The inherent toughness of Australian hardwoods usually requires that they be used while still 'green', at high water content, for easier workability. Cut from logs with a pronounced spiral growth and a high variability of moisture from heartwood to sapwood, the material continues to dry - usually while held in the building. Eucalyptus hardwood remains an active material after the construction has occurred. The timber is subject to inconsistent shrinkage, warping, twisting and cupping across the grain. This has traditionally been the criticism of hardwood for building construction. Because of its material strength eucalyptus timber permits the use of relatively small sections approximating the visual expression of steelwork. Unlike northern hemisphere softwoods with their larger sections Australian hardwoods offer the opportunity of assembling a framework of 'slim-line' timber members.

A tactic Andresen O'Gorman employ is that of simple lamination; forming components out of pairs of members, matched in opposing grain formation and so setting the movement of one component against the other to counteract warping and twisting. This strategy goes back to the house at Redbank Plains (1970) and is used in later work such as the Mooloomba House (1995-00).

Having 'tamed' the material in this way it can be freed from being hidden inside the stud wall. Exposed to take advantage of its durability and strength the hardwood is available to contribute to the expressive form of the building in which it can play such a physical part. With the release of the timber frame from its concealment in the stud wall a number of architectural opportunities become possible such as; to reveal the visual dynamic of the parts related to the whole; to offer visual patterning to the skeletal structure for geometrical order and proportioning; to create continuity and intensify spatial interaction through constructing transparency in relation to landscape, establish formal character and to develop metaphors including 'nests' and 'wooden caves'.

5 Conclusion

In summary, the timber frame is shown to be significant as the medium of transfer of architectural intentions in each of the three examples – in the medieval Norwegian basilica stave-church, in R.G. Suter's nineteenth century Anglican wooden churches and in the contemporary timber buildings of Andresen O'Gorman.

Whilst the church buildings express conventional church-like qualities and the house in part expresses conventional domestic shelter the architectural expressions rely essentially on a basic characteristic of the exposed timber frame - one that allows it to play a leading role in the transfer and transformation of intentions.

Exposing the timber frame on the interior and/or exterior of the structures is seen to release its matrix of timber members and its capacity to contribute architectural expression to buildings. The matrix, forming 'lines' in space, has an expressive potential that includes the capacity to delineate proportion, direct eye-movement, suggest spatial enclosure, create patterning, permit transparency and establish continuity with landscape. These expressive opportunities have been developed, to some extent, in the architecture of all three buildings.

This fundamental understanding led architects to amplify the visibility of the timber frame and particularly to highlight the visual harmony that results when the parts can be seen to contribute to the unity of the whole.

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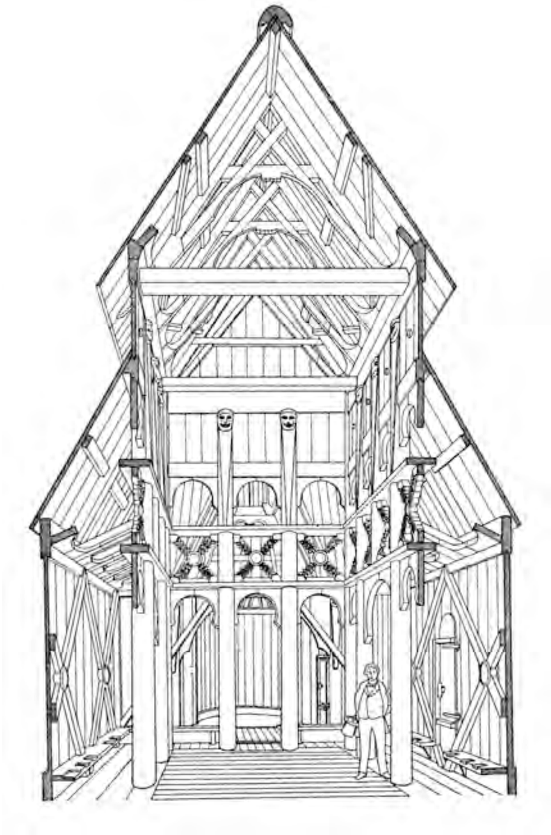

Fig 1

Perspective drawing: Stave-church at Borgund.
Bugge, Gunnar. and Norberg-Schulz, Christian. Stav og Laft I Norge. Oslo: Byggekunst Norske Arkitekters Landsforbund, 1969: 152.

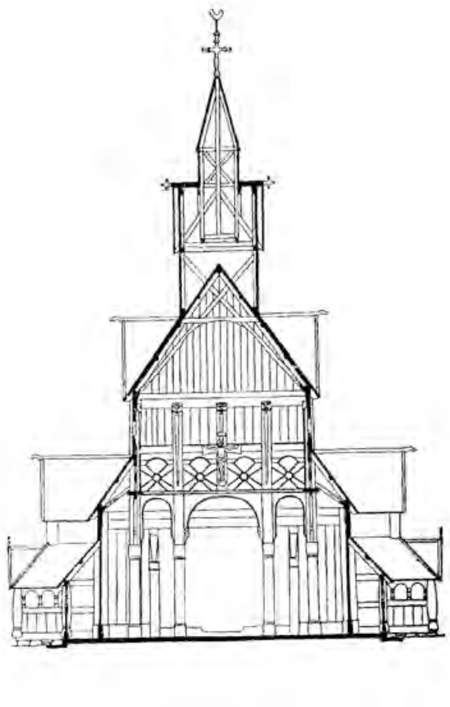

Fig 2

Section: Stave-church at Heddal.
Bugge, Gunnar. and Norberg-Schulz, Christian. Stav og Laft I Norge. Oslo: Byggekunst Norske Arkitekters Landsforbund, 1969: 166.

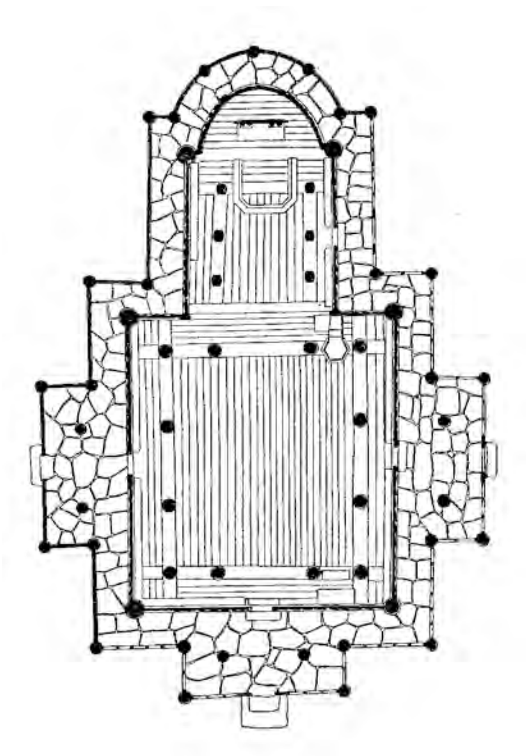

Fig 3

Plan: Stave-church at Heddal.
Bugge, Gunnar. and Norberg-Schulz, Christian. <u>Stav og Laft I Norge</u>. Oslo: Byggekunst Norske Arkitekters Landsforbund, 1969: 166.

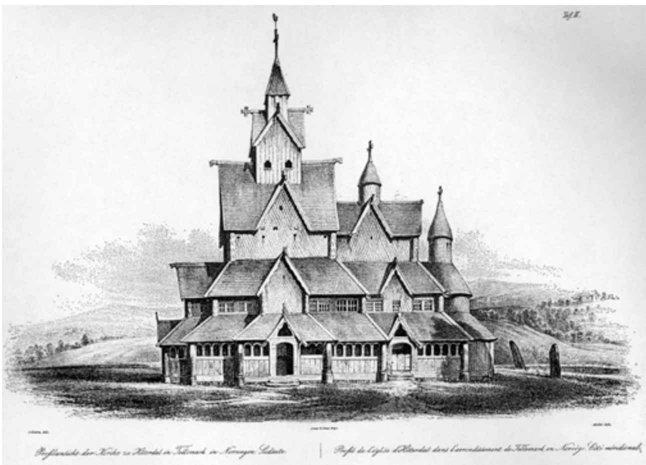

Fig 4

Schiertz (1837), *Profilansicht der Kirche zu Hitterdal in Telemark in Norvegen Sudseite*.
Lithograph after drawings of stave-church at Heddal in Hitterdal.
Bugge, Gunnar. and Norberg-Schulz, Christian. <u>Stav og Laft I Norge</u>. Oslo: Byggekunst Norske Arkitekters Landsforbund, 1969: 168.

Fig 5

John Kinder, *The Chapel, St. John's College near Auckland.* Monochrome wash.
Photograph: Alexander Turnbull Library, Wellington.
Mane-Wheoki, Jonathan. "Selwyn Gothic: The Formative Years". Art New Zealand 54 Autumn (1990): 80.

Fig 6

Richard G. Suter, *St Andrew's Church, Lutwyche.*
Photograph: Lutwyche Parish Archives, Brisbane.

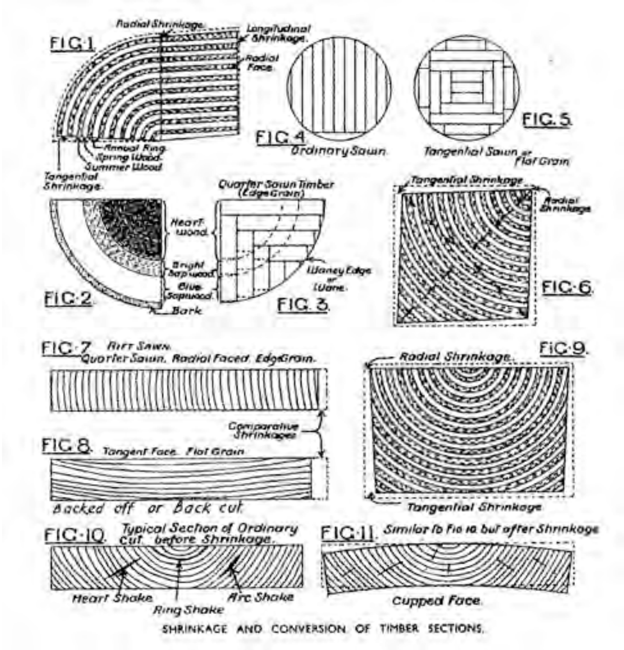

Fig 7

"Shrinkage and Conversion of Timber Sections", Architecture, Jun 1934.
"Rhetoric and Tone" by Naomi Stead and Paul Hogben, <u>Architecture Australia.</u> Vol 93 6 Nov-Dec. 2004: 26.

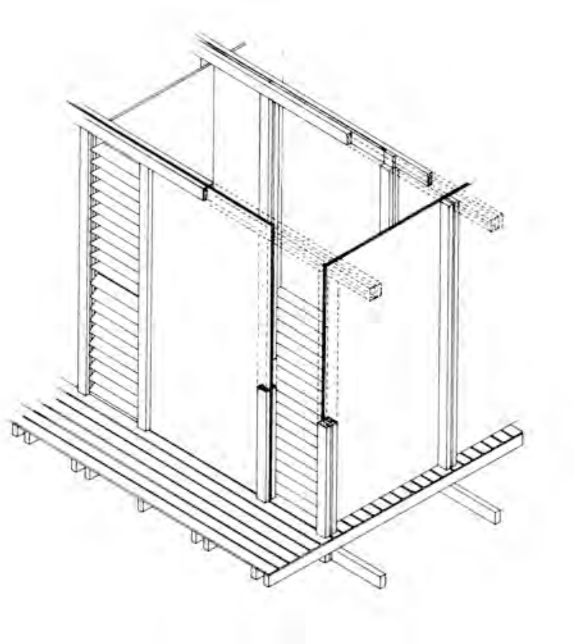

Fig 8

Andresen O'Gorman Architects, *Mooloomba House wall detail.* Axonometric.

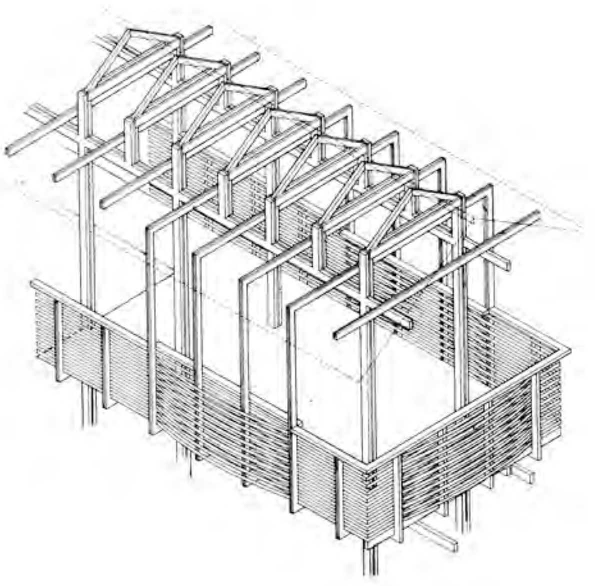

Fig 9

Andresen O'Gorman Architects, *Mooloomba House roof detail.* Axonometric.

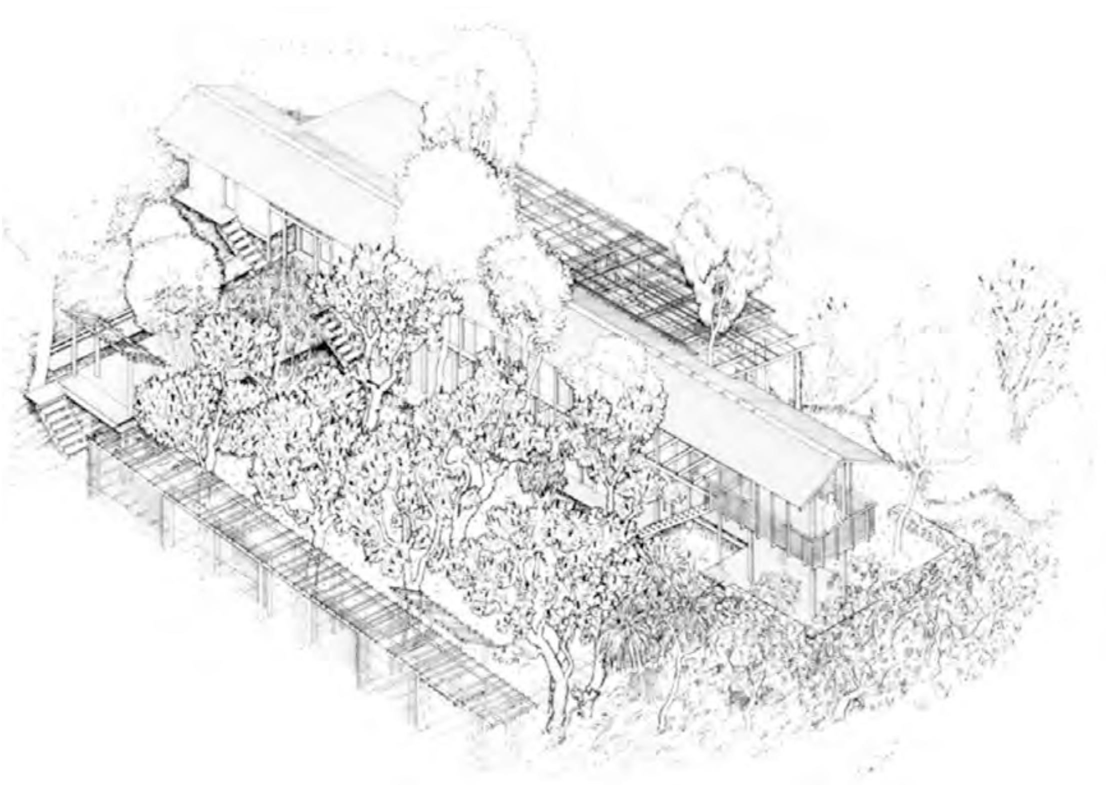

Fig 10

Michael Barnett, *Mooloomba House*. Axonometric.

SEEING DRAWING: REPRESENTING ARCHITECTURE ON-LINE

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Abstract

The capacity to engage with information held in drawings is vital to the study of architecture. For beginning architecture students to fully participate in this engagement requires the ability to relate to drawings in specific ways through a set of disciplinary conventions. These conventions are not merely about acquiring a knowledge base of architecture. They are also about techniques of reading and interpreting visual information and exercising judgements about that information. The student's means to 'find' architecture in drawing is to learn how to equate knowing with their seeing. This paper concerns the creation and implementation of a set interactive on-line tools designed to enhance learning for beginning students in architecture through the development and practise of skills for reading and interpreting architecture from drawings and images. Already at a remove from the drawing surface, the on-line environment provides a media for critical reflection on conventions of representation and their use by architects – a reflection made possible by the ability of users to manipulate parts of the drawing, dissembling and assembling knowledge in an independently controlled setting. In the making and manipulation of drawings, techniques such as adjustments of scale and reduction of detail perform vital roles in the mobilisation of knowledge. The discussion of these on-line tools and their workings provides an occasion for secondary reflection upon the conventions of architectural representation themselves and the manner in which such representations are not merely products of the discipline but a means of constituting the discipline – a surface situated as a critical juncture between the imagined and the built.

Keywords: Architectural Design and Drawing, History and Theory, On-line tools.

1 Introduction

The capacity to engage with information held in drawings is vital to the study of architecture. For beginning students to fully participate in this engagement requires the ability to relate to drawings in specific ways through a set of disciplinary conventions. These conventions are not merely about acquiring the appropriate knowledge base; they are also about techniques of reading and interpreting visual information and exercising discrete judgements about that information. These skills of reading, interpreting and judging drawings for the information they offer are not easily acquired. As David Leatherbarrow notes, the development and finetuning of judgement regarding architecture conveyed through drawing comes through immersion and longer term exposure and debate (230-8). Such skills once gained are relied upon intuitively, becoming what might be called 'architectural ways of seeing'. A lack of familiarity with the relatively subtle conventions surrounding drawings and an awareness of the presence of 'convert' knowledge can lead beginning students to an anxiety about 'what they are supposed to see' when looking at a drawing that affects their confidence and their ability to fully engage in critical learning activities within the discipline.

This paper describes the creation and implementation of a set interactive learning tools designed to enhance learning for beginning students in architecture, providing the means for students to use non face-to-face time to develop and practise skills for reading and interpreting architecture from drawings and images. These tools were created to augment face-to-face tutorial teaching in the existing introductory history/theory course, *Principles of Architecture*, within the Architecture Program at the University of Queensland and were delivered via a course Blackboard site. Funding for developing these tools came from the Office of Vice-Chancellor (Academic) and the School of Geography Planning and Architecture through a successful competitive grant application to the First Year On-Line Learning Funding Scheme initiated in 2005. Funding enabled collaborative work between academics of the Architecture Program and educational instructors and designers of the Teaching and Educational Institute at the University of Queensland.

2 Principles of Architecture Course

The Principles of Architecture course is introductory, directing beginning students to the premise that architecture is a discipline underpinned by a set of ideas and core principles, which have formed within a broad historical frame. Presenting architecture through reference to a set of precedents that embody core principles, including key concepts of form, space, place and scale, provides a window on a range of issues within the discipline highlighted differently through history. An advantage of this approach is to provide students with terms and concepts that would assist them in demystifying an infinitely complex but immensely rich subject area.

Traditionally, beginning students of architecture acquire the skills of reading architectural drawing through the design studio setting, the context where students produce drawings of designs themselves and learn the conventions through acts of making. History and theory courses in architecture conventionally adopt a lecture and tutorial model of delivery and rely on key texts as well as visual images to convey content. The move to incorporate the acquisition of skills for reading architectural drawing in an introductory architectural history and theory course brought with it the opportunity to make more explicit those skills that are implicit in the context of the design studio. It also provides students with the ability to enhance their understanding of textual information about buildings by interrogating and correlating visual materials – photographs and building plans – that are in themselves rich sources of content. It was also to understand that drawings, like texts, are open to interpretation and that the analysis of a drawing is framed by, or sets forth, a critical position. Understanding that drawings can be examined critically empowers students, providing them with a platform for forming their own judgements about buildings, qualitatively.

Most importantly, although the on-line tools were initially intended to provide a foundation for understanding the work of others, they also contribute significantly to the acquisition of skills necessary for architectural design. They do this firstly, by encouraging the development of a particular way of 'seeing' a design as it progresses. By providing a model structuring the reception of the work of others, the on-line tools also provides a mechanism that enables students to understand the role of precedent in architectural design and to utilise the lessons of precedent for their own design project work. The knowledge and skills required for learning in the two fields of design and history and theory within the discipline of architecture are not discrete and mastery in either is contingent upon developing architectural ways of seeing applicable to both.

3 Reading Architectural Drawings

Reading architectural drawings involves not just the visualisation of an abstract object, but also the interpretation of the set of spaces and spatial experiences contained therein. David Leatherbarrow writes that whilst structure and fabric are the elements of expression of architecture, space is its real concern (25). Charles Moore has stated that 'we do not draw space, but rather plans and sections in which space lurks' ("Dimensions"). Moore borrows the term 'mapping' from cartography to describe the process whereby beginning students might engage with drawn representation; 'you describe to yourself (and thereby discover) where you are and what you are near' ("Place of Houses" 207). But it is mastery of the knowledge and skills required to empathise with what is held implicitly in drawings that students must quickly acquire; a mastery that goes beyond a straightforward understanding of drawing as a tool for communicating information. Subtle yet critical meanings are revealed when a particular relationship is established between reader and representation, that is, where the reader is less a 'neutral receiver', and more 'a creative, interpretative being' (Pocock 11).

The capacity of the drawn representation to trigger perceptions or insights about space by arousing meanings in the mind of the reader has much in common with the reception of the poetic image, described by Merleau Ponty as being by 'excitement and a kind of oblique action' (8). Such action does not draw on learned knowledge alone, but knowledge that is held at a subconscious level. Simon Unwin draws on what others have described as architecture's analogous relationship to language (Forty 63) to describe the connections that beginning students must make in order to comprehend architecture:

> '…architecture seems like learning a mother tongue rather than a 'second' language because in beginning to learn it the mind has no points of reference other than experience of the world itself, and an awareness of how others do it …' ("A Bridge").

The linking of information held in a drawing to the consequences of that information for built form and space means bringing together in the imagination a knowledge of drawing conventions, disciplinary knowledge and one's own memory (or internalisation) of spaces experienced that are triggered through recognition of familiar configurations or patterns on the drawing surface. The on-line learning tools cannot directly address students' prior experience of the world but they do seek to provide a platform to practice a kind of 'oblique action' between drawings and images and in so doing understand how meaning is contained both within built form and within the modes of representing form.

4 On-line Tools

Each interactive on-line tool comprises a learning sequence incorporating interactive learning activities, instructional text, interactive quizzes, and a glossary of key terms. Three individual learning sequences were devised related to the following works of architecture [Kempsey Museum by Glenn Murcutt Architect, the Student Services Building at Morningside Campus TAFE by Project Services (Don Watson, Project Architect), and the Arthur and Yvonne Boyd Education Centre at Riversdale by Glenn Murcutt in association with Reg Lark and Wendy Lewin]. Resources made available through the tutorial included photographs, various architectural drawings, diagrams and text descriptions.

Particular themes are addressed in relation to each building including fundamental concepts of space and building form (Kempsey Museum), concepts of place, form and occasion (Arthur and Yvonne Boyd Education Centre) and ordering systems, abstraction and the role of historical precedent (Morningside Students Services Building). The sets of on-line tools were considered as a hierarchy of learning such that the progression between tools reflects students' developing knowledge bases. This involves the progression from simple to moderately complex buildings as well as a progression in the scope of questions based on the students' increased understanding of concepts through the semester.

Students begin their interaction by viewing a montage giving visual familiarity of the buildings and their settings, then work through drawings and diagrams that they control interactively to a series of quizzes and activities. In each instance the tutorial support activities were designed and ordered to create a learning sequence that builds upon the visual and textual descriptions of the buildings to the drawings and diagrams that provide information and the means of architectural analysis. Through play (the movement of the cursor over images, drawings, text and diagrams) students demonstrate to themselves how to 'see' connections between the various kinds of information that describe a built work.

By using their ability to correlate information held in plans and diagrams back to the photographic images presented in montage interactive activities enable students to orient within a work. Navigation of drawings is encouraged through a series of overlays, by which the students see buildings as comprising layers of variables – all orchestrated in response to an idea that orders elements of form and space via a series of hierarchies. Already at a remove from the drawing surface, the on-line environment provides a media for critical reflection that is made possible by the ability of the student users to manipulate parts of the drawing, dissembling and assembling knowledge in an independently controlled setting. In the making and manipulation of drawings, techniques such as adjustments of scale and reduction of detail perform vital roles in the mobilisation of knowledge. Techniques of reduction in drawings and diagrams allow for the elimination of certain details in scale drawings, to produce readings of form, space and materiality more difficult to perceive when witnessing the building in its completed state, particularly for students who are not yet trained in reading their environment in the conceptual and diagrammatic ways understood by architects. Through techniques of enhancement, drawings such as plans and sections can frame fundamental spatial dualities (eg. inside and outside) and rhythms of space and form not so clearly perceivable in photographs. Students answer quiz questions directed at demonstrating associations and assisting them to isolate and 'see' key ideas and principles at work. Immediate feedback is provided through analytical diagrams and over-drawn photographic images demonstrating relationships between principles and ideas as described in texts and lectures and their expression in built work.

The final step in the learning sequence occurs beyond the on-line environment and involves a site visit to one of the buildings [Morningside Students Services Building]. Students can test for themselves the accuracy of their reading of space and form as held in drawings and images interpreted on-line. More particularly, the student's were given to reflect upon the relationship between the drawings, diagrams and images and their own imaginations. For instance, many students expressed surprise at the scale of the built work they visited. Some had imagined the building to be bigger than they found it to be; some had imagined it to be smaller. This apparent 'failure of accuracy' between built form and its representation highlights the role of the interpretation and imagination in reading architectural representation. In each instance the misreading of scale could be traced to assumptions made about the scale of an element of building fabric measured in relation to human form as a consequence of an imagined occupation. The student's oblique action of interpretation, whereby their own work of understanding the building through drawings on-line does not entirely match the built outcome they witness, illustrates how form and space are projected as an imaginative act through drawing. The knowledge they have perceived through drawing is 'almost right' and yet a surprising 'gap' remains.

5 Conveying Ideas and Principles

The design of the interactive on-line learning tools is underpinned by the premise that although ideas and principles in architecture are conveyed in text and image they are overwhelmingly held in built and unbuilt works and their drawn representations. Accordingly knowledge of architecture gained from drawing relies on an understanding that ideas and principles are given presence through the ordering of structure and fabric, space and light in building; elements that constitute the language of architecture's expression (Anderson 35).

The notion that concepts cannot be separated from that which gives them presence is a difficult one, particularly when the linking of abstract knowledge to the material world hinges on a reception of drawings and images. In this instance diagrams reveal the strategic thinking that orders elements of structure and fabric and images capture the consequences of those strategies. Targeted questions prompt students to 'see' relationships by foregrounding elements of structure and form, linking them to the ordering principles and ideas that motivate them, with the added possibility that images might trigger recollections in students of previous experiences that can be cross-related. Through these moves students begin to form the disciplinary knowledge bank necessary for fully engaging with the discipline. Whatever the extent of learning gained, a vital platform is established, as students begin to realise that the means to 'find' architecture in drawing is to learn how to equate knowing with their seeing.

Introductory texts on architecture by Francis Ching and Simon Unwin provided an important reference point for the design of these on-line learning tools. Ching's graphic presentation of strategies for ordering architecture and Unwin's presentation of architecture as constituting a language of form, both provide an opportunity for students to engage with content that might otherwise remain difficult or 'covert'. The on-line tools described here differ in that rather than being wide-ranging and generic they are particular, focused on an extended description of specific built works, enabling students to piece together a reading of building through a series of correlations. Because the tools involve analysis of built works that are accessible to students they also offer the opportunity for continuing correlations between an understanding reached on-line and subsequent experiences.

6 Conclusion

Finally, discussion provides an occasion to reflect on how these particular tools respond to shifts in thinking about what constitutes a context for meaningful learning. The current popularity of on-line learning tools across the education sector is a response to the recognition that students are not 'passive recipients of knowledge' but 'adventurous, independent learners' who 'learn by doing - by trial and error' (Spender). Architecture is slightly different from other fields in that learning has never been linear and sequential in character and the focus of learning has always been student-centred. In the initial thinking about how students might access the on-line learning tools it was intended that they be able to shift between exercises, choosing where they want to be and opening and closing tasks as necessary in order to 'see' connections. It is interesting to note that this intention is, to a certain extent, undermined by the nature of the Blackboard platform itself, which promotes linear learning sequences.

Nevertheless, conditions for accessing the learning tools are designed to minimise student anxiety and encourage exploration and play. Rather than the surveillance of activities typically associated with on-line tools, students are invited simply to have a go. Instead of being directly assessed online, skills mastered in order to complete the exercises are assessed indirectly, being mirrored in assignment questions. Students may take their own time to 'see' the relationships drawn out by the tools, returning as required to practice skills for reading and interpreting, reflecting the reality that student learning is uneven. Evidence from student surveys indicates students have enjoyed using the tools. Feedback from tutors suggests a greater preparedness to use aspects of an architectural language to describe work, evidence of an embedding of a metalanguage, and 'covert' knowledge, revealing representation as that critical juncture between the imagined and the built.

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INSIDE SOLARIS: THE PRESENCE OF GAME TECHNOLOGY IN ARCHITECTURAL DESIGN

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Abstract

Tarkovsky's 1971 film *Solaris* is an exquisitely evocative meditation on the relationship between technology, memory and loss – not only through it's presentation of the characters, narrative and themes of Stanislav Lem's novel, but also through the specific qualities of film as a medium of perception (Tarkovsky). Tarkovsky's oeuvre itself, particularly *Nostalgia* and *Stalker*, are tours-de-force in this respect. Yet there is always a melancholic distance between the viewer and the medium, perhaps impossible to traverse in any medium, but especially recognized in Tarkovsky's work. This in fact is a key issue, as Doležel has outlined in his study of literature and possible worlds, in the understanding of the force of fictional constructs within the representative arts, including literature (Doležel). The need to explain how it is possible and necessary to construct possible worlds that have both representative similarities with the real world and with hylomorphic qualities (i.e. a purposive and necessary form) in and of themselves is an opportunity that the making of digital environments cannot avoid.

This paper questions whether the same material for 'world-making' might be possible in persistent digital environments as there is in film. In the quest for an increasingly vivid experience of the presence of architecture, digital means of representation have achieved significant successes. Interestingly, there remains the opportunity to consider modes of digital realization as being sufficiently material within their mode of delivery – digital media. If we stay within the digital there are a number of modes by which its architectural product can be experienced. The question of this paper concerns the manner in which a recent mode of digital representation and exploration has developed: the game engine.

1 Introduction

Tarkovsky's 1971 film *Solaris* is an exquisitely evocative meditation on the relationship between technology, memory and loss – not only through it's presentation of the characters, narrative and themes of Stanislav Lem's novel, but also through the specific qualities of film as a medium of perception (Tarkovsky). Tarkovsky's oeuvre itself, particularly *Nostalgia* and *Stalker*, are tours-de-force in this respect. Yet there is always a melancholic distance between the viewer and the medium, perhaps impossible to traverse in any medium, but especially recognized in Tarkovsky's work. This in fact is a key issue as Doležel has outlined in his study of literature and possible worlds, in the understanding of the force of fictional constructs within the representative arts, including literature (Doležel). The need to explain how it is possible and necessary to construct possible worlds that have both representative similarities with the real world and with hylomorphic qualities (i.e. a purposive and necessary form) in and of themselves is an opportunity that the making of digital environments cannot avoid. In film there are distinctions between diagetic content - sounds, effects, music, points-of-view, that seem to follow intuitive aspects of the narrative, and non-diagetic elements – sounds, framing, music, events that draw attention to an origin external to the narratival space of the characters. For a film such as *Solaris*, the transformations of time, space and form that ensues in the narrative are defining aspects of the project itself, they are the key questions regarding the 'reality' of the story's events. This paper questions whether the same material for 'world-making' might be possible in persistent digital environments.

2 Digital Issues in Architecture

In the quest for an increasingly vivid experience of the presence of architecture, digital means of representation have achieved significant successes. It is a matter of record that processes made available by the computational strengths of parametric modeling and animation software has produced new models of the 'possible' in architecture. This mode of thinking remains enmeshed in the idea that modes of representation have the ultimate aim of being realized in a material form. Interestingly, there remains the opportunity to consider modes of digital realization as being sufficiently material within their mode of delivery – digital media. A more radical, but still robust, proposition might be that a mode of architecture that is principally delivered within the attenuated sensibilities of the digital might nevertheless be ontologically full in its apperception.

If we stay within the digital there are a number of modes by which its architectural product can be experienced. Within the limitations of the code of the applications, then the experience is limited to either a rendered view or an animation. These remain simulations of conventional modes of representation. The quality of the surfaces, the issue of the degree of simulation of the Real or its inherent abstraction, rehearse a conventional contest between mimetic practices. Whilst this can traverse work from the seamlessly natural of commercial digital artists to the self-consciously contrived, for example Stephen Perrella's *Hypersurfaces*, the argument is familiar (Perrella). Whilst the subject matter of the representations may well be different, an empirical model opposed to an algorithmic process, the critical context is coeval.

A parallel issue, one that cannot be filly addressed in this paper, is the nature of the experience itself. Whether we consider the haptic content of AR and VR technology, pursued through the development of head-set, controller and other technology, or the optic issue of digital embodiment through forms of telepresence, the embodiment of the digital experience is considerably varied. For some, the nature of this question is pivotal as the search for seamless connectivity, whether by 'touching' the digital in some fashion or establishing developed emotional sensitivity to the avatar, is paramount. Even the relationship between avatars, the philosophical question of sentience and sapience in digital actors, is crucial. In all of these instances the appetite for total kinesthetic experience is intended to support a transition between normal bodily experience, a kind of empirical datum, and the incorporation of data sets that impart a spatialized experience. Instead, we would like to concentrate on the relationship between the representation of architecture, the expectations of vividness that may emerge from this process and the opportunity to see unique thematic experiences in digital environments that may emerge and contest our understanding of the 'real'.

3 Game Engines

The question of this paper concerns the manner in which a recent mode of digital representation and exploration has developed: the game engine. Game engines, as a form of code that traverses modeling, texturing, lighting and an animated scenographic view, rely on the workflow pipeline of 3D applications, but then place the content within first-person immersive environments. There are a number of questions that emerge from this process: How does this application differ, in architecture, from others in terms of its representative or mimetic role? how does it cater for issues of ontological vividness in comparison with AR and VR applications? how much use is it, for architecture, as a medium in comparison with the use of systemic, constructive algorithms?

Computer games consistently achieve levels of vividness that describe a position without precedent. In commercial games these spaces are influenced by narratological issues internal to specific tasks that are a part of a game, but in exploratory architectural work they are able to simultaneously act as a representation of a possible real and as a developed *mise-en-scene* of potential actions. They are both suffused with an aesthetic particular to the mechanics of the engine, how it delivers the idea of the Real, and the potential to act within this space. It is this last condition; the relentless need to consider the environments as persistent and transitive, which indicates the genuinely novel potential for digital environments. Put simply, if one could inhabit Piranesi's *Carceri* or Tarkovsky's *Solaris*, how would you act? These alternatives are qualitatively different, and mark a shift between architectural representation as an obsessive development of the architectural process of form-making, vs the spatialization of experience within the montage logic of film. The authors will present a description and analysis of work done within this media, arguing for its importance as a concept of 'the architectural' and hence within architectural education.

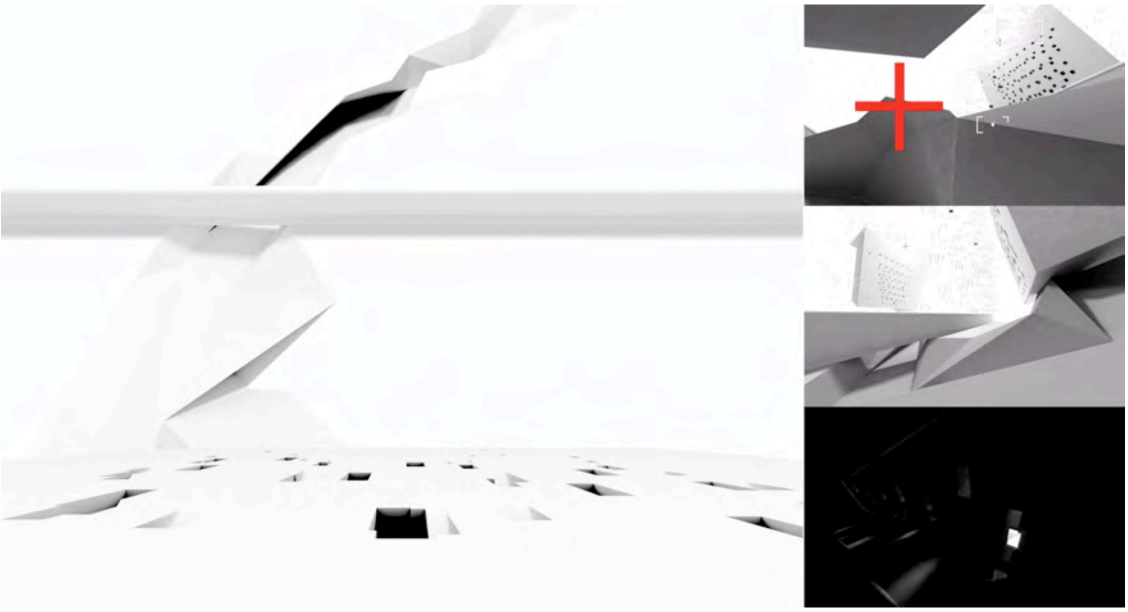

Figure 1: **Greg More, *Concrete Falls: 1000 Lines of Sight*, 2006, screenshots**

4 Architecture and Representation

There is nothing new in the idea that architectural design is driven by the means by which it is represented. A constant of architectural thinking is the manner in which the liminal aspects of architectural design, those aspects that seem to evade clear description, are governed by the search for the dissonant and unfamiliar. A governing presence in the evaluation of the oeuvre of practitioners is often the degree to which they pursued, or described a design agenda that is circumstantially different from the accepted sphere of influences, selected examples are: Eisenman's belligerent attempt to adopt structural linguistics into domesticity, Gehry's adoption of digital technologies as a mode of practice, ARM's adoption of a critical design practice that can simultaneously cherish and chide everyday culture and still find opportunities for revelation. In these instances there persists the accepted practice that the mode of presenting architecture is a valuable state of testing the relationship between the design and its reality.

Curiously, the critical apparatus of architectural criticism willingly considers aspects of unbuilt work in equal measure to that of built work. On empirical grounds this seems deficient, as there is clearly more material for investigation in a built work than is available in the product of representation. However, the counter argument is of course that it is through the means of representation that the most focused and semantically rich aspects of a work are presented. It's a challenging argument - that built work is only of marginal interest because of the confusing superfluity of its presence. Moreover, the extension of this argument seems to imply that meaning is only in use, not in intention - as if Ronchamp should always be considered in light of the cumulative vividness of pilgrims' experiences. In essence it is the same argument for a practice of thinking about the specificity of architecture that is being made again.

In an age in which the manner of representation is clearly evolving, the questions naturally resurface. Notwithstanding the structural similarities between the current means of representation and the history of the architectural image as a synechdocal effect of an overall design process, digital design involves the manipulation of a series of mimetic tools, themselves designed to reproduce the real as immaculately as possible – within certain parameters dictated by the physicality of the frustrum. Hence the significant subculture of practice dedicated to the reproduction of seamless or photo-real images. In architectural design, of course, the manner in which the play of the simulacra occurs is intimately linked with the manner in which the contract of authenticity is established between the design and its procession towards the actual. This is the commonsense view of the medium, in which its existence as a tool is premised in the real – to be defined as a tool it must economically function as a device for perpetuating the economics of the same and simulation.

5 Adamic Breeding – Things and Names

However, the use of digital modeling software with the design mode involves a series of choices that superseded the mimetic function. By applying complex geometrical transformations to simple formal primitives, increasingly exotic formal entities can be created. Taken as a simple practice, this transformation of form can be considered as a mutation of topography (Cache) in which the idea of topography invokes a seamlessness of surface that destroys the notion of scale. Form, thence, is an infinite enfolding of matter to create a series of opportunistic spatialities, surfaces and abundances of program. The caesura between form and program is complete. Further, the re-naming of these instances (Lynn) as blobs, blebs, strands, etc invoked a new literacy in homophonic aspects of the voice of the digital. In both instances there is the Adamic encounter between the work and the idea of the typological – through a search for alternate modes of description, the monstrosities of the digital are positioned in some periodic table of formal motifs. Cache resisted this temptation and became forgotten as an innovator principally because of his resistance to incorporating the work of *Objectile* into a catalogue of formal characters (Cache). The novelty of the language is itself a complete strand of study, as it involves not only the determining of new nouns, but also adjectival and verbal practices that are incorporated into the design process. The term 'spline' is a pivotal case in point, in which the fashioning of polynomial lines and surfaces has become a key act of design surfacing.

Figure 2: **Sean Pickersgill, *Bourgeois*, 2006. screenshot**

Similarly, the borrowing of descriptions from biological organisms that have modes of self-organization for complex systems has been fused with an expanded definition of where the parameters of the architectural lie. It has become a meta-tecture, incorporating a dynamic isomorphic model that investigates where the act of design lies. In many instances this is replicating the radical empiricism of Deleuze (*Logic*, Deleuze). Again, though, the means by which this process is visualized is via the dynamic animation processes available within 3d modeling software. Animation itself, as Lynn, has recognized, is a process of tweening that interpolates form between two or more static formal conditions, replicating in some instances the manner in which the eye will discretely adjust between the repetition of images produced at 24 or more frames per second. The differential is more though than just the convenience of allowing the animate to emerge from the dictates of the composed static. The differential preserves the opportunity for the new to emerge as an opportunity of form creation itself, as a model of how specific instances of the real make their presence in the world (*Difference*, Deleuze). Of course the application is premised on this process. In this instance the formal progeny that emerges once an epigenetic system is set in motion is made present by its means of representation. There is yet to be an alternative means by which epigenetically reiterative systems are made apprehensible and as such the claims that they represent an instance of a dynamic complex system are compromised. Whilst complex systems, of course, can be representatively 'shown' – the expanded analogy that they are inherently architectural needs more explanation (Fear).

In part this is pointed out by Manuel de Landa in his essay on Deleuze and the use of the genetic algorithm in architecture in which he points to the limitations in the use of algorithmic processes in architecture (De Landa). Implicitly, the transaction of 'explaining' the work, usually by referring to incommensurate data sets or the use of polynomial modifiers to visualize the morphological differences, tend to be descriptive of the process rather than explaining the manner in which 'this' form is appropriate. Indeed, in conversation, Bernard Cache referred to the selection as *Kunstwollen*, a will-to-select by some arbitrary sense of fitness. De Landa likens the process to that of a dog or horse breeder making choices about their animals (De Landa). In particular, the need to re-theorize the phenomenologically intimate is untouched, though Deleuze is clear on the need for the singularities of phenomenal experience to be treated as distinct entities, without them being subject to essentialist definitions (*Difference*, Deleuze).

So in architectural design, whether in practice or in its emulations within the design studio, the work of producing complex formal models requires the recoding of key terms within the language of architecture to imply a continuity of the project of the avant-garde. Thus, for example, Semper is invoked in discussing the use of surfaces, or strands, or the manipulation of UV texturing processes, whether the producing emerges from selective processes or not (Spuybroek). In many respects the arguments rehearsed the early twentieth century debate within the *Deutsche Werkbund* between *Kunstwollen* (a will to making form through the process of abstraction) and *Typisierung* (the delineation of typical models from which variations can emerge). We need only substitute the terms Objectile and Epigenetic for the debate to be contextualized to our present (Campbell).

6 Hylomorphism - Unreal and The Real

An alternate field in which an experience of form and programme takes place is that within persistent digital 'worlds'. These worlds are a consistent component of both stand-alone PC and console games that require a 3D environment for their games to occur within and MMOG spaces (Massive Multi-user Online Game) in which vast networked 3D communities exist. These take the form of both task-based (game) environments and social spaces. The most famous of the latter category, *Second Life*, is currently presenting itself as the evolution of digital communities made possible by the internet and associated technologies of mass communication. It allows users to exist as an avatar, of their own creation, within a 3D space that is dynamic in its evolution being constantly updated and modified by the participants. Both forms of these environments have formidable secondary communities devoted to social and economic aspects of the game/environment.

For no other reason, it would be sufficient for architecture to pay attention to these spaces given the fact that, for example, *Second Life* has property that participants construct digital spaces within. It would seem that the spatialised nature of the experience would lend itself to the translation of much of the theoretical digital work in architecture of the recent decade into this area. Yet this in itself is not enough to critically capitalize on the complex generative qualities of work such as Lynn and NOX, for example. This is a technological gap between the complexity of the models created within the digital architectural community and the level of complexity available to community environments such as *Second Life*. It would also neglect the clear intention for aspects of the architectural work to be made manifest in the real world - with all the complex sensate experiences that would entail.

But if we concentrate on the nature of the gamespace it is worth considering the manner in which the software necessary for creating a persistent environment is constructed. Game environment engines take polygonal models for both static and active elements of the map/level and apply the appropriate texture and lighting data to them in real time. The engine is able to optimise this process by only performing the texturing computations for those aspects of the model that are within the player's field of view. In addition, audio actors, environmental effects, and skyboxes all may be manipulated to increase the 'reality' of the experience.

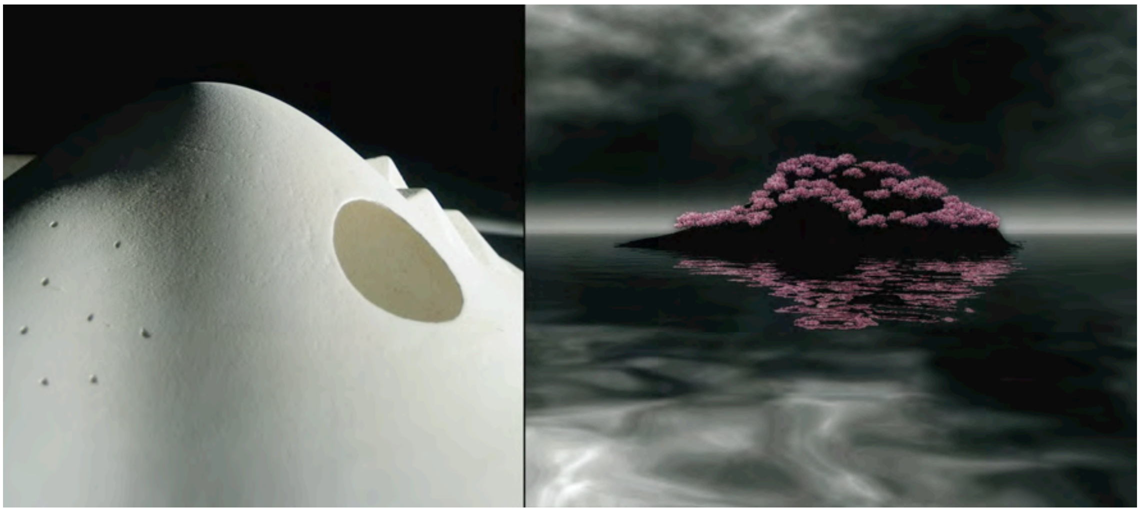

Figure 3: **Greg More, *Meta Island Beta*, 2007, embedded sensor model and screenshot**

Reality, in fact, is a key and contested aspect of the persistent digital environment. It is a matter of some debate within the game community as to the virtues of increased impressions of reality within games. Debate usually centres on a contest between narratological and ludological interests – are we there to experience something with textual depth or just to participate in some rule-based behaviour (Juul)? Debate usually follows the line that increased reality in representation is used to augment or cloud play (depending on which side of the debate one is on). I would suggest that a number of deeper philosophical questions are being enacted.

If you were to track the development of the representation of digital space over the last 25 years it is clear that key terms and questions recur that bear an uncanny resemblance to epistemological debates of the 17^{th} and 18^{th} century. The debate on the nature of vision and knowledge that originates in Descartes and Berkeley, particularly Berkeley's encomium *esse est percipi* (essence is perception) can be rehearsed within the constructed space of the digital environment (Berkeley). In some respects, like a clockwork universe, the answer is already known inasmuch as the programmers intuitively used these models in constructing a digital reality. Yet the texts of the philosophical works consistently approach the partitioning of experience into substances, attributes and geometrical metricisations that are mimicked by the evolution of game engine software.

What is interesting is, as digital environments grow to incorporate more complex forms of coded experiences, the degree to which 'knowing' an environment will be increasingly fraught – perhaps productively so. Many of the issues that have emerged as questions for the mind/body dualism of pre-modern philosophies of logic and language are being enacted as we speak by the coding teams of Source and Epic Games. The challenge for architectural theory is to situate itself within this development.

A key application used in this respect is UnrealEd, a modeling application that accompanies the commercial FPS (First Person Shooter) game Unreal Tournament. Like all FPS environments, they are composed of forms that have their genesis in the same 3D modeling applications currently used by architecture. However, as indicated above, there are significant differences in the experience of the digital content. Unreal proposes a simulation of the real that is ontologically different from that of the conventional 3D modeling tool and its representations.

The 3d tool exports it's sense as a static image, whereas Unreal paints a 'Berkeleyen' perspective idiosyncratically particular to the individual. Importantly too, it escapes the charge that it is merely solipsism because of the transaction of fictional vividness between programming team and player. It is in this sense that the idea of the digital world having pseudo-hylomorphic qualities is most appropriate. The FPS environment encourages a form of coded phenomenology, in which it is possible to entertain an engagement with simulacra as a 'genuinely' mediated quality itself. Much in the fashion that avant-garde music has investigate the sonic ambiences of aural effects of recording and reproduction as both a mimetic and collagistic practice.

7 Trifurcation

We suggest that this medium can develop in three directions: (i) towards an increasingly texturalised and reflexive practice that explores the qualia of the digital (un)real; (ii) towards an increasingly hyper-real attempt to emulate the immensely complex, and resource intensive, aspects of the artificial world; (iii) it may fetishize a nostalgia for low-fi models of itself as a means of recuperating control of the medium for independent agents with limited means. In essence the latter tow conditions involve the issue of labour and the ownership of the resources necessary to create these conditions. The last mode of practice, low-fi, is about the creation of digital environments sufficiently abstract to be performable and exportable to a broad community. Paradoxically, this practice is in some ways the most 'humanist' of the three as it assumes that the key interaction between the individual and the game environment lies in the ludic aspects, the 'play' of the individual as an emotive agent. The hyper-real environment, currently being pursued by the large game design and hardware manufacturing corporations is attempting to emulate a play experience that can deliver increasingly sophisticated morphological, textural, and physics-based effects. Without consciously recognizing it, and it is outside the scope of this discussion to do it justice, they are emulating the map/territory problem in philosophy – a problem that argues that no representation can be fully real and hence radical solipsism seems to be our endemic state.

The third opportunity, reflexive qualia, will investigate the manner in which the component elements of digital reality are scripted and reflexively recognize the experience of the digital. For architecture this may well incorporate not only an expanded knowledge of such issues as the map/territory dilemma mentioned above, or the question of whether there is possible empathy with the sentient and sapient characteristic of other avatars - the p-zombie problem, but also the materiality of the digital environment and its role in being the mise-en-scene of types of experience as yet unnamed.

Figure 4: **Sean Pickersgill, *Terror-ain*, 2006, screenshot**

Which returns us to the question of Tarkovsky and *Solaris*. If a task of architecture is to remember, remember the people that made it, remember the world that considered it new and vital, remember the promise of clarity and perspicacity in its processes, remember the vividness with which it mythologized itself and became the place in which imagination could occur, then the digital real has a task to fulfill. Digital environments, gamespaces, have the capability to offer an experience of the real that has both the frisson of mimetic fidelity – they look and sound real, whilst also permitting a vast array of counterintuitive events that may question the unfolding of experience. In a manner similar to the structural opportunities of film, both diagetic elements and non-diagetic elements can occur. Beyond the debate of the interrelationship between form and effect, and the sub-text of where the autonomous effects of design practice take place, the experientially full opportunity of the Unreal world is one place for future architecture. If we were to consider how one might build, code and explore the space station in *Solaris*, with its unnerving ability to make manifest the physical substance of our memories, what might we think of simulacra then?

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INTERNAL CONSISTENCIES: REGARDING WEIGHTS AND MEASURES

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Abstract

Rather than seeing a distinction between theoretical discourse and the science of building Vitruvius, a Roman architect and engineer active in the 1st century BC, argued convincingly for the breadth of knowledge necessary to practice architecture with authority, that "knowledge is the child of practice and theory". The crux of his argument is that a sufficient breadth of training, to appreciate both the theoretical and practical sciences, is necessary to lend authority to creative vision.

In like spirit, a series of workshops in UCD Architecture has sought to challenge the contemporary lack of sympathy between theoretical discourse and the science of building which disables the authority with which both students and practitioners practice. Embedded within each workshop are variations regarding intent, from the cultural discourse of the international collaboration of the North Atlantic Rim project, to the theoretical concerns of the Ateliers Series and environmental bias of the Irish Timber course, each drawing upon discourses external to architecture and leavening them against the inherent logic of material and structural imperatives. The resulting evolution in design process, linking both technological imperatives and conceptual intentions to the creative act, shatters the prevailing disjunction between theoretical concerns and technological explorations in the discipline of architecture.

Keywords: Technology, Material Practice, Design Build, Education.

1 Introduction

> *1. THE architect should be equipped with knowledge of many branches of study and varied kinds of learning, for it is by his judgement that all work done by the other arts is put to test. This knowledge is the child of practice and theory. Practice is the continuous and regular exercise of employment where manual work is done with any necessary material according to the design of a drawing. Theory, on the other hand, is the ability to demonstrate and explain the productions of dexterity on the principles of proportion.*
>
> *2. It follows, therefore, that architects who have aimed at acquiring manual skill without scholarship have never been able to reach a position of authority to correspond to their pains, while those who relied only upon theories and scholarship were obviously hunting the shadow, not the substance. But those who have a thorough knowledge of both, like men armed at all points, have the sooner attained their object and carried authority with them.*
>
> *Vitruvius Pollio, The Ten Books On Architecture, Chapter I: The Education Of The Architect*

The transfer of knowledge into the discipline of architecture is not a new phenomenon, although the rapidity of transfer and complexity of information on offer exceed historical trends. The validity of this transfer should be understood within this context, that architecture, by its very nature as a social, political and material art, necessarily demands a wide spectrum of knowledge on the part of its practitioners to achieve work both functional and meaningful, as so aptly argued by Vitruvius. Rather than a lack of sympathy between theoretical discourse and the science of building, Vitruvius appreciated the breadth of knowledge necessary to practice architecture with authority, that "knowledge is the child of practice and theory" [Vitruvius 1].

Contemporary debate should lie not in the validity of the transfer but rather its synthesis with the more specific and technical aspects of the discipline. In a recent publication on material based practice argues that architectural practice and the discourse surrounding it have historically and principally been form based, eschewing material resonance, and it is within these discourses that alternative fields of endeavor have had their influence on architecture [Lloyd Thomas, 2]. The implicit difficulty in this history, and its radical difference to the attitude expressed by Vitruvius in the first century BC, is the tension implied between form and its resolution as material artifact. Severing broader frames of reference from material realization creates a disjunction between critical imagination and the material constraints of building, disabling the authority with which architecture is practiced. As Lloyd Thomas argues in Material Matters, the potential of reversing this predisposition, to focus on material realities not as servant to form but as inspiration, can open up equally broad fields of inquiry; economics, environment, social custom and material production [2], describing a similar field of knowledge implicated in formal concerns yet from a significantly different perspective.

Doubt lingers within Lloyd Thomas' essay as to whether this shift in priorities repairs the oppositional character of formal conception and the material realities of building. A series of workshops developed within the Architecture Programme at University College Dublin has sought to encourage just such a shift in thinking and making, with results which imply that this oppositional condition can be leveled, that the generous image of a marriage between theory and the practical bequeathed to us by Vitruvius is indeed possible and still relevant within a far more complex world and profession.

2 Thesis Research and Les Grands Ateliers

Strategies to reconcile technical imperatives with theoretical discourse vested in the current Ateliers programme have a lineage from the AA with the Weather Register [Salter, 9], which focused on the elements of nature and landscape, and the Technical Study, intended to "test and reinforce the instinct behind the strategy" as Salter describes [14]. Adopted into the programme at UBC in Canada and later evolving into Constructed Order, a studio intent on instilling a similar intuition regarding materiality, it became apparent that these ideas, whether environmental or material, when introduced into design education at an early stage, became foundational to future work as a form of intuitive knowledge [Lui et al, 114] effectively linking imagination, conceptualization and making.

In contrast contemporary architectural discourse tends to understand building form in representational terms, which renders its materiality invisible [Lloyd Thomas, 7], aptly describing the prevailing ideology at the School of Architecture in Dublin, which eschews the compelling forces of materiality and environment for a more intellectualized attitude. Theoretical discourse typically has a generative impact but in a manner that is representational and static, failing to accommodate material and structural imperatives [Allen, xxv]. Set the task of revising this predisposition at thesis level, the principles gleaned from earlier work undertaken were adopted, leading to the evolution of workshop programmes intended to test theoretical polemics against the resistance of material, structural, environmental and economic issues.

Originally held at UCD, experiments were undertaken at model scale, which, while useful, remained within the realm of representation and reinforced the prevailing formalist attitude [Shotton, 164]. Significant to the evaluation of this programme were studies on cognitive learning and modeling by Parkinson, indicating that there is a differential in learning across different scales and types of representation. While all forms of modeling are useful to the development of imagination, modeling that reached a scale where 'engineering' concerns became relevant in addition to shape making, creating more strenuous experimental conditions, were more salient in the process of hypothesis creation and testing [Parkinson, 14]. Scale of experimentation then is central, as was to be corroborated with the experience of the programme as it developed into full-scale studies.

Image 1**: Les Grands Ateliers Workshop 2006 Students: Jacinta Curley, Gordon Chrystal, Dierdre Keeley, Lucy O'Connor, Sandra Sibley, Padraic Ward**

Relocated to a venue that could house 1:1 experiments enabled students to confront 'engineering' concerns in the form of actual materials and structures, to encourage hypothesis testing and transformation. Critical to the organization of this five-day exercise is the arrangement of students in teams, significant as it necessitates the negotiation of individual concerns into a mutually relevant premise. Equally important was the elusive character of the brief suggested; wall, chair, roof; evocative yet intentionally broad to allow for interpretation in terms hypothesis, form and material use. Initially structured as a sequence of drawing to building, this process again exposed the formalist predispositions as drawing studies bore no technical insights and were rapidly discarded once building was undertaken. Altered to a more promising structure in which material is engaged with immediately enabled the shape, texture and inherent properties of the physical to influence both negotiated position and resultant form [Image 1]. Working directly with material brought theoretical, social and political concerns, more commonly attributed to form generation, into direct confrontation with material and technological imperatives, allowing both to contribute to the conceptual positioning of the project.

Equally constraints aided investigations, for while the work from the first year was experimental and visually engaging due to risks taken in material choices and in the interpretation of the brief; ranging from a multi-tiered 'breathing wall' constructed exclusively of OSB and housing up to nine people simultaneously to a red lycra scrim which flexed interactively with the Atelier's folding door system; the provisional character of the constructions suggested a different approach was required. While the influence on the formulation of thesis was significant enough to infiltrate later design studies, the form of influence was on the level of metaphor, importing conceptual and formal ideas to later experiments yet failing to advance material instinct except in a few rare cases.

In response material was restricted to timber, to challenge construction skills more directly, while allowing the brief to remain elusive. However the form of brief was equally critical to the success of the later adaptation of knowledge as was to become clear. The second brief undertaken was the 'chair', the form and placement of which could act as a measure of space and thus could be understood as a primal form of architecture. The intimate nature of the object and restricted material palette proved a test of construction skill and elicited in later work a greater concern for the intimacy of material and implications of process. Yet the object like character of the constructions failed to engage spatial concerns, thus the intuitive knowledge later applied was limited to detail rather than influencing form.

Most successful was the 'roof' project, carrying with it implications of space, form, structure and material. The work undertaken, ranging from studies in adaptable systems building to experiments in "thick space", were less engaging as visual objects yet had profound influence of the work that was to emerge later in the year. The translation is by no means direct, but rather have engendered more synthetic resolutions of competing discourses where design studies, previously form driven, now explore attributes of form, structural resolve, tectonic expression and theoretical concern simultaneously.

These experiments have confirmed the hypothesis regarding the subliminal influence early material experiments have on the design process. Significantly though this phenomenon is influenced to a large degree by the scale of engagement, the complexity of the brief while lessons learned seem transferable across material. Crucial however is the simultaneous negotiation of material, form and conceptual premise in influencing intuition.

3 North Atlantic Rim Research Collaborative

Image 2**: Cheticamp, Nova Scotia Site Drawing, NAR 2006, Roger Mullin**

Drawing, as intermediary between creative thought and building process, is a critical tool for both investigative and communicative purposes and was used as the principal medium by NAR, an international research collaborative initiated in 2004, to identify salient aspects of landscape that inform culture, building and settlement patterns. Orthographic representation to translate experienced realities to measurable and comparable data enabled close examinations of the landscapes and buildings through measure, proportion, scale and materiality – with the emphasis on the underlying materiality of the land - that informed the secondary layers of the built. These studies culminated in 2006 with a design build project in Cheticamp, Nova Scotia, which was intended to transform this knowledge from perception to imagination and finally making.

Resolution to the contested territory of local school, summer theatre camp and retirement home was initially studied in model and drawing across three groups of students. Evident was a lack of regard for the constraints a two-week building project implied - material, technical, economic or process based – with notable exceptions among the students who had participated in the earlier drawing studies. Amongst these was a lingering attention to the natural features of the landscape and references back to construction typologies observed earlier. Nevertheless, when reviewed as a set of alternatives it became clear that pre-conceived formal agendas, inattentive to the specificity of physical constraints, prevailed. A shift in process was clearly needed to enable a more holistic solution to the difficult physical and social terrain to be negotiated.

Scott Poole, in his assessment of design processes among his own students, has suggested that "...simulation of mental images detached from the veracity of matter and the means of production can have an illusory effect on the imagination and foster constructive naiveté. [111]. Yet it is not simply digital media, to which he refers, which suspends realities in form making. Rather it is the over dependency on abstract representations which so often precludes a more intimate reading and authoritative translation of a context. Tactile engagement is a principle means of perception and thus critical to learning and invention, as Parkinson's research has suggested. Deprived of this experience visual imagination remains uninformed as to the weight and measure of reality. Addressing this issue meant developing a more precise structure to link tactile engagement, perception and imaginative processes.

As a means of measuring both site and building material, consisting of heavy timbers, rebar and plywood restricted in quantity by issues of budget, students and staff engaged in a form of 1:1 on site sketching, distributing the material across the site in response to sequences of instructions to articulate gathering places, solitary places and spaces of movement. From this position material was subtracted in a similar process to assess the potential of the site against the measure of the body and scale of the material. The outcome was a far more sophisticated reading of the site, both physical and social, than any achieved through earlier modeling. While initial representation in plan [Image 2] bore no recognizable form, when built a complex network of social spaces which negotiated a difficult terrain [Image 3] using a simple but sophisticated language of pin connections, with timber and rebar, inspired by local heavy timber wharf constructions resulted. Speculation, on a physical and collective level, combined with the urgent pressures of construction enabled the earlier landscape studies, so carefully absorbed through slow documentation, to surface in an imaginative and unexpected manner through an recasting of material, technology and cultural history.

Similar to the Ateliers project, engagement with material enabled a form of learning and invention to occur which was more comprehensive in its management of theoretical aspirations, societal concerns and material realities. The differences were equally significant however. While the use of prototypes in short design studies enables students to recognize the potential marriage between theoretical concerns and construction it can fail to open up the broader discourse implicit within materials and their assemblage into form, from the economic to the cultural or the regulatory, which influence the outcome of a project, such as at Cheticamp, and which are too easily overlooked in the controlled environment of the studio.

Image 3**: Cheticamp, Nova Scotia Construction, NAR 2006**

4 Irish Timber & Sustainability

Shifting attention from the formal to the material in design practice should not imply the loss of a broader discourse and intelligence being brought to bear on the creative process. Suspending our culturally insinuated predisposition to limit material relevance to the aesthetic and the techniques of assemblage opens a vast network of associated fields embroiled in the building materials with which we negotiate. Contemporary issues of environmental degradation, for instance, have forced the global community to recognize the weight of issues that factor in the production, use and reuse of materials. Unfortunately too many advocates of sustainable building practice reduce its potential through generalized principles which, when applied to specific regional contexts, undermine the basic intelligence of the proposition. Application in too generalized a fashion within Ireland has encouraged an expanded use of timber construction, inherently contradictory in a country where the quantity, quality and diversity of timbers available locally is limited leading to the importation of material, carrying with it significant embodied energy costs. A more positive scenario would be to use local timber more effectively in construction, and consider the species currently under cultivation as a long-term strategy.

A recent course at UCD aims to counter this simplified premise through examination of local timber resources across a range of interdependent issues such as historic changes to forestry, the associated ecological, social and economic causes and effects to more specific issues such as the appearance and workability of types of timber. Serving as a foundation for individual student research these lectures also inform the 1:1 collective design/build investigations undertaken by the class to enrich their attitudes toward material use relative to design intentions. The intention is that each subsequent session would focus on different potential applications and alternative construction typologies through the medium of the design build project. In 2007 the indigenous and exotic species currently under cultivation in Ireland was researched, underpinned by lectures in historic trends in woodland development and depletion on the island, contemporary silviculture and forestry management techniques, issues of biodiversity, and properties locally available timbers. These discussions alone raised awareness as to the complexity of economic, environmental, regulatory and cultural issues influencing the management and distribution of timber resources, the implications of which were underlined in the design build projects which followed.

Sitka Spruce, an exotic in Ireland, is the principal species currently under cultivation due to its accelerated growth pattern thus making it the ideal candidate for this initial project. The disparity manifest between the stocks of lumber supplied to the project was sufficient lesson in and of itself regarding the implications of sourcing locally. Irish spruce is significantly more porous and flawed due to both provenance and growing conditions, lowering its structural properties significantly. The scale of available timber was also limited resulting, for this project, in the importation of Baltic spruce which proved both larger, more materially stable and structurally reliable. Though one can describe in classroom settings the quality and scale differential between imported and locally grown spruce, in this setting, where choices having significant consequences on form, detailing and the sheer workability these differences became compelling.

The peculiar artifacts, which occupy the college green, are welcome additions that sponsor continual occupation. Equally, the traditional wood joinery used serves its own educational purpose [Image 4]. But the critical knowledge acquired in this course was the breadth and complexity of issues raised when one examines any building material closely, expanding an awareness well beyond notional ideas concerning appearance, material properties or assembly to encompass the social and cultural constructs so often associated with more formalist concerns.

Image 4**: Irish Timber & Sustainability 2007, Design | Build Team: Sorcha O'Higgins, Neal Patterson, Cormac Fahey, Neil Gleeson, Finn Christiansen, Tim Varian, Patrick White, Hugh Dolan, Brian Guckian**

5 Conclusions

When a poet's mind is perfectly equipped for his work, it is constantly amalgamating disparate experiences; the ordinary man's experience is chaotic, irregular, fragmentary. The latter falls in love, or reads Spinoza, and these two experiences have nothing to do with each other, or with the noise of the typewriter or the smell of cooking; in the mind of the poet these experiences are always forming new wholes.

T.S.Eliot, Metaphysical Poets

As a student of architecture I was told that architects were poets, thus were born into, rather than trained for, their profession. Though initially unconvinced experience has shed light on the implied meaning of such a statement. It is in the *constant amalgamation of disparate experiences into new wholes* that the practitioner of architecture shares an alliance to the poet. But like a poet one must be educated in the traditions of one's craft, as Eliot argues elsewhere.

The transfer and appropriation of diverse fields of knowledge within the discipline of architecture is essential to the meaningful practice of the craft. But to be truly valuable it is essential that a synthesis occur between the practicalities of building and the insights of experience and knowledge from other traditions. A synthesis possible by understanding the complex network of relationships that underpin materials and their use within society, best achieved through a tactile engagement, which enlivens our traditional intellectual training.

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PROSTHESIS, TECHNOLOGY AND TRAUMA IN THE MACHINIST FETISHES OF OMA'S VILLA AT BORDEAUX

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Abstract

The paper will look at the historical notion of prosthesis through an analysis of Rem Koolhaas's 1998 *House at Floirac* where technology becomes the literal and spiritual generator of the space mediating, through architecture, the uneasy collision between the body and the machine. Organised around a centralised passenger lift for the wheelchair bound owner of the house, and enveloped by the associated family spaces, the house is a highly calibrated architectural object which supplements the body and its internal desires, while at the same time being dependent upon it for its programmatic completion. In the House at Floirac technology is problematised as competing internal and external programmes which a spatial conversation between the sky and ground. The paper will explore the themes embedded in the spatial programme of the House at Floirac by connecting it with the broader theoretical speculations of OMA and a cultural history of prosthetics. Read as an extension of Koolhaas's gendered observations of the architecture of Manhattan, and eroticised speculations in "Strategy of the Void", the House at Floirac is evidence of a much deeper strand in OMA's work through which technology and the body are entwined.

Keywords: OMA, Rem Koolhaas, Prosthesis, Sigmund Freud, Psychoanalysis

1 Introduction

The problematic nexus between architecture, the body and the machine, first framed in the Enlightenment by the prosthetic imagery of Piranesi and Diderot, has been a favourite theme of avant-garde practices throughout the Twentieth Century, but particularly in the tumultuous interwar period. Representing a consistent trope in the writings of Surrealism and drawing indiscriminately from the work of Sigmund Freud, technology is positioned as a prosthetic "trauma", which mediates the relationship between the body and architectural space through a host of sexually originating psychoanalytical fantasies such as castration, seduction and the intrauterine. Accompanying these practices was a new cinematic regime where the body, the machine and the architectural volume were intimately connected as the nomadic agents of visual experience.

This paper will look at the way that a resurgence of these avant-garde practices can be read in the recent work of OMA, and specifically in the widely published House at Floirac (known also as the Maison á Bordeaux). Drawing from recent investigations in art theory, the paper will demonstrate how the House at Floirac is representative of a much broader architectural manifesto that, while not consciously articulated in the texts of Koolhaas, is inscribed in the work of OMA. This hidden programme seeks to problematise the relationship between architecture and technology by internalising the machinist logic of modernism and establishing highly eroticised connections between the architectural object and the human body. In the House at Floirac, technology becomes the interface between the living body and space, directly implicated in its protection and gratification as well as its marginalisation and exclusion. Throughout the house technology is articulated programmatically as a spatial exchange between substance (the material) and absence (the void).

2 House at Floirac and the prosthetics of programme

Since the early eighties OMA has concerned itself obliquely with the artistic resolution of the problems of the house. While recognised for their urban projects, the House at Floirac is only the most recent in a series of highly refined residential dwellings which sit on natural sites, with expansive views, removed from urban “congestion”, and surrounded, in many instances by nature. Completed in 1998 on the rolling hills surrounding the French city of Bordeaux, the $500m^2$ House at Floirac responds aggressively to the internal complexities of a steeply sloping site, the idiosyncratic requirements of the client and, more discreetly, to the overwriting intellectual themes that have governed OMA’s expanding body of architectural work across the last 30 years. In each of these categories, the external programmatic desires are mediated through an internalised order of technology, resisting gravity, domesticity and, most violently of all, the historical bond between form and programme. In this way the house uses technology to create an intimate connection between the architectural object and the bodies that inhabit it. It functions, in the historic sense, as a prosthetic, enabling and enhancing the body/inhabitant, but at the same time constraining it.

The story of the commission for the House at Floirac is well known: originally commissioned by a married couple, the husband (after the initial commission) had a serious car accident which confined him to a wheel chair. The house was, as a result, designed around this altered brief, to create a space of freedom and versatility where the husband would be assured maximum mobility and access to the dramatic views that surrounded the site. As a result the House at Floirac is organised around an internal platform lift (3m x 3.5m) which functions as a movable office (what Koolhaas calls a ‘station’) and allows him access to the various levels of the house as well as the three-storey storage wall which houses his books, artwork and wine cellar. Around this diagram, three separate levels are arranged. The ground floor, carved out from the rock on one side, houses parking, kitchen, servant and guard spaces. Koolhaas describes this residual level as “cave-like—a series of caverns carved out from the hill for the most intimate life of the family” (2000, 54). The middle floor, an extended living zone, is largely transparent with operable glazed partitions opening onto an expansive deck area. Above is an enclosed box, punctured with scattered glass portholes. The floating steel box houses separate dwellings for both parents and children, or in Koolhaas’s words: “a house for the couple and a house for the children” (2000, 54). The final line of Koolhaas’s short narrative text for the house is the widely quoted epigram “a machine was at its heart.” The line has been central to almost all writing on the house, both theoretical and otherwise.

A vast array of spatial strategies connect the House at Bordeaux with a broader culture of psychoanalysis. The striated family home, separated from servants, is divided in its nature between children, mother and father in a concentric oedipal configuration. The house is also, as Dovey (2002) has illustrated, patriarchal in nature, giving unprecedented architectural supremacy to the male father figure despite his disability. While there are four separate vertical circulation stacks in the house, the central lift, which becomes an office, study and viewing platform for the wheelchair-bound father, takes spatial predominance and creates an internalised male sanctuary within the broader envelope of the family. To control the centre is thus to displace the father. There is also a mythic dimension to the way the house nests its “earthy”, wet spaces in the ground, creating a clear, transparent internal platform and an ornamental floating box above. The box, floating in the sky, becomes the symbolic face for the building, while the internal plumbing is nested deeply in the bowels. Servicing, servants, kitchens and residual activites like storage and parking are contained on the lower level. Living, is contained in the transparent intermediate zone with commanding views of the surrounding area. The elevated box, punctured with carefully positioned visual openings, becomes the place for sleeping, dreaming and the unconscious. These three stratified zones comply to widely held polarities in psychoanalysis such as ground/sky, solid/void, conscious/unconscious, wet/dry, visual/sensual and indirectly, male/female. Technology, manifested in the inner hydraulic platform (connected through telecommunications to the broader world) and the externalised structure which constrains them—is the physical and conceptual connection that links these conflicting poles of psychic space.

Koolhaas, as well known for his charismatic texts as for his buildings, has remained conspicuously silent on the question of the house and its relationship to his work. As Koolhaas said famously of Manhattan (1977, 9) the residential projects of OMA can be read as "evidence without manifesto"—idiosyncratic obsessions unadorned by any conscious or deliberate text or polemic that accompanies and justifies the architectural objects and their spatial arrangement. While Koolhaas has accumulated a vast and expanding written oeuvre addressing the way that architects should engage with the problems of the city, the relationship of the home, the house and the family remain untheorised. As Bart Verschaffel (2003, 161) points out, not only are terms such as "house" omitted from the expansive glossary of quotes that runs continuously across the length of *S, M, L, XL* but photographs of the intimate, central spaces of the completed houses are rarely revealed. This absence creates a "void" in Koolhaas's otherwise consuming rhetoric about the function of architecture and its relationship to the broader urban projects of OMA. Verschaffel attributes this silence to a Roman "withdrawal" from society where the houses function like Palladian Villas as a (untheorised) respite from the hectic life of the Roman city, or, in this case, the highly publicised urban projects, of OMA. For Verschaffel, the silence guarantees an autonomy and independence for the houses, freeing them from the theoretical constraints of the practice as well as the intrusive spectre of publicity. While this "creative respite" explains in part the apparent omission of a theoretical attitude towards the house in OMA's work, this paper will argue that the projects, and in particular the House at Floirac, represent an important arm of OMA's creativity and, in Koolhaas's terms, constitute a kind of "petri-dish" where the broader intellectual themes of the practice are expanded and articulated. The House at Floirac can be read as evidence: a manifestation (or even crystallisation), in a highly specific architectural sense, of the overwriting themes—technology, the interior and the centre/void—that have predominated over the last 30 years of OMA's creativity. Rather than a withdrawal, the house in OMA's work represents an internal laboratory where the body and the architectural machine are placed in a state of perpetual crisis.

3 Prosthetics: the machine, the body and the mechanical heart

Writing in 1992, before the commission for the House at Floirac had even arrived, Spanish critic Alexandro Zaera (1992, 6-31) wrote that:

> "OMA's recent projects […] constitute bodies rather than objects. Body in the sense of material without linguistic overcoding; neither pure nor fragmentary forms, but vague essences: rounded, elongated, oblong […]. No more constants, no more ideal forms, nor their fragments but instead their deformations".

The observation, repeated in *S,M, L, XL* (66) under the glossary title "bodies", is made explicit in Koolhaas's accompanying text for the House at Floirac. By insisting that "a machine was at its heart", Koolhaas renders the house anthropomorphic (through the possession of a heart) as well as prosthetic (through the machinery which proliferates it). As the machinery of the house becomes "human", the human inhabitant is equally symbiotically connected with machinery, firstly his wheelchair, and then the lift which controls his access, and the access of others to the house. While the focus on the "machine" has been central in many analyses, it is the way that the "body" interacts with this machine that is revealing of a deeper ancestry. It has immediate associations with prosthetics and the complex Twentieth Century history of humans, machines and the spaces that enclose them, in particular those of the house.

Anthony Vidler has argued on a number of occasions (1990, 2006) that a transition occurs over the course of the Twentieth Century from the constructed humanist body (present from Vitruvian Classicism to the high Modernism of Le Corbusier) to the psychological or pyschoanalytical body which, rather than being the idealised inhabitant of architectural space, is transformed into the constructing body, which shapes spaces through its insecurities, phobias and compulsive disorders. This schema of the body was explored widely in Surrealism, particularly through effects of photography and film. The House at Floirac accelerates this 1920s view of prosthetics, to the point where the architectural envelope and the human body become seamlessly entwined and symbiotically dependent on each other. The body completes the architecture as much as the architecture enhances the body. Programme is constructed as a prosthetic to architectural space, enhancing and enabling, but also infiltrating its autonomy. With the evolution of technology, the nature and awareness of this “prosthetic armature” is increasingly less visible, to the point where its operations are so discreet that they can be silently embedded within the body or the architectural envelope which encloses it. They are no longer supplementary, but part of the physical material and psychological substance of architecture and the body. In Floirac, this relationship is dramatised. As Beatriz Colomina wrote, following her visit to the house in 1998

> “The ideal client of modern architecture, the culmination of a century of research, is a wheelchair bound body, mechanised in its movements, fully connected to cyberspace. The free section extends seamlessly into the internet.” (45)

The House at Floirac, while locating a machine at its heart, is at the same time creating a void, or an empty space fulfilled only by a silent technology. The human body, no longer adequately equipped to experience the house, becomes supplemented by the technology of the lift, and, in the process submissive to it. The moving hydraulic lift controls the space in plan and section filling the central spaces of the sleeping quarters, living space and domestic kitchen when it is in place, and creating a void, unprotected by balustrades, when it, and the father, is absent. The father’s body is dependent on the lift for mobility, and the house itself is dependent on the presence of the father’s body for stability or completeness. The prosthetic machinery of the house in this way acts as a supplement not only to the father (allowing him exclusive access to his most intimate possessions), but also his marriage (completing the floorplate of the couples sleeping quarters) and, most dramatically of all, the family (functioning as the central zone of the living quarters and as an empty void when the father is absent or elsewhere in the house).

The structure of the house is equally prosthetic, celebrating the house’s vulnerability rather than its stability. Poised dramatically on an oversized column and beam at one end (the parents), and delicate cable connection at the other (the children), the support of the floating box creates a dialogue of push/pull; compression/tension. If the cable is to snap, as engineer Cecil Balmond reveals in his notes for the structure (2002, 30) the box will tilt precariously; not enough to collapse, but to remain in a state of perpetual instability until the cable is reinstalled. Despite the simplicity of the box floating above the landscape, the harsh complexity of the technology that locates, positions and ultimately impales the box is indiscreet and, throughout its operation invasive in its relationship to the body and space.

Where the mechanical (moving) technology of the house is internalised, the structural (static) technology of the house is dramatised creating a complex dialogue between interior and exterior. The mechanical celebrates gravity, the structural resists it. In each case these technologies are positioned against their opposite. In the structure, stability is architecturally married with the drama of collapse. In the mechanical lift core the presence of the moving platform which connects the house, is equally experienced against the hole created by its absence. In each case the body is made aware of its prosthetic nature, enabled through movement but paralysed through collapse. It is through this diagram that technology is articulated not as the *substance* of architecture (its material), but as the *absence* of architecture (the void).

4 Technology and the Interior: Voids and Cavities in the spatial strategies of OMA

The relationship between substance and absence which underpins the technological schema of the House at Floirac is, rather than an isolated fetish, a central motif in the work of OMA and in the writings of Koolhaas in particular. While difficult to historicise, the gymnastic nature of OMA’s practice over the last 30 years has moved from the obsessively programmatic (embodied in the canonical urban plans of Melun-Sert and the Parc de la Villette of the early 80s) to the relentlessly formalistic (recognisable in the more recent programmatic ambivalence, such as the seamless transition from House Y2K to the Casa de Musica). Within this is an attitude towards technology that is, for the most part consistent and, at the same time, radically polemical in its relationship to modernity. The themes embedded in the House at Floirac, as well as responses to an idiosyncratic problem of housing, can equally be positioned in a much broader intellectual context, informed by Koolhaas’s writings on the city, and inherently embedded in the primary conceptual preoccupations of the practice.

Koolhaas's fascination with technology was first articulated in his 1978 book *Delirious New York*. Koolhaas's retro-active manifesto for Manhattan was based intrinsically on the logic of the passenger lift and the programme of the repetitive grid, advocating a bustling, imperfect urbanism where blocks are transformed into competing city-states by the spatial autonomy of vertical movement. Koolhaas linked the architecture of Manhattan to the surgical processes of the "lobotomy" whereby the outer skin of the building is freed from its internal programme. The passenger lift enabled a "vertical schism" where independent floors could be isolated and used for a range of programmatic activities unconstrained by activities above or below them and independent of the expression of the external façade. This programmatic separation between the interior (services) and the exterior (clothes) of the building is inherently related to anthropomorphic readings, from the "surgical" analogies that Koolhaas' uses to describe it to the metaphorical association between city blocks and soldiers, aggressively poised in potential combat.

However the connection between bodies and the internal schema of Manhattan, is at its most eccentric in Koolhaas's account of the Architect's Ball in *Delirious New York*, originally published in *Oppositions* (1974). Here the dialectic between external clothing and internal servicing is expressed literally through the extravagant costumes which saw leading architects come dressed as the iconic buildings they had designed, comprising a literal human army of high-rise buildings documented unemotionally in a sober press photo from the time. The only feminine representative amongst the collection of men is, as Koolhaas points out, the "basin girl" who:

> carries a basin as an extension of her belly; two taps seem even further entwined with her insides. An apparition straight from the men's subconscious, she stands there on the stage to symbolise the entrails of architecture, or, more precisely: she stands for the continuing embarasssment caused by biological functions of the human body that have proved resistant to lofty aspirations and technological sublimation. (157)

This technological schema that is articulated in the House at Floirac was central throughout Koolhaas's analysis of New York: torn between competing impulses of structural defiance and biological necessity. The prosthetic relationship implied in the observations on the Architect's Ball is a crisis played out between ostentatious external expression and convoluted internal conceit. This spatial "labotomy" separates the necessities of technology at the interior from the external architectural expression creating a clear dialogue between interior/exterior and up/down. Koolhaas returns to the "masculine" struggle against gravity (1978, 158) in his discussion of the Downtown Athletic Club where verticality, enabled by technology, has lifted the well-toned Metropolitanites "beyond the reach of fertile brides". In a moment of Nietzschean candour Koolhaas writes "the men are on a collective 'flight upward' from the Spectre of the Basin girl."

These two competing, gendered and overtly simplified technologies, one upward towards the sky and the other downward towards the ground, are replete throughout the work of Koolhaas and explicit in the House at Floirac. Already present in *Strategy of the Void*, OMA's unsuccessful competition entry for the Paris Biblioteque, Koolhaas connects the relationship between positive and negative space with explicitly sexual imagery. The image which introduces the project in *S,M,L,XL* is a sexualised image, where the male genitalia is replaced with a void, a manufactured "gap" in the image screen. This omission or censure (observed by Whiting (1999, 52) in her interview with Koolhaas as a "very one directional eroticism") is descriptive of the project where the solid spaces are inverted, becoming in themselves cavities. Public space is conceived as an "absence of building" in an otherwise continuous block of information and technology.

The erotic nature of Koolhaas's work in well known. Kipnis describes his model of dismantling conventional programmes as "[m]ore like a sadist than a surgeon" (1998, 29) and Matthew Stadler considers him "our most profoundly carnal architect" (127). For Stadler, Koolhaas's work should not be read theoretically, but phenomenologically, through the experiences and implied sexuality of the spaces and programmes. This is a theme in critical accounts of the House at Floirac which have isolated the "gendering" of its spaces, explicit in Koolhaas's own terminology: "the *man* had his own 'room'" which contained everything the "husband" might need. Dovey points out that while the programme is not inherently chauvinistic (a female could occupy the lift space) it does make the lift intrinsic to the power structures which underpin the spatial programme. The perceived gendering of space is further confirmed by its isolated inclusion in Joel Sander's work *Stud: The Architectures of Masculinity* which implies a connection with the bachelor pads of the 1960s portrayed in Playboy magazine, where the cavities of walls became the embodiment of technology (from hi-fi equipment to rotating beds).

Sanders describes the House in Floirac briefly as a “prosthetic architecture” where the central male occupant is granted “visual and physical freedom, attributes necessary for the successful performance of masculinity.” (21)

While these gendered themes in the house are pervasive, they are embedded in a much more complex schema of technology. The dialectic that Koolhaas establishes in Manhattan and hypothesises in Strategy of the Void is not so much between male and female, but between the technologies of structure (exterior) and biological mechanics (interior), effectively displaced by the spatial “lobotomy” that sees the programme and its expression disconnected. This dialectic between substance /absence, solid/void achieves its most lucid diagrammatic expression in the House at Floirac where the mechanical and structural technologies that underpin the house are effectively dramatised as the internal and external expression of the building, harmoniously complementing the vertical aspirations of the programmes they encompass. Expressed metaphorically as a complex labyrinth of family life, striated between earthy, residual spaces below and elevated floating spaces above, the house embodies these competing aspirations towards sky and ground. The technological umbilical cord of the central patriarchal lift becomes the passage into and out of this internalised labyrinth, functioning as a “prosthetic” against the castrative effects of the internal programme and enabling the human body to engage with the architectural envelope and, at the same time, escape from it. At Floirac, architecture is expressed as this exchange between competing prosthetic technologies into which the human body and its associated desires are irrevocably sandwiched.

It is within the context of Koolhaas’s theoretical speculations, and a historical notion of prosthesis, that the relationship between the body, architecture and technology in the House at Floirac can be conceptualised. Constituting an internalised prosthetic, the boundaries between architecture and the body at the House at Floirac become irrevocably displaced by the competing technologies which position it. Rather than an isolated intellectual speculation, the themes embodied in the spatial programme of the House at Floirac are part of an internalised trajectory that has been central to the architecture and research of Koolhaas, and the Office for Metropolitan Architecture.

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TRANSFORMING METAL INTO SKIN

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Abstract

Frank Gehry's 1997 Guggenheim Museum Bilbao drew international attention to the physical and rhetorical potential of titanium for use as a building 'skin.' Titanium was transformed from a material previously associated with the aerospace, medical and jewellery industries into a signifier of architectural eloquence. Metal and metal-clad buildings have a largely functionalist history in architecture of the past century; some are intentionally severe, while others result from necessity occasioned by poverty. Less commonly, they are the work of architects including Gehry, Kisho Kurakawa and Daniel Libeskind using metals such as titanium for their physical and narrative possibilities. This paper examines the extended possibilities of the metal-clad building through the tectonic and metaphoric use of titanium, set in the context of the historic uses and symbolism of metal in architecture. Titanium is one of the most common elements in the earth's crust. It is assertively resistant; to heat, to electrical current, to decay, and to the metal working techniques common to most other metals. In architectural application, it is a post-industrial material that challenges the traditional hierarchy of material use. In the hands of architects such as Gehry, Kurakawa and Libeskind, the titanium skin becomes a medium for poetic transformation of architectural form.

Keywords: Titanium, architectural skin, architectural metal, Frank Gehry.

1 Transforming metal into skin

This paper examines the metal-clad building through the tectonic and metaphoric use of titanium, set in the context of historic uses and symbolism of metal in architecture.

Frank Gehry's 1997 Guggenheim Museum Bilbao spectacularly demonstrated titanium's potential as a building's 'skin.' Bilbao's 'quilted' titanium wrapping drew international attention to the physical and rhetorical potential of the metal, transforming a post-industrial material previously more readily associated with aerospace, medical and jewellery industries into a signifier of architectural eloquence. In the following decade, other architects adopted titanium as a material appropriate for twenty-first century architecture. In 1999, for example, Kisho Kurakawa, sheathed his eloquently gestural addition to the Van Gogh Museum in Amsterdam with matt-finished titanium.[1] More recently opened in 2006, Daniel Libeskind employed titanium cladding in his first completed building in North America, the Frederic C. Hamilton Building extension to Colorado's Denver Art Museum.[2] These and other late-20th/early-21st century buildings reply upon the language of metal as a building's 'skin' or covering 'fabric,' while reinterpreting the traditional hierarchy of material use. Since Bilbao, and accompanied by its increasing affordability, titanium has been successfully promoted as a 'material of the 21st century.'

2 Skin and bones

Discussion of the language of building cladding or skin has a long history, especially since its consideration in the context of material and materiality by German architect Gottfried Semper in the mid-nineteenth century, and his advocacy of 'dressing' (*Bekiedung*)[3] as foundational to understanding the origins of architecture.[4] In *Der Stil*, published in 1863, Semper included an important discussion of the "four elements" of architecture based on his observations of a Caribbean hut displayed in London at the Great Exhibition of 1851. Harry Francis Mallgrave, in *Gottfried Semper: Architect of the Nineteenth Century,* describes Semper's encounter with the "Caraib hut" [*sic*] as the "simple habitat [which] exemplified for him perfectly his 'four elements' of architecture in their prototypical form" (198).[5] These individually distinguishable elements, the mound or platform, a tectonic framework supporting the roof, and the woven walls hung between the roof supports, comprised the archetypal architectural form for Semper (Mallgrave 197–199).[6] They represented a 'return to origins,' as for Vitruvius in the first century, a return to authentic order. The 'skin and bones' of Bilboa has resonance with Semper's allusions to weaving, and dressing, especially where the 'woven' substructure which supports the thin 'quilted' titanium cladding is seen in construction images. Semper's discourse on structure (load bearing), cladding and dressing was continued by others through the nineteenth century, including in 1898, Adolf Loos' "Law of Dressing" (*Gesetz der Bekleidung*).[7] Otto Wagner, in his guide book for students, *Modern Architecture*, emphasized the evolution of the "basic forms of supports, walls and rafters to art-forms [*Kunstformen*]," which suggests craft forms such as carpets or tapestries (93).[8]

Through the twentieth and early twentieth centuries, building skin possibilities expanded exponentially with the emergence of advanced materials and technologies. Continuing the model established in Joseph Paxton's Crystal Palace for the Great Exhibition of 1851, subsequent international expositions through the twentieth century provided a setting for architectural experimentation in materials and form. At Expo '67 in Montreal, for example, Frei Otto and Rolf Gutbrod's German pavilion was noted for its spectacular steel cable, 'woven' tensile mesh structure, and translucent skin (Mattie 232–233). At Expo '70 in Osaka, [9] The USA Pavilion, designed by architects Davis, Brody, Chermayeff, Geismar and de Harak Associates, was a 142 x 83.5 metre super-elliptical structure consisting of a shallow pneumatic skin of white fibreglass-coated vinyl over a grid of steel cables. The 29 April 1970 *Architect's Journal* declared it "the most significant new structural technique at Expo" (1064). Thirty years later, as Christian Schittich observed, the 2000 Expo in Hanover was a "fair for skin materials, a trade fair for contemporary potentials," noting the Finnish pavilion's glass skin, and the Iceland pavilion's membrane structure, where water flowed on all sides (21). Such exemplars set the aesthetic and metaphoric understanding of titanium in the context of late Modernism's penchant for 'transparency.'[10]

Titanium – named for the Greek god, Titus – is one of the most common elements in the earth's crust. Though identified as an element by the 18th century, efficient extraction technologies for titanium, and its sister refractory metals tantalum and niobium, were not developed until the 20th century**.** In metal form, titanium is highly refractory**,** strong and corrosion resistant. Low specific gravity and resistance to heat conduction facilitates its extensive use in aerospace rockets, as well as in the construction of jet fuselages and engines. Titanium is used for replacement heart valves which require a light weight, biocompatible material that remains inert in bodily fluids. The metal's working properties are limited by the technical difficulty of processes such as welding, such that larger-scale sheet use in aerospace or architecture is usually in cold-connected form. Its capacity to be decoratively treated with interference colouring (a process later described in this paper) was initially explored by jewellers, especially in the 1970s and 1980s.

This adoption of titanium into the lexicon of contemporary architecture participates in a complex history of the functional uses and symbolic social value of metal. Metal and metal-clad buildings, for example, have a largely functionalist history in the architecture of the past century. Some, such as structurally economical Quonset or Nissen huts, or transportable buildings destined for scientific use in extreme climates, were intentionally severe. Others resulted from necessity occasioned by varying degrees of poverty. Less commonly, metal or metal-clad buildings are the work of architects using a particular metal for its physical and narrative possibilities and through that process re-negotiating, or transforming, the material's relative status. Notable exemplars include Buckminster Fuller's c.1949 aluminium-clad *Dymaxion* house, and Frei Otto and Gunter Behnisch's spectacular steel cable net and polyester fabric 'tents' for the 1972 Munich Olympics, and more recently the work of Glenn Murcutt.

Application of metals, including titanium, aluminium and steel, as finish or cladding in twentieth and twenty-first century architecture is set within the larger history of the functional and decorative uses of metal in architecture and the emblematic roles of metal in society. Metals play a central role in most civilizations, such that ancient cultures were in part defined by the metals that they processed and used for vessels, weapons and for ritual, as in the bronze age and the copper age. Until the 17^{th} century, the functional role of metal in architecture was predominantly that of joining, as in hinges, locks, strapping, fastenings and nails. As such, metal both symbolised and bore an essential role in the fabrication of buildings, marking the place where one material met and supported another. It was traditionally celebrated in doors, where its expense and refinement could be appreciated, and its values celebrated. Elsewhere, architectural metal defined a physical condition of boundary, as exclusion, forced enclosure, or barricade, as in the bars of prisons, or treasuries. Metal used as finish or as cladding of a roof or walls has another history, linked to but partially distinct from its use as a joining element or structural component. Like metal in the larger setting of society, metal in architecture participates in an extended discourse of value and of symbol. Gehry's, Kurakawa's and Libeskind's use of titanium 'skins' is necessarily situated within this broader historical context.

It is a truism to say that gold is commonly held to be the standard bearer of value for metals. From the ancient world, where knowledge of gold working was highly developed, gold artefacts are comparatively plentiful. Etruscan vessels made from electrum, a naturally occurring alloy of gold and silver, have occasionally been found in the Tuscan region of Italy. Pure silver objects, however, are exceptionally rare, as large silver deposits had not then been discovered. While symbolically and metaphorically gold is historically pre-eminent, in monetary terms other metals have borne similar or even greater relative value. In each case, such value reflects comparative rarity, the difficulty of extracting the particular ore, the technical challenges of alloying or working or a combination of such factors. This is in contemporary times the case with the precious metal platinum, with certain rare ores, and historically the case with other metals, including aluminium and titanium.

During the European Industrial Revolution in the 18^{th} century, metal took on greater structural, architectonic roles, as the technologies of iron and steel working rapidly developed. The imperative to transport increasing numbers goods and people resulting from the twin factors of industrialization and urbanization gave impetus to development of bridges and railway stations where metal became the predominant structural material. In 1778-79, Coalbrookdale Bridge (designed by Abraham Darby III and Thomas F. Pritchard) became the first cast iron frame bridge, constructed over the Severn River at the site of an ironworks dating from the late 17^{th} century. An immediate success, it was followed by other celebrated 'marvels' of engineering. Many endured, including the graceful Clifton Suspension Bridge over Avon Gorge, Bristol, designed in 1830 and begun by Isamabard Kingdom Brunel, is still in daily use. Improved metal casting techniques soon facilitated development of wide span construction in railway stations including in 1854 the New Street Station in Birmingham and the second Paddington Station in London. Railway station facades, however, remained aligned with more 'classical' notions of appropriate public space.

The use of metal for structural skeletons of buildings was established by the first half of the nineteenth century, especially in the design of winter gardens and conservatories. Here the inventive structures of Joseph Paxton came to the fore. Though not the first to design a 'glasshouse,' Paxton improved the conservatory type in greenhouses through the use of iron structures while maintaining wooden substructures for the glazing. In the 1836 Chatsworth greenhouse in Devonshire, Paxton developed the structural language that would be employed in his design for the Crystal Palace in 1850.[11] In Paxton's buildings, like other mid-19^{th} century exemplars such as Burton's 1845 Palm House at Kew Gardens, iron frames were entirely clad with glass supported in light wooden frames. While the modular structural framing was admired, especially in the Crystal Palace, it was the glass that particularly excited the public fear and imagination. The material of glass and its allegories of transparency subsequently became powerfully emblematic of twentieth century architecture in the work of Mies van der Rohe and others.

The history of aluminium's transformation into an architectural cladding material provides an example comparable to that of titanium. Prior to development of modern smelting and mass manufacturing techniques, the monetary value of aluminium in the 19th century was analogous to gold. In the Paris International Exhibition of 1885, for example, a bar of aluminium was displayed as a wonder of the modern age. When refining and manufacturing capabilities expanded in the 20th century, aluminium became used increasingly in domestic artefacts such as jewellery and furniture, then was put to service in the developing automotive and airplane industries, and in architecture, where its role was both functional and symbolic.[12]

In the 1930s, aluminium was dramatically used to sheath the top of the Chrysler Building in New York City. Crowned with a thrusting spire and powerful aluminium bald eagles functioning as did water spouts on gothic cathedrals, the Chrysler Building epitomized the optimism, expansiveness and industrial modernity of the United States. Images such as Margaret Bourke-White's 1938 photographs of the aluminium-clad, eagle-headed zenith offered powerful confirmation of such beliefs. The time of the Chrysler Building also coincides with the rapid increase in advertising in the press and in the expanding audio media in the United States. Where in earlier centuries sacred architecture served as a city's identifying marker, by the 1930s, edifices such as the Chrysler Building establish a new decorum, becoming advocates for a new status of architecture, and for the status of a city.

The use of aluminium in the Chrysler Building reiterates another historic use of metal in building, that of value signifier where used as a spire or roofing material. Gold, in leaf or fused tile form, was naturally the supreme material with which to sheath the apex of a usually sacred building. Occasionally gold was used even more lavishly, as on the Shwedagon Pagoda complex in Myanmar, and on *Kinkakuji* (Golden temple) in Kyoto. Elsewhere, the gilded laurel leaf dome of the secular Secession building in Vienna deliberately alludes to this tradition in metals. Cladding a roof or spire with a less noble but still costly metal such as copper was in the nineteenth and twentieth centuries comparatively ubiquitous, such that copper roof tiles on houses are widely found in the United States and in Europe, but only on the homes of the wealthy. Titanium architectural skins have in the past decade articulated a parallel material 'language,' especially where used to signify a building as a 'destination' in itself, and as such to embody and convey the values and status of the city. Simple use, however, does not necessarily delight the eye, when the signage is adopted with insufficient exploration of its potential. This appears the case with the Cerritos Millennium Library in Los Angeles, which on its website claims for its 1999–2002 the distinction of being the first titanium clad building in the United States.[13] The Library additions, undertaken by Charles Walton and Associates, who had completed an earlier award winning expansion in the 1980s, constitute a polite building. The 'sign' is present, but its articulation is rather prosaic.

In finishing treatments, titanium differs from other metals in its capacity for modification with optical interference colours. These are achieved through electrochemical deposition of surface oxide films, rather than by patination or by the use of metallic dye salts, as for aluminium. In brief summary, the surface of ferrous metals such as steel, and non-ferrous metals including copper, bronze and silver, are often chemically treated through patination to achieve a wide range of colours.[14] Aluminium anodizing is an electro-chemical process through which a honeycomb surface of aluminium oxide is 'grown' in an sulphuric acid bath. The porous surface can be coloured with various metallic or organic dyestuffs, then sealed in a water or water/chemical bath. The anodizing process differs from the dyeing of textiles, for example, where colour is bonded with the fibre; in anodized aluminium, colour is effectively trapped within the cellular surface structure. In titanium, colour is achieved through utilization of the optical qualities of light refraction, resulting in 'apparent' or interference colour in the same sense as a film of oil on water appears to have colour.[15] Titanium is especially receptive to interaction with oxygen, a property that can be accelerated by applying an electric current through an electrolyte solution to develop a transparent film on its surface. The film is fractions of a micron thick, leaving the substrate of the metal unchanged. Light travelling through the transparent film is refracted at angles dependent on the film's relative thickness, resulting in consistently predictable colours.[16] The film can also be achieved through the application of heat, but the results are generally less controllable and the colour therefore variable.

These particular qualities of titanium permit the architectural use of colours such as rose and gold, as in Gehry's exuberant Marqués de Riscal Winery Hotel, built in Elciego in the Rioja region of Spain. However, while the substrate is stable, and the physical transparent film largely impervious to permanent change other than through abrasion, the apparent colour may be obscured by oil, dirt or other contaminants. In architectural application, this requires a kind of ‘white glove’ handling of titanium sheet in installation, to minimize the transfer of skin oils to the film (Proctor). Post-installation ‘staining’ of the titanium at Bilbao was controversial in its early years, and was variously attributed to effects of atmospheric pollution and to inadequate post-installation removal of residual sealants. Cleaning by mountaineers was planned (Wilkinson).

Gold, in its pure state, does not corrode or deteriorate: it is the alloy metals that leach out over time. Most other metals are less stable, depending on their environmental conditions: iron and most steel rusts, while copper and bronze shift from reds to greens and browns. Nonetheless, metal has a portent of resisting time.[17] As with gold, the physical properties and the metaphor of temporal resistance are especially evident in the case of titanium, which remains inert in all but the most extreme environments. The intrinsic properties of corrosion resistance are such that at least one major distributor, Timet®, warrants its commercially pure architectural grade 1 titanium for one hundred years (Timet).

Titanium architectural skins further participate in metaphors of temporality through their responsiveness to the ambient qualities of light and shadow, reflecting in their surfaces the daily passage of time. While Gehry also uses stainless steel panels, as in the Walt Disney Concert Hall in Los Angeles, this chameleon-like effect of titanium is particularly evident in the jubilant sculptural forms of Bilbao and other of Gehry’s titanium skins. It is more soberly expressed in the case of Kurakawa’s elegant Van Gogh Museum and in Libeskind’s addition to the Denver Art Gallery, where titanium clad ‘crystal’ forms reiterate or embody in the architecture the presence of the nearby mountains. In the hands of such architects, the titanium skin becomes a medium for poetic transformation of architectural form.

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3 Notes

[1] Kurokawa’s 1999 building faces the Van Gogh Museum’s original building, which was designed in 1963–64 by Gerrit Rietveld and completed in 1973 by Rietveld’s partners after his death. See http://www3.vangoghmuseum.nl

[2] The 146,000 square foot Frederic C. Hamilton building, by Daniel Libeskind and Denver-based Davis Partnership Architects opened in October, 2006. It adjoins the Museum’s North Building, designed by Gio Ponti in 1971. See Denver Art Museum Fact Sheet.

[3] See also Harry Francis Mallgrave and Wolfgang Hermann. Trans. Gottfried Semper: The Four Elements of Architecture and Other Writings. 102–106, 246–263.

[4] Semper was preceded in discourse on tectonics by Karl Friedrich Schinkel and Karl Bötticher. See Mitchell Schwarzer “Ontology and Representation in Karl Bötticher’s Theory of Tectonics.”

[5] See also Wolfgang Herrmann, “Semper’s Position on the Primitive Hut,” in Gottfried Semper: In Search of Architecture. 165–173.

[6] See also Joseph Rykwert, “Semper and the Conception of Style,” in The Necessity of Artifice. 122–130.

[7] For discussion on Loos’ “Law of Dressing,” see Mark Wigley, White Walls, Designer Dresses: the Fashioning of Modern Architecture. 10–11.

[8] Wagner noted: “The first human form was the roof, the protective covering, surely a substitute for the lack of a cave. The roof preceded the supports, the wall, even the hearth. After the roof came the supports, artificially built of tree trunks, and stones, and finally the wickerwork, the partition, the bearing wall” (93). He advocated cladding in “a modern way of building […using a panel system of…] nobler material […] to be fastened with bronze bolts (rosettes)” (96). Though outside the scope of this paper, it is of note that Wager asserts his (*Gesumtkunstwerk*) belief in importance of the harmonious ‘cladding’ of a building’s inhabitants: “The appearance and occupation of the inhabitant should harmonise with the appearance of the room” (118).

[9] For discussion of Expo ’70, see Eugenie Keefer Bell, “Celebrating Equivalence: Expo ’70 in Osaka, Japan.”

[10] See Colin Rowe and Robert Slutzky, ‘Transparency: Literal and Phenomenal (Part 2),’ in Joan Ockman. Ed. Architecture and Culture 1943–1968. 206–225.

[11] For an engaging biography of Joseph Paxton, see Kate Colquhoun, A Thing in Disguise: The Visionary Life of Joseph Paxton.

[12] For discussion of the history of aluminum, see Sarah Nichols, Aluminum by Design.

[13] "As the Second and Third Floors of the [Cerritos] Library are future-oriented, the exterior of these levels were wrapped in a skin of titanium. The Library was the first titanium-clad structure in the United States. Titanium expresses the concept of change as it has subtle color shifts from reflecting the angle of the sun and atmospheric conditions. Titanium also allowed for a fluid design with compound curves. The material suggests the Library's "Save the Planet" theme as it does not have a negative impact on the environment and is maintenance free." http://www.ci.cerritos.ca.us/library/libhistory.html

[14] See Richard Hughes and Michael Rowe, The Colouring, Bronzing and Patination of Metals.

[15] Titanium's 'sister' metals, tantalum and niobium, can be similarly treated. Their colours are more intense than titanium, but are less frequently used, due to their significantly greater cost.

[16] For a technical explanation of the small-scale colouring of titanium, see I.J. Keefer [Eugenie Keefer Bell], Spatial Narrations in Metal.

[17] For an evocative discussion on weathering, see Mohsen Mostafavi and David Leatherbarrow. On Weathering: The Life of Buildings in Time.

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ADVERTISING TO ARCHITECTS: CREATING DESIRE AND ESTABLISHING CREDIBILITY IN THE CASE OF ALUMINIUM

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Abstract

Media advertising, sponsorship deals and office visits are some of the main mechanisms through which manufacturers and suppliers attempt to place their materials and products before architects and find a way into professional consciousness. As scholarly interest in the promotional practices of manufacturers and their agents builds, there is a need to formulate and discuss analytical terms and tools for this research. The paper puts forward two terms through which the promotion of new materials and products to architects can be studied: desire and credibility. As a case study, it examines the introduction of aluminium as a building material in Australia in the mid-1930s and its subsequent promotion to become a major part of building construction in the 1950s.

Keywords: advertising, architects, building materials, building products, marketing, promotion, desire, credibility, aluminium.

1 Introduction

In the historical study of building materials, their manufacture and application in the production of architecture, there are a number of studies that consider the specific processes and devices through which materials and products have been promoted to architects. Patricia Cusack has examined the role played by institutional bodies and the journal, Concrete and Constructional Engineering, in promoting independent standards for the use of reinforced concrete amongst British architects in the early twentieth century. In her study of the modernization of existing buildings in the United States during the 1930s, Gabrielle Esperdy recognizes the importance of the marketing activity of material manufacturers to shifts in professional attitudes towards this type of work. In Exporting American Architecture 1870-2000, Jeffrey W. Cody describes the channels through which American materials, building technologies and construction methods have been marketed in different countries. These studies show that building material and product marketing is not a negligible influence on architectural practice. Indeed, over the twentieth century, building material and product marketing has attempted to live close to the world of architects and to permeate the day-to-day tasks of building design and documentation. There are the regular office visits by company representatives promoting the latest catalogues and trade literature making sure office libraries and records are up to date and new products are made known. There is the litany of glossy product magazines and brochures that are distributed and the sponsorship deals upon which many architectural exhibitions, conferences and other events depend. Then there is the ubiquitous flow of product advertising within architectural and building journals and magazines which is produced in the faith that advertising is seen and taken notice of by architect-readers.

In a previous paper I outlined several analytical and thematic considerations for the study of building product advertising (Hogben). Drawing from the work of Judith Williamson and others, the aim of that paper was to show how building product advertisements can be read in detail and unpacked in terms of semiotic analysis. This paper continues this research by proposing that studies can benefit from the examination of two concerns that come into play in the promotion of new materials and products to architects. These two concerns are those of creating desire and establishing credibility. In the well-known A-I-D-A copy formula of "get attention, hold interest, arouse desire, obtain action", desire is a linchpin of the advertising mechanism. What constitutes a desirable idea or image depends on the difference between a perceived lack and the promise of its fulfilment. The illusionary creation of this promise is where advertising makes its play. The question as to what constitutes this space for professional architects is an interesting one and one that promoters and advertisers have configured in various, and often simplistic, ways.

Apart from the imperative to create desire for a new material or product, promoters and advertisers also need to couple this with statements about a material or product's credibility. Credibility depends on technical reliance and also on professional, intellectual and theoretical associations and backings. Generally, advertising cannot contain detailed arguments but rather presents signifiers of integrity and trustworthiness: images, messages and endorsements that provide an aura of seriousness and believability. There have been several consistent strategies for establishing credibility, even in experimental times such as the ones examined here.

To provide a focus and test case for the study, the paper considers the introduction of aluminium as a building material to architects in Australia in the mid-1930s and the rapid take-up of this material in different product forms in the 1950s. The year 1884 saw the first recorded use of aluminium as a building material for the cap of the Washington Monument, yet it was only in the 1920s in the United States and to a lesser extent in Europe that architects started to really appreciate its applications to building construction (Kelley). Aluminium possessed the qualities of being light-weight, non-corrosive, durable, easy to extrude and strong in certain alloy combinations and promoters saw its potential as a substitute for traditional building materials such as copper, bronze, brick and terra-cotta, even structural steel. The introduction of aluminium as a modern building material to architects in Australia occurred under particular discursive circumstances in which desire was a very real factor in the manner of its reception and subsequent promotion.

2 "The most modern of commercial metals"

Aluminium as a building material was theoretically introduced to architects in Sydney through Norman Warren Waterhouse, an engineer, who had travelled to the United States in the early 1930s and upon his return became an expert on the material and wrote a number of articles for Architecture, the journal of the New South Wales Chapter of the R.A.I.A. In December 1935 he addressed a Chapter meeting and presented an outline of the history and uses of aluminium, "the most modern of commercial metals" (34). Waterhouse explained that aluminium was no longer a novelty for architects in the United States and Europe and was now an "established building material" (34). He described in detail the specification options for aluminium and its different alloys. After this, Waterhouse presented a number of examples where aluminium was seen en mass, including the Empire State Building (5,704 cast spandrels and internal decoration), the Field Building in Chicago (3,244 cast aluminium spandrels and 3,285 aluminium windows) and the Waldorf-Astoria Hotel in New York City (26,000 lbs. of cast spandrels as well as skylights and 3,100 aluminium chairs). The most spectacular example was the Rockefeller group of buildings which were under construction during his visit and which would employ a wide range of aluminium applications. Waterhouse reported,

> The total weight of aluminium in the project is 3,000,000 lbs., and 700,000 sq. feet of surface area is aluminium, including 22,000 cast spandrels, approximately 1/6th of the exterior surface of all buildings forming the group, being of aluminium. Many of the spandrels weigh 100 pounds each, and have a semi-lustrous appearance between the limestone pilasters forming the façades of the various units of the development. Due to the use of aluminium in this construction, the reduction in weight on the columns and foundations amounted to 3,000 tons (42).

The images Waterhouse used to illustrate his lecture not only depicted buildings of a scale completely foreign to Australian cities but were also striking in their photographic style and intensity. One of these images showed an aerial view of the R.C.A. building of the Rockefeller Centre with a Pitcairn autogiro passing over the rising building in a show of twin modernity (Figure 1).

Figure 1: **R.C.A. Building, Rockefeller Centre, New York City. From N. Warren Waterhouse, "Aluminium in Architecture," Architecture 25, 1(February 1936): 38**

Many of those at the meeting were stunned at the promise of this material. The President of the Chapter, Arthur W. Anderson, thanked Waterhouse for his "most interesting lecture" and said, "[i]n this part of the world the structural uses, the size, the colour and the application of aluminium is all very new. It appears to have so many different forms, types, styles, etc., that its usefulness is not yet fully comprehended; it is indeed a truly wonderful material" ("Royal Australian Institute of Architects" 22). Colonel Hurst stated that aluminium would "open up a new vista altogether for us" and that "[i]ts uses are so varied that it will fill every want that we have known in the past" ("Royal Australian Institute of Architects" 22).

These enthusiasms for aluminium existed in a realm of desire: marvellous properties and images offering Sydney architects a view of an architectural present in other places and of a material that possessed almost inexplicable possibilities for a profession that was struggling with wasteful and restrictive construction by-laws (Ward 114). In the late 1930s terra-cotta, granite and sandstone remained the main facing materials for major commercial buildings. Wunderlich even had to explain what spandrels were in its advertising. Added to this, there was no aluminium smelter plant in Australia until 1955 and all raw supplies needed to be imported. As it happened, Waterhouse became the local representative for Aluminium Union Limited of Britain, the only aluminium advertiser in Architecture in the late 1930s. War curtailed the promotional momentum built by Waterhouse as the government placed restrictions on the use of building materials for non-military architectural work.

3 Scientific Credibility as Promotional Image

Pre-war enthusiasm and desire for aluminium amongst Sydney's architectural fraternity was mostly fostered by individuals like Waterhouse and images of otherness. This changed after the war with the emergence of the Australian Aluminium Company Pty. Ltd. (AAC) as the major local fabricator of aluminium products using imported feed. Established in Granville, Sydney, in 1936, the AAC's production was initially limited to military requirements, but once war-time restrictions were lifted it expanded operations and in 1948 began advertising its name and brand of aluminium alloys to the architectural profession. In July that year it initiated an advertising campaign that centred on the theme of "The 3rd Metal Age." Published in Architecture from 1948 to 1950, its advertisements promoted aluminium as a modern, universal material with exceptional versatility and advantages over other metals. Each advertisement contained an image or set of images that showed laboratory settings and testing equipment meant to represent the research laboratories of the AAC (Figure 2). The realism of these images was reinforced through the technical captions and a visual emphasis on the objectivity of scientific observation and measurement.

Figure 2: **Advertisement from <u>Architecture</u> 37, 2(April 1949): xxiii**

Inspiration for this campaign is evidently found in the juggernaut of scientific building research that had taken hold of architectural discourse in Australia by the mid-1940s. The Commonwealth Experimental Building Station was established in June 1945 and was modelled on the Building Research Station in England which already had a 25-year history of scientific research into building materials and methods. “Scientific building” and “strictly objective” reporting became the catch-cries of Institute Presidents, journal editors and outside advisers. Technical notes and publications on materials were issued from research organizations. According to Perth architectural educator, W. H. Robertson, the influx of new, scientifically formulated information would revolutionize professional approaches to materials and construction technology: “to arrive at a reliable judgment, we must adopt an attitude of scientific enquiry and approach. . . . To-day, methods of experiment and scientific enquiry can establish in months what the past could do only in centuries. Architectural conceptions, thus widened by the time dimension, are released from the restrictions imposed by empirical methods” (43).

To overcome the lack of empirical familiarity in Australia with architectural uses of aluminium, the strategy of the AAC campaign was to dramatize laboratory realism and tap into the prevailing discourse of science and professionalism and thereby create at the same time a sense of desirability and credibility for their product brand. Furthermore, whilst the advertisements projected an image of objectivity and controlled testing, they also appellated the viewer into a position of authority and centrality by stating that “This research is aimed at providing the exact metal YOU need for your purposes.” A seductive mechanism was incorporated into the circuitry of this campaign that offered the viewer a feeling of ultimate control over need and usage, hence not compromising the idea of the viewer-architect as the design authority. To complete the loop, the AAC placed itself as the source for advising the viewer on the modern qualities and potentials of the material.

Promotional ploy masked as objective appeal was not new to building product advertising, but the themed nature of the AAC campaign with its particular usage of scientific language and visual references is important to the manner in which architectural credibility was being configured in the post-war promotional environment and to the AAC’s strategy for creating a professional market for itself.

4 Advertising the Curtain Wall

Once Australia’s aluminium smelter industry was in operation in 1955, competition between aluminium product manufacturers quickly grew. The AAC continued to advertise in the R.A.I.A.’s journal and was joined by Pain MFG. Pty. Ltd. (makers of Mello-Lite awnings and venetians), Selley’s Chemical Manufacturing Co. Pty. Ltd. (aluminium glazing), Wunderlich Limited, Econo Steel Company and H. T. Worrall & Sons Pty. Ltd. The market for architectural aluminium had expanded into residential design and whilst journal advertising reflected this, the major and most lucrative market was commercial office building construction and the embrace of the curtain wall as its primary architectural treatment. Curtain walling consisted of light-weight materials: glass modulated by aluminium frames. As curtain wall buildings started to appear in Australian cities, so too did the sale offices of aluminium companies. The AAC had established offices in all major mainland cities, and other companies followed, and by 1957 architects faced a fiercely competitive promotional and sales environment. It had become an aluminium age. The emphasis of advertising campaigns at the time had shifted distinctly away from the laboratory realism of the 1940s to a display of scale and productive capacity. Advertisements centred on images of buildings held up as trophies for particular producers with strong perspectives signifying not only the visual sleekness of curtain wall design but also corporate uniformity and strength of direction.

Figure 3: **Advertisement from <u>Architecture in Australia</u> 46, 3(July-September 1957): 34**

This advertising used certain “hooks” to attract attention, foster desire and establish credibility. Firstly, it featured buildings on the drawing board, models of buildings and photographs of completed buildings, all of which were said to be connected to a particular aluminium product or supplier. Whether on the drawing board or as a real edifice, these buildings were shown in a very productive light and advertisements implied that the use of the advertised product resulted in success of production at a large scale. With the amount of new office buildings being commissioned and constructed in the mid-to-late 1950s this message was designed to carry persuasive power. It was a common strategy and used consistently which suggests it was considered effective. Secondly, advertisements featuring images of buildings were published in conjunction with review articles and illustrations of the same buildings. This was the case with Figure 3 and the publication of the M.L.C. Building in North Sydney by Bates, Smart & McCutcheon in the July-September 1957 issue of <u>Architecture in Australia</u>. Another example is the publication of the Qantas Building in Sydney and the advertising that accompanied it. The profiling and review of these buildings in the Institute’s journal bestowed a professional credibility on the building, its design and material construction, which the advertisers could then exploit for their own purposes. Thirdly, several of the advertisements at this time made reference to American buildings and claimed their product makers had knowledge of or were using American testing procedures (Figure 4). This reference to American practice was a powerful hook considering the interest in America and American architecture that pervaded the Australian profession in the 1950s. Pietro Belluschi, Dean of M.I.T., was a keynote speaker at the 1956 R.A.I.A. convention and during his address showed a large range of slides depicting vast building projects recently constructed in the United States. Fourthly, advertising continued to use the themes of realism and objectivity but unlike the advertisements of the 1940s this time the viewer was appellated with promises of commercial success and achievement. The scientific neutrality projected by the earlier campaigns had changed to an open display of corporate building ambition.

Figure 4: **Advertisement from Architecture in Australia 46, 3(July-September 1957): 23**

5 Conclusion

This paper has shown that advertisers have attempted to draw attention to a given material product (in this case aluminium) through the use of hooks that were intended to create desire and at the same time present a credible impression. Campaigns have been built on tapping into desire for the modern, the flexible, the scientifically approved and the commercially productive. These campaigns have appeared when there has been a growth in enterprise and a drive to expand and develop markets and the focus here has been on how aluminium promoters and companies have addressed and advertised their products to architects in Australia.

Such a study can contribute to a larger history of the promotion of modern materials and products to the architectural profession in Australia. Conceived both in international and national terms (as many products have been part of an import trade), such a history (or histories) would show that the introduction of new materials and products and their incorporation into the lexicon of architectural design is a nexus of industrial, commercial, promotional and professional interests. There are a number of documented histories of Australian architectural practices and firms such as Bates Smart (who were major users and beneficiaries of the aluminium industry in the 1950s) and the argument here is that there now needs to be an expansion of focus to consider the industrial and promotional complexes in which their material preferences were formed. This case study is presented as an explorative foray into this field by foregrounding terms and themes through which we can begin to locate lines of connection.

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(BIOLOGICAL) LIFE: THE PEDAGOGY OF AN ARCHITECTURAL CONCEPT

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Abstract

This paper analyses the techniques and technologies mobilized under the imprimatur of biological life in architectural production beyond their manifestations as (bio)mimetic processes. The arguments do not take 'life' as *a priori* to architectural thinking, but as immanent to each enactment of technique or application of technology within the biological paradigm. Using the work of Roger Caillois on pyschasthenia as the collapse of space between an organism and its milieu, the analysis avoids elevating biological life to a transcendent concept. Biological life in architecture instigates the pragmatic concern for whether a philosophical or scientific concept works, or matters, regardless of whether it fits within an ontology or metaphysics. Thus, architectural production using biological life subscribes to a Deleuzo-Guattarian "pedagogy of a concept" – the creation of perceptual and affective habits that are self-jeopardising and highly idiosyncratic to ensure further concept formation.

Keywords: Biological life, biomimicry, immanence, pedagogy of the concept.

1 Introduction

Concepts of emergence and self-organisation in architectural practice, whose foundations lay in the concept of 'life', herald a return of the biological paradigm to architecture. Current transfers of the biological to the architectural stand more as technical and technological concerns – that is, concerns of process and method – than straightforwardly formal ones. In this paper I argue that it is more productive to see biological life in contemporary architecture, especially in the field of experimental digital architecture or what Michael Hensel and others have called "morphogenetic design", as not *a priori* to architectural thinking, but rather as a force effectuated at each enactment of particular techniques and technologies. The potential of the biological paradigm for architecture is much more than its manifestation as mimetic formal or methodological processes because in the enactment of the biological is the very possibility of differential conceptions of life. Life in this case becomes more of a contingent but generic quality rather than a predetermined condition; which moves the notions of transfers of technique, and transformations of the technological, away from instrumentalist definitions. Life *is* the immanence of biological techniques and technologies to its transfers and transformations in architecture.

The aim of this paper therefore is not to find new potentials for the biological paradigm, whether from science and philosophy, to be used in architecture, nor will it outline how architecture is appropriating the biological, or why we are seeing a resurgence of this practice. The paper argues that in the current biological paradigm, the concept of life does not arrive in architecture from the outside through interdisciplinary transfer, nor is it intrinsically internal to the biological. Life as a concept in architecture can be cultivated (as in habits), and remains divergent (as in mood or atmosphere) without relying upon an *a priori* object.

2 Searching for and identifying life

The appeal of a biological paradigm in architecture is, in short, to find relations between the material world and the possibility of its own generation, development and therefore sustainability. This model of the world relinquishes the human being as progenitor and creative source of material transformation towards cultural production. In corollary, the biological paradigm instates the non-human world with an interior, perhaps primordial, creative force given by a certain consistency or organization of the beings within it. What this means is techniques and technologies arising from a biological paradigm in a cultural production such as architecture become the search for life within categories of materiality, systems and their relations, outside the imprimatur of the category called the human being.

The process of identifying life in the material world – to ascertain if something has the quality of being alive or not – whether as biological organisms (animal or vegetative) or biochemically synthetic forms (naturally occurring or otherwise), adheres to strict criteria. The main criterion is the capacity for self-organisation and dynamics. For example, in discussing the literal transfer of the biological paradigm into architecture, Michael Hensel, quoting Hungarian chemical engineer and biologist Tibor Gánti, states that the criteria for life identify the ability of the organism or system to enact transformations of states and material (for example metabolism), communicate and transfer information, control internal states in relation to the external environment, development and reproduction, and finally mortality (19-20).

The ground for these criteria is given by two metaphysical assumptions. Firstly, the existence of a frame which partitions the inside and outside that establishes an architectonic unity. And secondly, the registration of life within this unity relies upon the enactment of a visual difference from the unity, taking the form of a ‘response’.

Architecture has since the beginning of Western thought provided philosophy with the ground for the operation of metaphysics and culture. Architecture in descriptions of itself sets up relations between inside and outside, above and below, and space and boundary; relations which philosophy protects as incontrovertible in order to do its work, and in doing so establishes what Mark Wigley calls an “epistemological contract” with architecture (5). More importantly, philosophy’s debt to the architectural already always defines the how the life can appear through the definition of what is human. Architecture in its history has played a role in partitioning human life as outside an undifferentiated interior biological life. In Aristotle, *zoé* or bare life as the unqualified life of natural (or domestic) reproduction that does not subscribe to constituted sovereignty, is differentiated from the *bios* as life exteriorly qualified by the law/language towards a usefulness within a political community (Agamben 7).

Within the biological paradigm in architecture, life emerges as a functionalist explanation. In order that human life can be partitioned from biological life, the latter must be defined in such a way that it is available as a unit of differentiation and manipulation. The definition of biological life literally arrives from the possibility of ‘containment’, that is, a differentiation between interiority and exteriority. At its most elementary scale containment is given by the unified space of the biological cell as a basic unit of life. As a criterion for life, containment “implies that a system must be inherently an individual unit, a function provided by biological membranes”, and is given by the unity established as the equilibrium between complex “environmental stresses from the exterior as well as the pathogenic processes from the interior of the cell” (Hensel 20-21).

Biological life forms are also recognized as having the quality of being ‘alive’ because they respond. Their responses are organized by an energy that appears as involuntary reactions to their milieu, whether defined by external environmental stimuli or internal need. The ability to respond is another frame that sets up a difference between interiority and exteriority of life. The frame of stimulus and response ‘spaces’ life.

The frame becomes an architectural limit idea which conditions the very possibility of life itself, even before, according to Bernard Caché, we can recognize the frame as an image (xi). The issue with life as a functionalist explanation is not the use of biology to explain the human being, but lies with the *visuality* of biological life in relation to human beings. Biological life can be seen; it is a Kantian *a priori* idea. It has a predetermined image whose characteristics are historically understood and admired, leading to the desire for mimicry to establish a visual correspondence between the processes of human material production and natural processes. However, the image of the biological life in such biomimicry arrives from one that which is already partitioned in a certain manner (away from the human, arguably by architecture since the Renaissance). The image of biological life is one based on a contained, captive organism reduced to its fundamental behaviours of survival.

What are the implications of this line of reasoning in response to biological life as a frame for contemporary architectural techniques and technologies, especially those that have arisen with the development of digital visualization and design capabilities? More specifically, how do we philosophically deal with the mimetic cor*respond*ence between biological life and architectural production as a quality whose frame primarily relies upon relations that are governed by a certain regime of visuality, when it is architecture that provides the frame which makes visible the qualities of that life in the first place? The rest of this paper traces a line through the complex field of framing in biomimicry, the implicit collapse of the space between the biological organism and its milieu, to argue particular digital techniques or computing technologies in architecture are not anterior to the concept of life and vice versa, but that the concept of biological life is something that is inseparable from the techniques and technologies in architecture, where the latter are themselves emergent in their grasping of, and being grasped by, the concept of life. It is more productive to see the concept of biological life as habit that can be cultivated, with a 'pedagogy' that can be developed.

3 Captivation

Biological life, having been defined in history through an architectural partitioning of space between inside and outside, provides the condition of captivation necessary for the identification and categorization of the organism. The conventional sense of captivation is the enclosure by architectural walls, as in 'captivity'. Captivation can alternatively be read as an inconspicuous (un)attentive comportment to the world, as in 'to be captivated by'. Giorgio Agamben, working inside Heidegger's idea of 'the open' in which human beings captivated by the world have the possibility of authentic thought, argues that human beings in fact become more animalized when they are captivated in or by the unconcealment of the world. The condition which reifies Agamben's reading of 'the open' is boredom (61). The experience, or more specifically the non-experience, of boredom results from suspension of conscious thought or circumspective comportment. Here existence is undifferentiated from the milieu. The world of captivation is close to an existence that matters no matter what comes, as it is life sharply cued into certain conditions in which the world is open to the organism as an unending horizon of events that pertain to basic biological activities such as eating and shelter. For humans, this occurs in the partitioned spaces where the architecture is inconspicuous where there is a suspension of self-consciousness, where the human can be naked or disclosed, and where it pursues its basic survival activities. This is the space of habits, or particular combinations of materiality, structure and movement which hold off conspicuous introspection towards a kind of releasement. This is quite possibly the space of the home, or the daily work environment. Here is where the human in captivation learns to be bored, and becomes biological, becomes animal. Life in captivation is therefore not related to consciousness or biological form *per se*, nor is this state of biological life a pathological or 'other' condition of the human. The definition of biological life that is of concern here is, as Catherine Ingraham puts it, radically outside, as unknowable, to humanness (86).

4 Mimicry

Captivation, as a space of biological survival, sees the collapse of difference between the milieu and the organism. In some animals, insects in the main, this pursuit of survival manifests as a repertoire of behavior related to mimicry, or morphogenetic transformations, where their forms mimic the surrounding environment. For example, stick and leaf insects evolve to be visually similar to their habitat, and the large eyes on butterfly wings develop in such as way to make the insect look like a bird. Natural mimicry is the limit state of the captivation of an animal by its milieu.

In his seminal essay "Mimicry and Legendary Psychasthenia", biologist and dissident surrealist Roger Caillois argues that the Darwinian evolutionary advantage of mimicry is on many occasions a fallacy (16-32). Leaf insects by their appearance as leaves increase the propensity of being cannibalized by their fellow insects; and stick insects by being sticks have the propensity of being snapped off as twigs or fed on by sparrows. Furthermore, mimicry does not serve survival because it works in the realm of the visual while hunting primarily works at the level of smell (Krauss 155). The evolutionary non-benefit of mimicry therefore overturns functionalist explanations of the animal and biological behavior. But yet, there is an undeniable primitive and overwhelming tendency to imitate – and this applies as much in the human realm as that of the animal; all we have to do is look down the history of architecture or art for the imitations of nature – with a belief in the efficacy of this imitation.

What is of interest to me in Caillois's work is that mimicry enacts a *spatial* condition, namely the collapse of the space of difference. Mimicry, as a visual act which relies upon similarity or likeness, puts pressure on the space of differentiation that subsists between things, between the biological organism (and in the current discussions of architectural practice, the human animal) and its milieu. Caillois compares the natural phenomena of mimicry and the psychiatric condition of psychasthenia, the loss of ego owing to a disturbance in the experience of space, whereby the ego no longer has a form because its difference from its milieu is dissolved by that experience of space. The ego has a lessened individuality so to speak as it sees itself as one point amongst many others, until it knows not where to place itself. This biological human is in dark space where there is no differentiation between its body and its surroundings.

Architectural theorists such as Ingraham in *Architecture, Animal, Human: The Asymmetrical Condition* and Elizabeth Grosz in *Architecture from the Outside* have used the condition of psychasthenia, largely through a reprise of Caillois's essay, to breach the separation of the Cartesian subject from its non-human milieu, or generally the inside-outside distinction, in architectural thinking. If we apply this thinking to the biomimicry implicit in some digital architectural practice, whether the resultant architectural forms mimic natural organismic behavior or structuration, or the use of parametric modeling which introduces design methods able to instrumentalize complex systems and control morphogenetic structurations; which in turn provide designers with the capacity to develop 'long chain' associations of geometric constructs, changes in behavior and procedural representations, and responsive materiality; and where editing and re-execution of design history is made possible; we are faced with a visuality in architecture that diminishes the perspectival relations between the viewer and the milieu in favour of a diffracted visuality. What I mean here is that the conditions of vision and perception may not be a possession of the human subject, but might in fact *constitute* the human subject, or dispossesses it. The human is dispossessed of its assumed centrality in vision. Instead its milieu pinions the human as a biological subject within its stare, or captivation. This dispossession, where the human gives itself over to its own blinding, and its primary existence is merely a spot within the complex scopic field, inscribes human life into the biological picture rather than being removed from it as the source of creation. We stand in a milieu we cannot place, that absolutely cannot be mastered by the logic of vision. Through captivation, the human is seen as immanent in, rather than sees, the milieu.

To me this is when the human moves closest to the quality of biological life. Such an existence associated with the collapse of space brings about a radically indeterminate comportment to the world. Life itself, the natural and the biological, is co-produced in architecture as material, processual and spatial. It is here that relations between form and content, thought and matter, organic and inorganic, the organism and its milieu, are reworked. Biological life becomes a concept that works like a generic category. It remains as having no accepted measure, but it nevertheless functions as an event site. As generic quality, the life can only be approached always and only as *becoming*-life. Life as concept and process in architectural production is therefore immanent to the forms it takes.

The revelation by the techniques and technologies in architectural production cannot therefore be anticipated, and is highly impersonal (it has less to do with the individual biological human, and more the non-individualistic or generic category of the biological). And in this way the newness in architectural production within the biological paradigm is both transcendental (as in trans-historical) and immanent (as in emergent in the event). This double fold forces knowledge to increase the anticipation of the full truth of life – a truth which never arrives – but allows architectural theory and practice, as Alain Badiou says of the politics of philosophy (29-31), to act with conviction and fidelity.

5 Pedagogy of a concept, habit formation

Such a non-teleological and ontologically indeterminate framework treats biological life a 'concept' as described by Deleuze and Guattari. Life is a concept and not a proposition, because the truth of a proposition relies upon an outside state of affairs to which it refers, while the concept is internally organized whereby it is always already, and only, the partial interconnections with other concepts around it. Life as a concept has its own regions of visibility and effectuation, each with a series of techniques and technologies. Concepts are not created out of nothing; there is no genius-creator behind concepts, but their creation is immanent to a constant reaching out and being reached by other concepts. Deleuze and Guattari describe the internal consistency of concepts as follows:

> "As fragmentary totalities, concepts are not even the pieces of a puzzle, for their irregular contours do not correspond to each other. They do form a wall, but it is a dry-stone wall, and everything holds together only along divergent lines" (23).

Concepts are therefore created by a self-positing. So, on one hand, the concept in its self-positing is absolute and therefore ontological; on the other, it is relative in its creation and therefore has a pedagogy. What does it mean to have a 'pedagogy of a concept' in inherent in its creation? For a concept to live, it necessarily summons certain words, images, and structures. The choices of these material instantiations evoke a link to what Deleuze calls a 'philosophical taste'.

> "The concept's baptism calls for a specifically philosophical taste that proceeds with violence or by insinuation and constitutes a philosophical language within language – not just a vocabulary but a syntax that attains the sublime or great beauty" (8).

For example in the biological paradigm, the qualities of life resonate within words such as 'emergence', 'evolution', and 'consistency'. These words then make up a whole way of speaking that is immanent to the concept of life; it is what the concept is. The concept's sole object is the inseparability of the components which constitute its consistency and through which it passes back and forth. The philosophical concept does not refer to the 'lived' by way of abstraction, but through its own creation it sets up an event which Deleuze and Guattari says "surveys the whole of the lived no less than every state of affairs" (33-34).

So how does the Deleuzo-Guattarian concept of the concept relate to the conditions made available by biological life as a concept in the techniques and technologies in digital architecture? Biological life as a concept gives life to strange beings, beings which matter if they fulfil with fidelity the scientific and design constraints set by the techniques and technologies to unfold the architectural problem to its fullest potential, a move which at the same time holds the risk of being monstrous, dangerous, and disastrous (Stengers 165). This relativity in the pedagogy of a concept means being in a debt we need to honour in relation to what makes one call up the concept in the first place. Science has given architecture the concepts of 'nature', 'animal', 'biological life'. Architectural philosophy needs to deal with the flights they induce, concepts they create and habits they disturb; not to justify, rationalise or interpret biological science in architecture, but to care that truth of the problem achieves the production of its own specific empowering means and obligations.

6 Conclusion

The biological paradigm in architecture does not merely provide formal concepts which are mimicked or appropriated by human designers, nor are the relations between human and biological beings made closer. The concept biological life is where human beings encounter a comportment to the world which it cannot anticipate, which plunges them into an immanent relation with specific techniques and technologies, their transfers and transformations, whereupon life itself emerges. In this way, the paper is interested in the space of the subject and the space of architectural design, not in and of themselves, but because they are co-emergent.

In biological life is a pragmatic concern of whether a philosophical concept works, or matters, regardless whether it fits within a universal ontology or metaphysics. Life, which subscribes to the 'pedagogy of a concept', is necessarily a non-consensual and divergent convention. Herein lies a new paradigm of ethico-aesthetics, whereby life becomes a pragmatically functioning but constantly diverging event which serves nothing more than to empower new habits; habits that are self-jeopardising and highly idiosyncratic, to ensure further concept creation.

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THE DRAMATISATION OF ‘ECO-TECHNOLOGIES’ IN RECENT HIGH-RISE TOWERS

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Abstract

Architects select, specify, organize, integrate and innovate specific technologies. In doing so, architecture also plays a dramatizing role in concealing or revealing the effects and operations of selected technologies. This paper addresses the ways in which the architecture of recent high-rise towers gives theatrical presence to so-called ‘eco-technologies’, as well as the ambitions and consequences of this dramatization. High-rise towers have become, as Russell argues ‘the lab benches for sustainable technology innovation’ (1 of 5). Major banks and corporations such as Commerzbank, Bank of America and even the Guangdong Tobacco Company, are choosing to invest in high-rise projects using a variety of emergent technologies to reduce their environmental impact and energy needs. The capital investment made by corporations in sustainable technologies in high-rise building is, at this stage, not financially recouped in reduced running costs and is made with other ambitions that necessitate making those technologies visible in the broader marketplace. This paper will examine the ways in eco-technologies are given a dramatic presence in the high-rise tower independently of requirements for installation and operation and then put to market advantage through strategic media campaigns. In doing, so the paper more broadly examines the transfer of technology from ‘thing’ to architectural form to discursive carrier in the marketplace.

Keywords: High-towers, eco-technologies.

1 Introduction

Rem Koolhaas proposes that the architectural role of the tower is reduced to an empty monumentalism, its sheer volume making it a memorial or billboard for its own creation, since economics, rather than architects, determine the form of tall buildings. The tower, he fumes, is ‘a solipsism, celebrating only the fact of its disproportionate existence, the shamelessness of its own process of creation’. The argument is a familiar one. Tafuri argued that the tower serves a ‘self-proclaiming, publicity function’ for capitalism (457). Pertuiset claims that the success of the office tower in representing corporations lies in its distinctiveness from others of its type, leading to the paradox that ‘the office building as a semantically neutral type is yet most likely to be dressed in a seductive image’ (87). Or as Clarke states, the skyscraper ‘is sunk capital which must have credentials in the marketplace’ (54).

A more nuanced view is needed to recognize the entanglement of technology and its representation in high-rise building. The raft of technologies needed to achieve height have been used to convey a range of potential meanings that may confirm corporate capital, but have also the potential to convey philanthropic benevolence, intransigence, political agility, patriotism, a belief in progress, nostalgia, civic pride, romance, pragmatism, religious belief, etc. Following the events of September 11, 2001 the cultural meanings ascribed to the high-rise tower have again been much debated and there has been, contrary to those who declared the death of the high-rise, a resurgence of tall building developments and public discussion about them. 'Tall buildings' were the subject of an exhibition at MOMA in 2003 at which it was evident that the building type was the focus of renewed experimentation in urbanism, particularly in new cities in the developing world, as well as in form making using digital techniques and manufacturing. Where the drive to go higher and higher has led to the high-rise being the site of the most intense innovation of hard technologies, more recently the high-rise has also been used for testing new forms of workplace organization, hybrid programming and construction financing. Most significantly, high-rise towers have become, as Russell argues 'the lab benches for sustainable technology innovation' (1 of 5). This paper is focused on the relationship between the set of specific technologies directed at environmental sustainability and their representation in the marketplace through current projects including: Turning Torso by Calatrava in Malmo, Sweden; Editt Tower, by Hamzah and Yeang in Singapore, the COR tower in Miami and One Byrant Park by Cook and Fox in New York. While attending to one set of technologies and a small number of examples, broader conclusions about the architectural representation of technology will be drawn.

2 Technological innovations and the high-rise tower

It is worth first considering the high-rise tower through the incremental history of technological innovations that have made them possible. Buildings over six stories were rare until the 19th century, largely because water pressure was insufficient to supply running water over about 15 metres. The advent of Otis' elevator and the introduction of steel-frame construction are the most obvious innovations of the early twentieth century making it possible for buildings of greater heights. The geared high-speed, electric elevator evolved only after the early 1880s when cities were electrified. Air-conditioning for heating and cooling was the next necessary innovation. The first paper mill was air conditioned in 1906, but its uptake in commercial buildings until after the 1930s when coil systems reduced the size of ducts and deep interior space became rentable.

Subsequent technologies that have enabled increasing heights include: technologies of waste management and services comprised of tanks, exhausts, pumps and generators; technologies of fire fighting and sprinkling; and technologies of information and telecommunications that make possible the generic open plan through their reticulation in the computer floor or the false ceiling. Envelope technologies of curtain walling along with technologies of cleaning that include cherry pickers, cradle systems and telescopic equipment are also crucial. Surveillance, security and even pre-emptive defence technologies have more recently become paramount.

As heights increase, levels of vibration under the action of wind and seismic disturbance become more prevalent and can provoke vertigo and nausea (Kareem, Kijewski and Tamura: 1-2). Advances in height are often accompanied by increased structural flexibility, and the most recent generation of tall buildings research has been devoted in part to the mitigation of wind-induced movement through passive technologies of aerodynamic tailoring, stiffening and energy dissipation, as well as active auxiliary dampening systems that may also include rotor, jet and aerodynamic appendages that generate a control force to reduce wind-force coefficient (Kareem, Kijewski and Tamura: 40-41).

3 Different forms of technology

Without these interrelated technologies the contemporary high-rise building is not possible. Yet, the high-rise depends upon additional technologies that go unrecognized if technology is only considered as an entity or thing and not, as it also is, effect, metaphor, sets of practices and processes, economic engine and historical subject. As Marchand observes in relation to the motorcar, its technological reach also includes 'the network of gas stations, highways, neon signs, parking lots, and all the altered habits and perceptions that arise out of the existence of the car—the ground, in other word, of the automobile. (Marchand 1990, 248) Larry Ford notes that the production of the tower is the convergence not only of industrial technologies, but also cultural values, economic organization, skilled labour and governmental policies (180). The tower requires large corporations for its commissioning and occupation, zoning laws that encourage higher buildings and policies that allow the consolidation of land. The organization and application of hard technologies and the determination of floor plans and heights is regulated by a set of techniques and soft technologies of information management, financial modelling and statistical analysis, property valuation and market prediction that are new to the twentieth century.

Michel Foucault usefully distinguishes between four kinds of technologies: technologies of the self, by which we know and look after ourselves; technologies of production with which we interact with the material world; technologies of sign systems, through which we mediate culturally; and technologies of power, by which societies discipline and organize individuals within them. These are not watertight categories into which specific technologies can be placed rather, each technology takes effect in all four arenas. Writing, for example, is a technology. It calls for the use of tools and other equipment, is governed by rules and processes, and enhances and transforms the self and society. Technologies of writing and seeing have been interiorised to the point that we forget them, but both of these technologies mediate all other technologies. The wind-turbines used in the COR-tower in Miami, for example, are mediated by design technologies that shape form and give presence through motion or visibility. These are in turn mediated by technologies of visualisation such as photography and 3d computer modelling, paired with marketing techniques that influence community perception and reception.

4 Technology transfer and architecture

The revealing or concealing of certain technologies in tower design, such as the wind turbines in the COR-tower, is an act of transference and transformation of economic, political and architectural consequence. In using the term ‘technology transfer’, it must be admitted that this use departs from its most common application in management studies where it refers to how new technologies are brought to markets across nations or from research institutions such as Universities, to corporations and governments (Bozeman 627-655) The abundant literature in this area is concerned with the effectiveness of technology transfer, with the conditions and agents of failure and success that surround the technology and are independent of its actual attributes. The cultural meanings given to technology are also regarded as significant in technology transfer, but the movement from technology as an entity to the raft of cultural meanings given to its application is largely understudied and left to other branches of the humanities. Also understudied is the transfer of technologies and techniques developed in one field or industry to another and the ways in which these technologies are represented in the new field. It is these ways of thinking about transfer through the vehicle of architecture that is of interest here.

Architecture imports technologies developed in other industries and disciplines such as space exploration, food preservation, gaming and mapping. These adoptions and adaptations are not always apparent, and may, indeed, be intentionally concealed. When technologies from outside of architecture are engaged as a potential for design expression—for representative potential in addition to operational value—different approaches are taken. Rüdiger Lainer and Ina Wagner, distinguish four ways in which architecture gives representation to technologies from outside the discipline (145–146). The first is to present technical objects and exhibit the technologies, functions and achievements they build upon. Early modernist architecture and large-scale technical objects such as power stations that combine utility with its symbolic enhancement are situated in this category (146). The second approach they identify is that of making technical elements and processes visible, as in Richard Roger’s Lloyd’s building with its exteriorization of services pipes and shafts, elevators (147). The third approach lies in intensifying the effects and qualities of an object. This approach to architecture “may increase a functional aspect of the building. It also may augment representative elements and have strong dramaturgical effects” (148). Arguably, the Lloyd’s building does this too. Fourthly, they identify space as mise-en-scéne of technology. In this category, they locate architecture which, with the support of programmable lighting and multi-media projections, mobile furniture and rapid changes of scenery, creates ‘spaces within space’.

Lainer and Wagner’s short essay is a useful departure point, but when considering the high-rise tower, it becomes apparent that all of their four approaches to ‘narrating’ technology are at work. These are large-scale technical objects wherein some, or all, of the enabling technologies are made visible or dramatized. In the theoretical discussions of theatricality in other cultural forms, dramatization is thought to support an experience distinct from the physical object with the viewer aware of exaggeration. Theatricality in the cultural arena is connected to exaggeration, illusion and a fictional framing that allows the spectator to recognize both resemblance and deviation. The theatrical demonstration or concealment of its technologies is not uniformly recognized by all audiences in the case of the high-rise tower. Both the use and the representation of technologies, especially of recent eco-technologies, as will be demonstrated is, in parallel, framed by extensive media coverage that directs perception of the building.

5 Eco-Towers

Turning Torso in Malmo, Sweden is a good example of the theatrical representation of a structural technology in architectural form whilst environmental technologies remain invisible. Completed in 2005, it was designed by Calatrava and has been much imitated with similar turning towers including RMJM's City Palace in Moscow and SOM's Infinity Tower in Dubai. Calatrava's tower is a 54-storey building made up of nine cubes that twist towards the city's waterfront. The structural challenges of Turning Torso are the theatrical gesture of technology for this building, yet unlike other Calatrava projects, the actual structural solution and the apparent structural dynamic are not congruent. Each floor consists of a square section around the core and a triangular part supported by an external steel structure. This core is stiffened by the Torso's exoskeleton, which is effectively a steel truss erected on the outside of the building with the same clockwise rotation as the tower itself. The building looks like the structure is twisted but this is not the case.

Turning Torso has an environmental agenda. Kitchen waste, for example, is transported to a collection tank where it is then piped to a decomposition plant producing biogas. There is diode lighting in common corridors. Its energy efficient envelope has passed several laboratory tests concerning air and water sealing and heat insulation according to stringent Swedish standards. None of these technologies are signified in the visual appearance of the building and their inclusion in the media releases is subordinate to the celebration of the twisted form. By contrast, the 'eco-technologies' of wind turbines, photovoltaics, solar hot water generation and a hyper efficient structural system are highly elaborated for visual consumption in the COR tower in Miami, currently under construction. Designed by Oppenheim Architecture, with energy consultant Buro Happold and structural engineer Ysreal Seinuk, the 25-story COR tower is being touted as the first sustainable mixed-use apartment complex in Florida. Each residential unit will include Energy Star appliances, recycled glass tile flooring, and bamboo-lined hallways. Its exoskeleton simultaneously provides structure, thermal mass for insulation, shading for natural cooling, enclosure for terraces and armatures for turbines. The revolving motion of the turbines at the top of the building is underscored by the repetition of the circular motif across the whole of the façade. The building is being promoted pre-sale on sites such inhabitat.com, a weblog advocating sustainable design; and treehugger.com, which describes itself as the "leading media outlet dedicated to driving sustainability mainstream."

Editt Tower by TR Hamzah and Yeang, Singapore is even more explicit in its incorporation of ecologically sustainable technologies. The project won a 1998 competition for Ecological Design in the Tropics and is co-sponsored by the Urban Redevelopment Authority and the National University of Singapore for an urban site in which the natural ecosystem has been erased. The project integrates green space to human-use area in the ratio of 1:2. The organic spaces are intended also to ramp up from the street level to the top of the building, effectively integrating its 26 stories into the surface landscape. Plants incorporated in the building project do not compete with indigenous species and this point is reiterated in all promotional material. The building will have over 55% water self-sufficiency based on collection of rainwater and water reuse, and is designed to achieve almost 40% energy self-sufficiency through a system of solar panels. Sewage will be reclaimed to fertilizer and built-in waste hoppers will drop separated waste streams to the basement to facilitate recycling. Architectural elements are designed to direct wind for ventilation and ceiling fans with water misters minimize refrigerant based air conditioning. These technologies are made visible—in addition to the planting, the naturally ventilated toilet areas are hung on the edges of the building and the water collection scallops along the side of the building, leading to media claims such as that made by Lepisto, that the building is a 'living breathing organism'. Other aspects, such as the mechanically jointed construction that addresses the potential life-cycle of the building and material reclamation, are not immediately apparent.

Designed by Cook and Fox Architects, One Bryant Park, New York City is a 50:50 joint venture between the Durst Organization and Bank of America who will occupy most of the 54-story building. Bank of America were the first financial services company to become a member of the EPA's Climate Leader Program and won the 2005 Corporate Climate Champion award from Clean Air-Cool Planet. The tower will be built largely from recycled and recyclable materials, incorporate a cogeneration electricity plant, capture and use all rainwater and wastewater and have a planted roof to reduce heat island effect. The most, or indeed only visible portion of the building where the ‘green’ strategies are visible is in facets of the curtain wall.

Given that the building is less evidently ‘green’ than Editt Tower, Bank of America have sought, and gained, considerable media coverage and high-level political support. In the media release for the building Governor Pataki lauds it as ‘a shining example of how you can create jobs while also protecting the environment’. Publicity has focused on the intention to qualify for a LEEDS platinum rating, a first for a building of this scale. Joining the Bank of America as a corporation keen to announce its green credentials through architecture, is the Guangdong Tobacco Company with a proposed zero-energy tower in Guangdong, China designed by Skidmore Owings and Merrill. The 300 metre tall tower features integrated wind-turbines on two separate mechanical floors and a southern façade with louvers calibrated to automatically adjust to sun angle and intensity.

Guangdong’s tower was reviewed by Deborah Snoonian in Architectural Record, and covered in the online *Metropolis Magazine* and *Business Week* as well as numerous ‘green’ websites such as the *Energy Blog* and *jetsongreen*. When it featured on the *treehugger* website, one anonymous respondent quipped: ‘Well good luck on the solar power . . . the sun rarely shines through the pollution in Guangzhou. If it could run on smog power or cigarette fumes now that would be something!’ Silas Chiow, director of China business development at SOM is less cynical, but in *Business Week* confessed that "I would be surprised if the Pearl River Tower was a 100% zero-energy building upon completion, because that would be 10 times the cost of a normal building that size."

6 Conclusion

For any developer of a high-rise tower using technologies that alleviate environmental impact, potential long-term savings on energy costs and workplace productivity do not currently offset the higher capital investment. Perceived market benefits for corporations in using sustainable design technologies appear to be a factor in their uptake, and these can only accrue if the broadest audience is aware of their use. The range of technologies used in the new wave of sustainable high-rise buildings varies greatly in their potential for visibility and dramatization. Eco-paint, for example, looks much like any other paint, whereas planted walls and roofs, channels of flowing water and rotating turbines are readily transferred into architectural design and given dramatic presence.

These technologies project a different fiction to that of earlier high-rise towers wherein the expression of technologies is brought to bear upon the landscape of competitive capitalism and appeals to notions of technological prowess and mastery over natural forces of gravity, wind and sun. Eco-technologies are being used in high-rise towers to project an image of civic and corporate concern and responsiveness to place through appealing to ‘nature’. Cook and Fox, for example, claim that One Bryant Park has ‘the dynamic and crystalline structure of forms encountered in the natural world’. Emphasis is on the potential of achieving metaphoric associations through integrating environmental technologies with new technologies of structure and envelope. Editt Tower is presented, quite literally as a vertical garden. The dramatization of technologies in the recent wave of high-rise buildings purporting to achieve sustainable results presents these technologies as benign and working with, not against, natural forces, both in architectural form and in associated publicity. Technological transfer is effected both in operation and representation.

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LIVING WITH THE SUN: ARCHITECTURE AND THE ASSOCIATION FOR APPLIED SOLAR ENERGY, 1954-1958

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Abstract

At the end of 1957, a group called the Association for Applied Solar Energy held an international competition for the design of a solar house, to be built in Phoenix, Arizona. In the mid-1950s – before the development of the photo-voltaic cell – the use of solar energy in residential design was both an architectural project *and* a technological project; in no small part it was an investigation into architectural design *as* technology, engaging concerns over site orientation and cubic volumes as much as ideal angles for solar collection and methods of heat storage. The 1957 competition, called *Living with the Sun*, intended to exploit this connection between design and technology. Parallel with the development of modern architecture as an expression of a contemporary lifestyle, this early instance of solar architecture intended to allow innovation in design to produce a new relationship to technology and, by simple extrapolation, to the material, environmental, and political issues that accompanied the slow depletion of fossil fuel resources, a phenomenon already becoming clear in the immediate post-war context. *Living with the Sun* was thus a straightforward attempt, on the part of architects, to engage environmental problems.

Keywords: Solar Collectors, Modern Architecture.

1 Living with the Sun

At the end of 1957, a group called the Association for Applied Solar Energy held an international competition called *Living with the Sun*, calling on entrants to design a solar house for a site in Phoenix, Arizona. In the mid-1950s – before the development of the photo-voltaic cell – the use of solar energy in residential design was both an architectural project *and* a technological project; as this paper will demonstrate it was in no small part an investigation into architectural design *as* technology, engaging concerns over site orientation and cubic volumes as much as ideal angles for solar collection and methods of heat storage. Transformations in the concept of 'modern architecture' were, by this period, in part defined by residential design producing and representing a modern lifestyle. Richard Neutra's 1947 *Kaufmann House*, in Palm Springs, and Pierre Keonig's 1959 *Case Study House #22* are two of the best-known examples. Prominent design characteristics of both of these houses – including open plans, expansive use of glass, and new interior/exterior relationships – were also central to the solar heat gain and distribution innovations of many *Living with the Sun* entries. In fact, in this competition we can glimpse a moment where the lifestyle project of modern design proposes to produce a new relationship to technology and, by simple extrapolation, to the material, environmental, and political issues that accompanied the slow depletion of fossil fuel resources.

The Association for Applied Solar Energy [AFASE] was primarily a scientific organization, formed in early 1954 to promote investment in solar energy technologies. In November of the following year, the AFASE held a five-day *World Symposium on Applied Solar Energy* in Phoenix. The symposium acted as a clearing-house for dynamic, multi-faceted, and international discussion of the use of solar energy. Sessions were held on solar water heaters and solar furnaces, on solar-powered water desalinization systems, and on the use of the sun's energy for the growth of micro-food sources in famine inflicted areas (Putnam 213). If the primary focus of the symposium was to demonstrate the usefulness of the sun's energy in applications relevant to developing regions where electricity was not readily available, a secondary ambition was to present solar power as a "complementary resource" (Daniels); complementary, that is, to large-scale and infrastructural developments that supported the generation of electricity through fossil fuels or – at this point still experimentally – nuclear power. As a complementary resource, the possibility of using solar collection units to heat residential buildings was one of the most promising applications, and the session on "Solar House Heating" reviewed a number of experiments in solar collection techniques.

For the most part, the 1955 session reiterated presentations made at a five-day "course-symposium" held at the Massachusetts Institute of Technology in 1950 entitled "Solar Energy for Space Heating", organized jointly by the Department of Chemical Engineering and the Department of Architecture. In 1939, the Chemical Engineering department built what became known as the *First MIT Solar House*: a one-room laboratory shed with a solar collector spanning the south-facing pitched roof. Though not sophisticated architecturally, the collector unit established the basic technological parameters of solar collection: glass plates enclosed a few feet of rock and insulation, through which water (or, later, air) was pumped. In the 1939 house, the heated water drained down to a large tank in the heavily insulated basement. A ventilation system drew cool air over the hot water and then back into the house as warm air. As with most solar collector systems, this required the use of electricity and it was therefore an *active* solar system. The experiment was largely successful, able to maintain a temperature of 72º throughout the winter, though not economical due to the cost of materials and construction (Hesselshwerdt 99).

After the war, and following a failed second experiment, the *Third MIT Solar House* of 1949 became something of an industry standard for solar space heating; it was largely to celebrate this project that the 1950 'course-seminar' was held. The house was a simple bar building, constructed with triple-glazed south facing windows that, following a careful curtain-operation regime, retained most of the absorbed solar heat. A heavily insulated a-frame collector spanned the length of the roof, with a water tank inside of it. Instead of a forced air system heating the air over the water, the hot water itself circulated through radiant ceiling panels, which reduced the electricity needed for water circulation (Hesselshwerdt 102). The combination of passive and active solar heating provided for almost 75% of the required winter heat, and the set up costs, though still far beyond that of conventional mechanical systems, was significantly less than earlier experiments (Butti and Perlin 211).

Though not designed by an architect, the *Third MIT House* reflected knowledge of architectural experiments in passive solar heat gain, and was an explicit attempt to merge this architectural technology with that of the solar collector unit. George Fred Keck's houses outside Chicago from the mid-30s were perhaps the best known passive solar houses in this period – both Keck and one of his clients presented papers at the MIT conference. Keck's solar houses, of which the 1941 Duncan House is exemplary, were simple bar buildings with large south-facing windows in every room. Keck's designs were popular with developers; at a time when modern design was just beginning to catch on in mainstream building culture, they made an argument for the relationship between the open plan, full glazing, and reduced cost of heating that was attractive to many home-buyers: the modern house, if nothing else, had the benefit of being warmer (Menocal 15). Indeed, we can think of the Third MIT House as a flat-roofed, open-plan house, it's hipped roof profile being the result of the design of the collector rather than of the house itself. George Lof, an engineer who worked on the First MIT house and would develop solar collector houses in Denver, Los Angeles, and Dallas, suggested at the 1955 AFASE symposium that, by virtue of the flat roof, the freedom of internal cubic arrangements, and consequent potential for efficiency in heat storage and distribution, "the use of a modern idiom could increase annual solar heating provision by as much as 25%" (Lof 202). The purpose of the *Living with the Sun* competition was, quite self-consciously, to integrate the design the collector units with that of the modern house itself.

Before discussing the competition, however, a few words as to its political and institutional context. For if, as has been indicated, the AFASE was a primarily scientific and industrialist organization, it was at the same time formed out of a complex of geopolitical concerns. The period right after World War II, it should be remembered, was one of a severe worldwide energy shortage, the war not only depleted known resource deposits, it also disrupted systems of production and distribution. In 1950, President Truman established the Materials Policy Commission to, as the directive put it, "answer the question: has the United States of America the material means to sustain its civilization?" ("Resources for Freedom" 1). One of the major proposals of the Commissions report, issued in mid-1952, was that the government encourage the development of alternative energies – nuclear power, solar power, and synthetic fuels – to alleviate dependence on foreign oil. In this early 50s moment, the technology for all of these methods was relatively undeveloped, and the summary of the report states that "the direct utilization of solar energy [is] the most important contribution technology can make to the solution of the materials problem" ("Resources for Freedom" 54) and further that the "comfort heating" of the single-family house is the most appropriate application of the use of solar power (Putnam 216).

While this could have led to widespread experimentation with solar energy, in fact the reception of the report was seriously compromised by the victory of Eisenhower, in part through support of the energy industry, in the 1952 presidential elections. Eisenhower set up his own Cabinet Committee on Energy Supplies and Resource Policy in early 1953 which claimed that, in fact, there was no short term energy problem to contend with (Strum 50). Following the administration's rhetoric of limiting intervention in the economy, The Cabinet Committee proposed that "the use of alternative energy sources should be as far as possible that of the free choice of the consumer" ("Energy Supplies and Resources Policy: Report of the Cabinet Committee" qtd. In Strum 39) and the burden of research and development should be placed on industry rather than on government.

The Association For Applied Solar Energy was formed in response to both the initial elation at the prospect of increased funding for solar research and the disappointment of seeing that funding source evaporate. The basic proposal of the organization was to prove the economic viability of solar power in the context of an expected rise in energy costs. Simply put, the set-up costs for solar power were only justifiable when the real costs of nuclear power or oil were passed on to the consumer. However, the Eisenhower administration's retreat from the funding of 'alternative energy' sources did not extend to the corporate interests lobbying for a new nuclear power industry: reactor design, fissionable material, and personnel were all freely shared freely between government research groups and Westinghouse, GE, and others. Furthermore, the development of a post-war oil economy was dependent on associated political and military activity, the most obvious example being the CIA engineered coup in Iran in 1953, only months after Eisenhower took office, which effectively delivered 40% of the Iranian oil fields to American companies (Kinzer 215). The various economic and geo-political machinations to mask or effectively reduce the costs of industrial energy production found no corollary in the distributed potential of solar energy generation.

In discussing the *Living with the Sun* competition, it is important to recognize that the AFASE was desperate to maintain its relevance in light of an inability to establish an economic logic for the use of solar collection. The competition, as a result, seeks to establish a cultural movement, a solar lifestyle that would ride on the heels of the emerging modern sensibility in architecture culture. The Chairman of the competition jury, Pietro Belluschi, described this dynamic as follows: "The way in which architects succeed in integrating [the utilization of solar energy] with the design of buildings and giving it aesthetic appeal will have a great effect on the rapidity with which it will receive general acceptance" ("Living with the Sun" vi). The competition brief indicated that the entrants were free to assume that "the occupants of the house, having great respect for the sun and its influence on their way of life, would feel strongly that the energy of the sun should be harnessed," thus the alteration of the design for this purpose would be welcomed ("Living with the Sun" iv). The progress of modern architecture, both of these statements assume, would be productively inflected by the design and technology concerns of solar heating processes.

The competition was relatively ambitious in its definition of a solar house; the brief stipulated that energy from collectors would provide for year-round water heating, including heating the pool, as well for winter space heating. The technological specifications proposed a basic collector unit, based on the standard MIT module but with (not-yet-available) plastic sheeting instead of multi-paned glass as the cover. A precise angle and square footage of collector were stipulated, and entries were to provide a cubic diagram analyzing heating requirements and ventilation parameters, as well as a proposal for heat storage ("Living with the Sun" v).

The projects premiated by the jury demonstrate an integrated approach to the design of the house and of the solar collectors. The winning entry, by Peter Lee of Bliss and Campbell in Minneapolis, was a straightforward rectangular shell surrounding a concrete and glass box, with outer walls of brick screens and patios covered by mechanically-tiltable solar-collection louvers. It was cited by the jury for the "logic of its solar equipment, which acts in double capacity of shade louvers in summer and heat collectors in winter" and also for the "direct organization of the plan" ("Living with the Sun" vii). The second place winner, by Anna Campbell Bliss, a principal in the same Minneapolis firm, is dramatically different in design *[fig 25]*. More concerned with formally expressing its energy generating capacity, optimally angled panels form the exterior walls; as the jury comments put it: "the solar collectors themselves produce the architectural quality of the house… there is a consistency of approach and directness which the jury liked, however the north wall slopes in the same manner as the south wall, without having the same reasons for doing so, thereby becoming a cliché rather than a logical solution" ("Living with the Sun" vii). Thus presumably the reason this entry is relegated to second place is because the integrated architectural-technological design logic is not carried to its conclusion.

Beyond these winning entries, three important manifestations of the conflation of modern architecture and solar technology are evident in the 60 published competition panels. The first involves the design of the solar collector itself, as the winning entry's louver-collectors already indicate. Two selected entries from the team of John Morphett and Hanford Yang, MIT architecture students, stand out in this regard. Their third place entry has a roof covered with a visually dynamic array of diamond-shaped collectors. Their other entry has a more stoic alternating bank of extruded cone shaped collectors, in staggered rows. Both designs use the collector as a functional ornament and to express planometric arrangements.

Engagement with the roofline provides a second prominent connection. Some exemplary entries in this regard include Manuel Dumlao's channeled flat solar roof, whose heat distribution ducts allow the collectors to be leaned against them at the optimum angle. Evison, Lester, and Ottum's entry pitches the roof slightly, angling the collector units on one side and using the slope of the other to distribute water through radiated ceiling panels. The most dramatic is Ashok Bhavnani's space frame entry, in which the floating tensegrity structure surrounds the rectangular house with multiply angled panels – those at ideal collection angle have collectors embedded in them, and the space between the frame and the house are used as heat storage.

Finally, a number of interesting entries separate solar collection completely; what is compelling here is how these entries on the one hand act as a foil for the 'solar lifestyle' and on the other hand replicate it without explicit technological engagement. In a proposal by Enis Kortan, an architect in Marcel Breuer's office, a staid rectangular house is separated from the garage by a pool area. Along side and above the pool, like a billboard, a large panel of collectors generates adequate energy to meet all of the requirements. The project received an honorable mention; the jury commented that it was "worthy of mention because of the strong statement made by the solar-collecting devices, although it was felt that such a feature should be more sculptural than indicated" ("Living with the Sun" vii). The entry by Morton Karp, also receiving an honorable mention, was of the most obviously Wrightian in the competition. Karp's heat collection system was separate from the house itself, involving a "hot pit" in the side yard, where collectors were dug into the ground at an optimum angle and reflected onto glass covered gravel beds. In both cases the connection of technological to design innovation is abstract, if not ideological.

Numerous architectural tropes - the open plan, the integration of interior and outside spaces, and prominent use of breezeways, screens and moveable partitions – connect the *Living with the Sun* projects to the discourse on the modern house – if the book does not, in fact, represent one of the more innovative and comprehensive compendiums of residential design in the period. At the same time, *Living with the Sun* is clouded by a fantasy of the technological improvement of solar collectors leading to economic efficiency – which is to say, a sort of science fiction in which solar energy resolves its own economic-technological conundrums, rather than being reconfigured, as a cultural and technological project, relative to events and ambitions in the geo-political sphere.

Bracketed out of the above discussion is the invention of the photovoltaic cell at Bell Laboratories in early 1954, unveiled to the public at the 1955 AFASE conference, which would eventually change the discussion of solar power. The technological discourse around photovoltaics is far removed from that of solar collection or the passive absorption of heat: the pv cell reacts to light, not heat, and converts light directly into electricity; furthermore, the use of an expensive, production heavy panel is more in line with the industrial use of nuclear power than the distributed potential of south-facing windows or solar collectors.

Indeed, the potential impact today of the photovoltaic panel on the culture of architectural design, as with most technology that claims to be 'environmental' or 'sustainable', is slight at best. Unlike the technologies of solar collection, the snap-on system of photovoltaics does not require that architects engage complicated relationships between design and technological efficiency. The most hypocritical – and, unfortunately, one of the most prominent – proposals of the growing 'sustainable' tendency in architecture today is the elision of epistemological, cultural, and ethical issues for the ability to, as with the photovoltaic panel, specify a new set of purportedly more efficient materials and products. In this context, the proposals in *Living with the Sun*, in their attempt to *design* a response to political problems, are, one hopes, tantalizing for practitioners and historians alike.

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EMERGENT PROCESSES

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Abstract

Emergence is a well established though highly contested concept in science that is found in a range of disciplines from biology and artificial life to physics and complexity. It is not in doubt that emergence is of interest to other fields including design, though the manner of its relation to this discipline is much less clear and its effect remains an open question.

This paper will argue that emergence has set in motion a shift in the way we understand design. Building on the theoretical and philosophical resources provided by Gilles Deleuze (1994) and Manuel Delanda (2002) in particular, emergence marks a reorientation in the techniques and practices of designing, away from the specific designation of an objects qualities, towards the specific designation of an environment in which the object's qualities might emerge from a range of potentialities.

1 Introduction

Emergence is a well established though highly contested concept in science that is found in a range of disciplines from biology and artificial life to physics and complexity. It is not in doubt that emergence is of interest to other fields including design, though the manner of its relation to this discipline is much less clear and its effect remains an open question. Architecture or urbanism, for example, would place quite different demands on a concept like emergence than those placed on it by neuroscience. Whilst the former might engage with those aspects of emergence that pertain to the generation of form or pattern as it relates to a city; the later might try to explain the development of cognition as it relates to a substrate of neural networks. Silberstein and McGeever define emergence as follows:

> "…features of systems or wholes that possess causal capacities not reducible to any of the intrinsic causal capacities of the parts nor to any of the (reducible) relations between the parts. Emergent properties are properties of a system taken as a whole which exert a causal influence on the parts of the system consistent with, but distinct from, the causal capacities of the parts themselves." (182)

This paper will argue that emergence has set in motion a shift in the way we understand design. Building on the theoretical and philosophical resources provided by Gilles Deleuze (1994) and Manuel Delanda (2002) in particular, emergence marks a reorientation in the techniques and practices of designing, away from the specific designation of an objects qualities, towards the specific designation of an *environment* in which the object's qualities might emerge from a range of potentialities. These environments are simply mathematical spaces whose properties we can both describe and attach meaning to. Though fields like biology (Strogatz 1994) or economics (Krugman 1996) might use these tools as analytical devices to gain information about complex phenomena (like the tendency for business agglomerations to form), in design the question of empirical use value takes on a different inflection since evaluation criteria are rarely self evident and not always quantifiable.

With these qualifications regarding empirical status in mind, for designers emergence still marks a fundamental movement away from the direct production of form – what is being re-conceptualised here is the mode of *control* over the designed object. Rather than manipulate the materiality of the object or the object's representation directly, an emergent designer manipulates the properties of a mathematical space in which an infinite series of potential forms might be packed.[1] The emergence or actualisation of a specific form out of this space is understood to be a contingent product of the self-organized interaction of the space's different components. The danger here is that emergence comes to be understood as a naturalised model of formal development, authenticated via the intimate connection between the object and the world from which it emerges.[2]

The shift away from the direct and directed production of the architectural artefact towards an engagement with the space in which the artefact exists as potential carries with it all the predictable revaluations of authorship that attend to many new mediums.

In this instance however, what is new is the way questions regarding the status of control, continuity and difference can be posed.

To claim that the production of some object is the natural consequence of a space or environmental field as represented digitally or mathematically, is to make a claim for a certain continuity between the environment and the objects that arise out of it. Emergence, crucially, would describe a mode in which this continuity is not simply the elaboration of that which already implicitly exists in the environment as a possibility, but the very creativity of the environment itself, its ability to self-generate pattern and form.

In order to substantiate this claim for material creativity we would need to make an assessment of the qualities of the object produced with regards to the environment and decide whether this represented a novel development that could not be retrospectively explained by its initial state. In other words, because emergence is an account of the development of form, we would have to understand the history of the world or system that conspires to produce said form and decide whether the material sequence of this history is evidence of novelty or simple mechanical elaboration. Whilst a mechanical elaboration would be evidence of continuity, it would not be evidence of emergence because it would be reducible to the sum of the component interactions. Irreducibility is seen as key feature of 'strong' or 'ontological' forms of emergence, in that the behaviour of the system taken in total cannot be reduced to the sum of its component interactions. As Silberstein and McGeever note "(Ontological) …emergence therefore entails the failure of part-whole reductionism." (182)

Further, simple mechanical interaction is invariant with regards to time: time invariance or reversibility must follow from a deterministic and mechanical view of the world. If given a sequence of events, time plays no part in determining the properties of that sequence, then we can assume that given perfect knowledge with respect to any stage of the sequence we can clearly determine the properties of the sequence at other stages.

This conception of time as nothing but a neutral container for the clockwork elaboration of a pre-determined sequence has been critiqued in philosophy through the work of Henri Bergson (1959) and in science through the work of Ilya Prigogine (1996). Emergence on the other hand implies a conceptualisation of time that is irreducible to metric determination and more importantly works to drive differentiation.

2 Epistemological emergence

To explain this further it is worth introducing a distinction between the *properly emergent* and the *epistemologically emergent* (though this in itself will require further elaboration). The *epistemologically emergent* is that which *can* be explained by recourse to the history of the system, but that with regards to an observer is unanticipated.

In other words the historical account of an object's development, its morphogenesis, can be given through a description of the mechanical interaction of its components. Though the complexity of these interactions might mean that predictability is difficult, it does not mean that predictability is impossible, only that we have insufficient information to describe the system correctly. The difference between that which is difficult to predict because of complexity and that which is impossible to predict is crucial with regards to emergence. Whilst both might produce unexpected results with regards to an observer, only the latter would be evidence of novelty. This is because in the former case, it is the observational or descriptive apparatus that is blind with regards to the system, where as in the latter case, the system itself is blind with regards to its future. As Silberstein and McGeever note:

> “A property of an object or system is epistemologically emergent if the property is reducible to or determined by the intrinsic properties of the ultimate constituents of the object or system, while at the same time it is very difficult for us to explain, predict or derive the property on the basis of the ultimate constituents. Epistemologically emergent properties are novel only at a level of description. For example, even systems with very few parts and with simple mathematical rules can sometimes be said to exhibit epistemological emergence.” (186)

With regards to digital design processes we should be careful to distinguish between the unanticipated and the unaccountable. The power of computational systems can regularly produce unanticipated effects in design processes, but these effects will be accounted for through the simple mechanical interaction of the systems codified components.

3 Strong and weak emergence

The higher order development that has been crudely referred to as the *properly emergent* can also said to exist in a variety of types. In order to produce a more nuanced understanding of what constitutes emergence we should distinguish between its strong and weak forms, not simply to construct contrasting categories for a taxonomy of emergent behaviour but to see how these categories pose two very different horizons for design.

An example of weak emergence can be found in the use of analogue modelling techniques.

At the Institute for Lightweight structures in Stuttgart Germany, Frei Otto (Bach and Otto 1988) has developed form finding techniques using simple material analogues like soap film that recall Antoni Gaudi’s inverted catenary model for the Sagrada Familia in Spain. Frei Otto’s use of soap film for these experiments takes advantage of the material tendencies of the soap molecules. At a molecular level soap molecules will arrange themselves into configurations that minimise energy bonds between them, the emergent effect at a macro level is that the soap film will find a form that minimises its surface area, thus ‘solving’ the problem of spanning a surface efficiently.

There is a characteristic entanglement of scales at work here with energy minimisation at the level of the individual molecules driving a process structured by the surface tension of the components taken as a population- to produce an efficient configuration at the level of the total system. Though the shape of the surface might be changing in each case, the system is being focused on the same goal, namely optimisation. In fact the soap film will always move through a sequence of different volumes until it settles into its most efficient state. The time in which the soap film is ‘finding’ its equilibrium state can be thought of as a series of samples from a search space, in which each less efficient configuration is discarded for a more efficient one.

What is important to note here is this notion of a *search space* or more correctly a *state space*. In the case of the soap film, the state space of possible configurations that the soap film ‘explores’ is itself *closed and stable*. Its closure is less relevant, this simply means that the potential types of shape the soap can acquire are bounded, what is more important is that it is stable. In other words the system will always be driving towards a single outcome, and that once this outcome has been actualised, the systems behaviour becomes locked in place.

4 State spaces and search algorithms

The concept of state spaces can be explained more fully through an example taken from the world of computer animation. Inverse kinematics is a means of defining relationships between parts in a digital computer model such that each component will at its joint propagate a force to its adjoining component. It is used to efficiently model the skeletal system of characters in animation because it provides an efficient way to control joint rotation between rigid elements. It is efficient because inverse kinematics, unlike forward kinematics, propagates forces from the bottom of a hierarchy back up the chain of components (figure 1) (Elias).

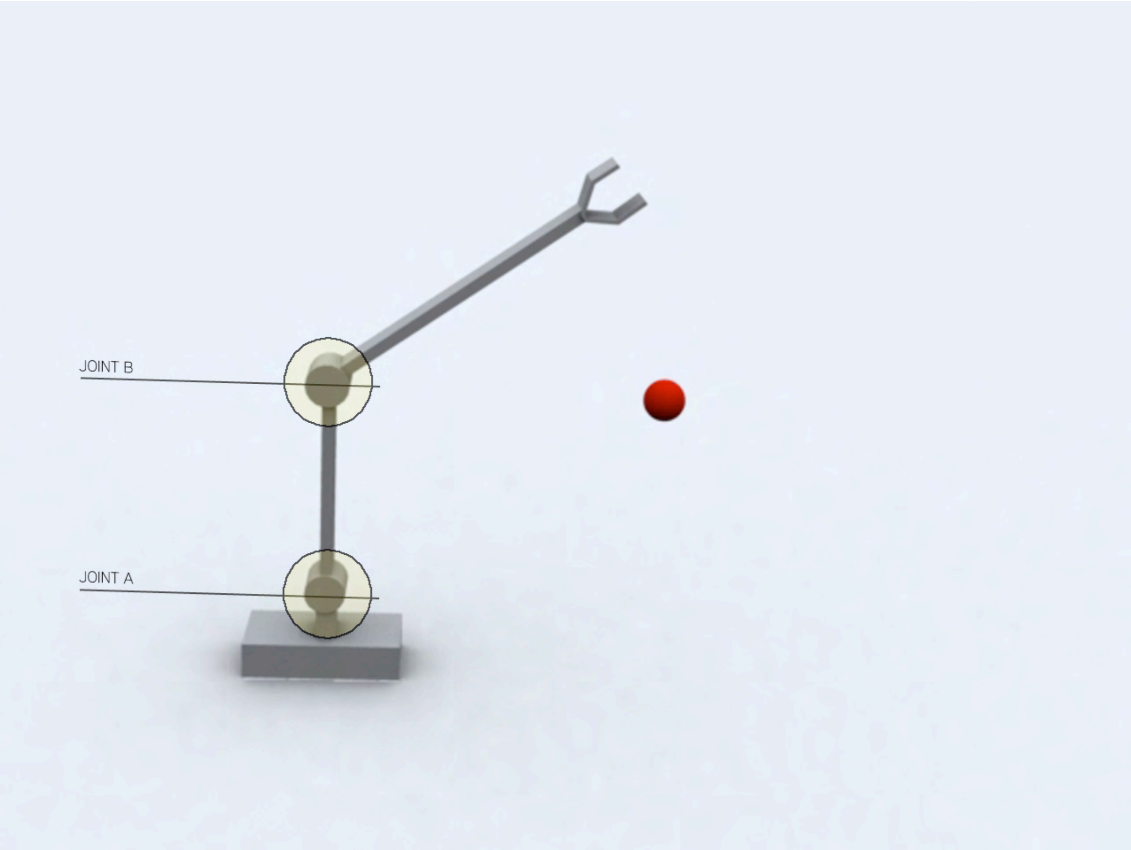

Figure 1: **Robot arm 01**

With regular or forward kinematics, to animate an arm picking up a ball we would first need to rotate the shoulder, extend the arm and open the palm before finally wrapping the fingers around the ball to clutch it. With inverse kinematics I define a series of properties for each joint, the shoulder is a ball and socket type joint, it can rotate within this range, the elbow can extend this far, fingers cannot bend backwards etc. Further each joint is given a weight or resistance, when we move naturally the hand opens early to anticipate grabbing the ball, the elbow moves quickly etc. Now once we have defined these relational properties between members, in inverse kinematics we simply grab the fingers and move them towards the target object, the other components automatically respond based on the properties of the joints in between.

The difficulty arises when we ask the computer generated arm to find the object, rather than simply direct it towards the object manually (figure 2), especially for systems in which joint rotation can move across three axes. Whilst the starting point and goal object or target points of the arm are known and we can solve the shortest possible route between these points very easily, what is much more difficult is the solution for what angles the joints will assume during this movement. In fact for circumstances with 3 or more joints there is often no analytical solution to the problem (figure 3).

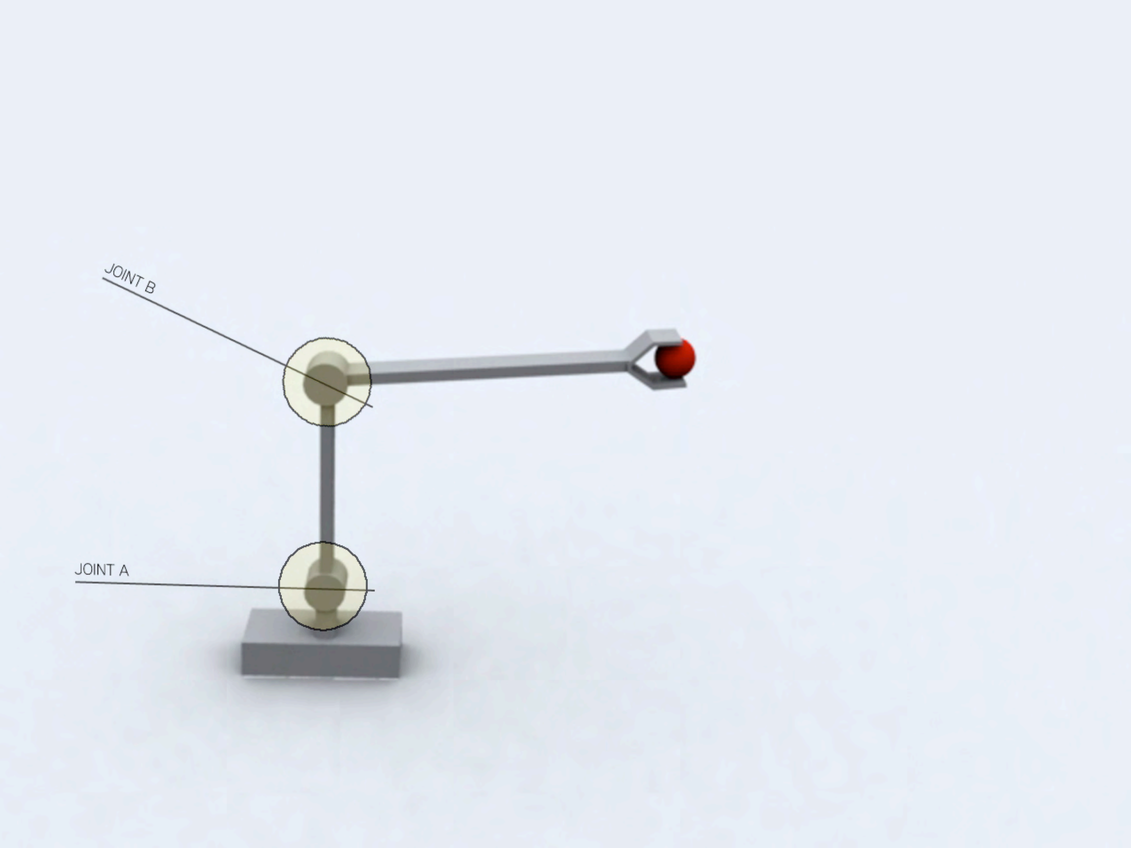

Figure 2: **Robot arm 02**

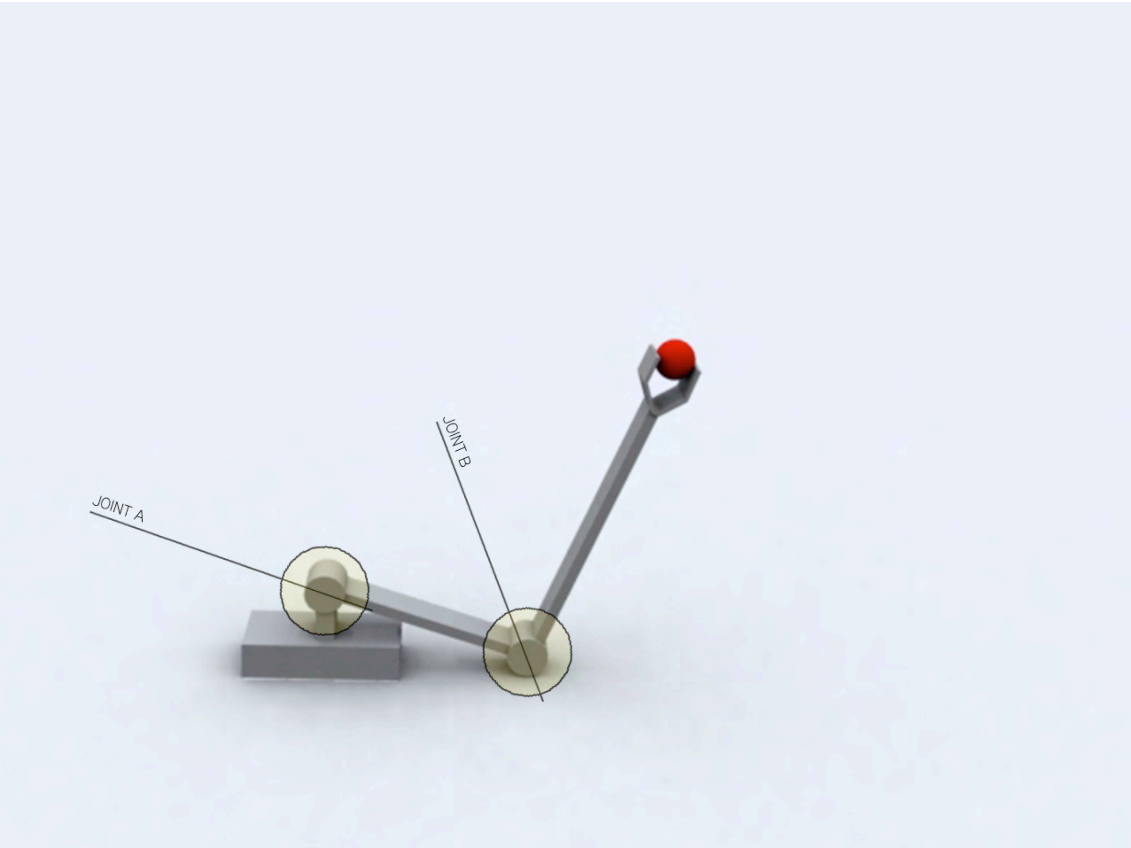

Figure 3: **Robot arm 03**

Staying with this simple example, when we ask the computer to find the most efficient way, given the joint constraints, to find its object, one solution that is often used is to deploy an iterative algorithm (non-linear programming techniques are often the only ones that will be able to deliver *any* solutions to the problem). The iterative algorithm can be said to search the space of possible solutions from a given starting point, when more efficient values are returned they are favoured over less efficient ones. The space of possible solutions can be called a search space for the algorithm.

What does a search space look like? (figure 4) In the case of this robot arm, we could assign to each joint a variable measured in degrees. Plotting each of the rotational ranges of each joint on separate axis would allow us to describe a space bounded by the 180 degree limit of the maximum extension of each joint.

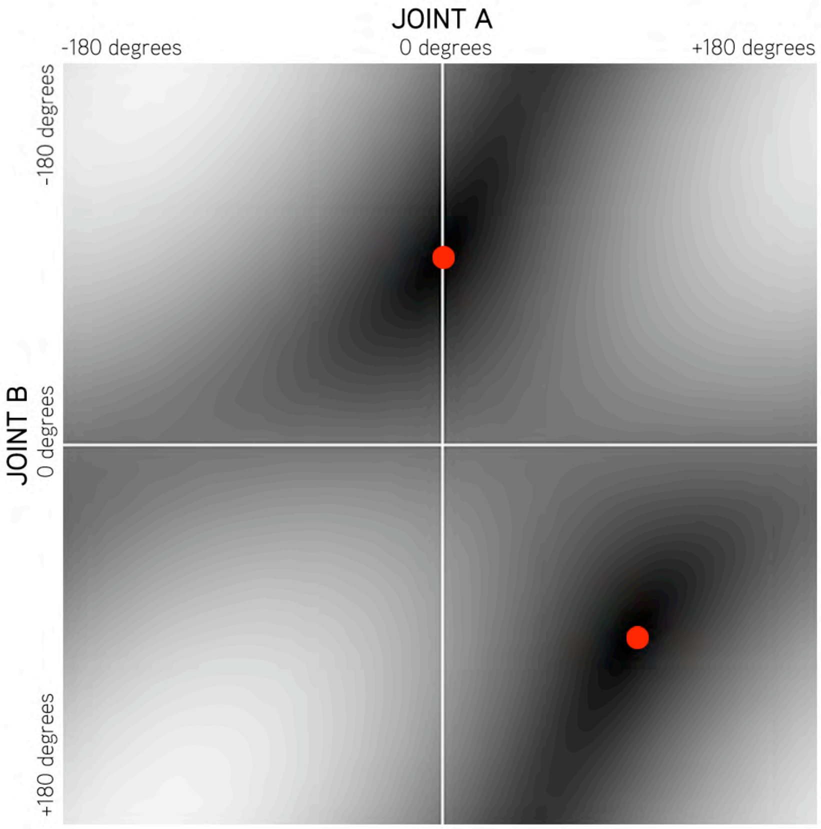

Figure 4: **Graph**

What is critical here is to understand here is that this graph is *not* a representation of the real two dimensional space in which the arm exists, we could not simply super-impose the arm onto this graph because the graph is measuring degrees and the physical space of the robot arm picture would be measured in distance units. What this graph is showing is all the potential configurations of joint angles in the arm. We can see that two points on the graph refer to the two combinations of angles on each joint that will get us to the target.

The darker areas show combinations of joint angles that get the hand closer to the target, the lighter areas show combinations of joint angles that move the arm further away from the target. This landscape describes all possible combinations of movement for the arm- it is a perfectly complete description. This space of possibility can be subdivided infinitely, there are literally countless ways of occupying this space, and yet it is an infinity that is delimited by the extent of the graph. More interestingly however we note that it is not an undifferentiated space, it is literally a landscape (figure 5). The algorithm is simply a machine that explores the landscape by looking for the minimum or darkest point using mathematical differentiation, similar to trying to find the maxima or minima on a curve.

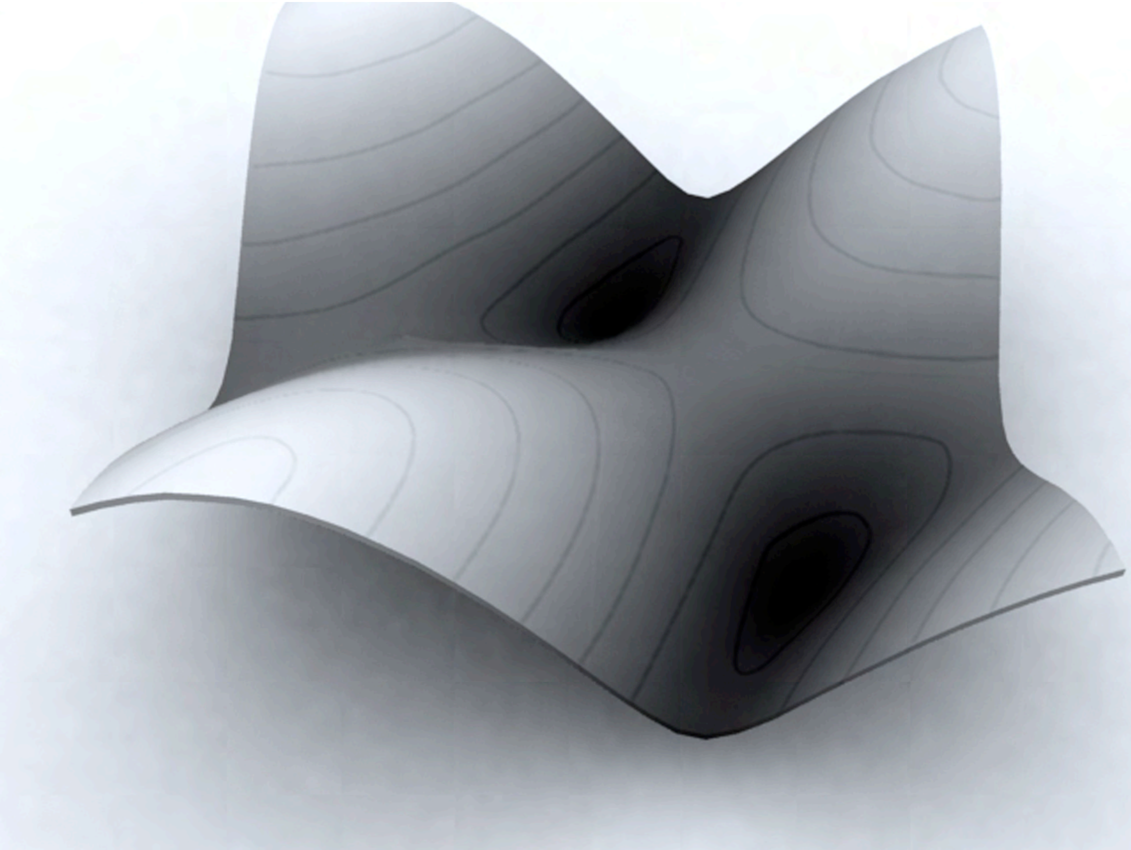

Figure 5: **Graph landscape**

We can treat any system in which we can describe the degrees of freedom of its parts in the same way. Conceptually, we might therefore treat the landscape as more than an expression of possibility but as the very field that determines the behaviour of the system (figure 6). Crudely speaking we could reverse the causal chain and see the properties of the graph or landscape driving the arm and not the other way around. This is how evolutionary or algorithmic design processes operate. Evolutionary design processes produce iterations of form by populating successive locations in these spaces. Formal variation in the object is driven by the variation of the mathematical landscape occupied at any one time. Considering the system at this level provides a description of the overall tendencies, potentials and most importantly impossibilities that govern specific behaviour. The specific history of a system's behaviour is given by the line a point inscribes as it is travelling across this mathematical surface.

5 Basins of attraction and bifurcations

The minima can be thought of as a basin of attraction (figure 7), so whenever the point tips over the precipice or edge of one of the higher contours it will drop into a different basin of attraction and thus change its behaviour. An attractor is a point that governs a specific pattern of behaviour (many attractors can exist in the same space). A basin of attraction is the zone of influence for the given attractor (when a point enters into a basin of attraction its behaviour is influenced by that attractor). A system poised at the border of two basins of attraction can be said to be at a bifurcation point (figure 8), with the slightest perturbation sending it into a different path. Stuart Kaufmann has suggested that complex systems can maximise their adaptability by locating themselves on these bifurcations zones, effectively increasing their freedom to change behaviour.

> "Networks on the boundary between order and chaos may have the flexibility to adapt rapidly and successfully through the accumulation of useful variations. In such poised systems, most mutations have small consequences because of the systems' homeostatic nature. A few mutations, however, cause larger cascades of change. Poised systems will therefore typically adapt to a changing environment gradually, but if necessary, they can occasionally change rapidly." (Kaufmann 81)

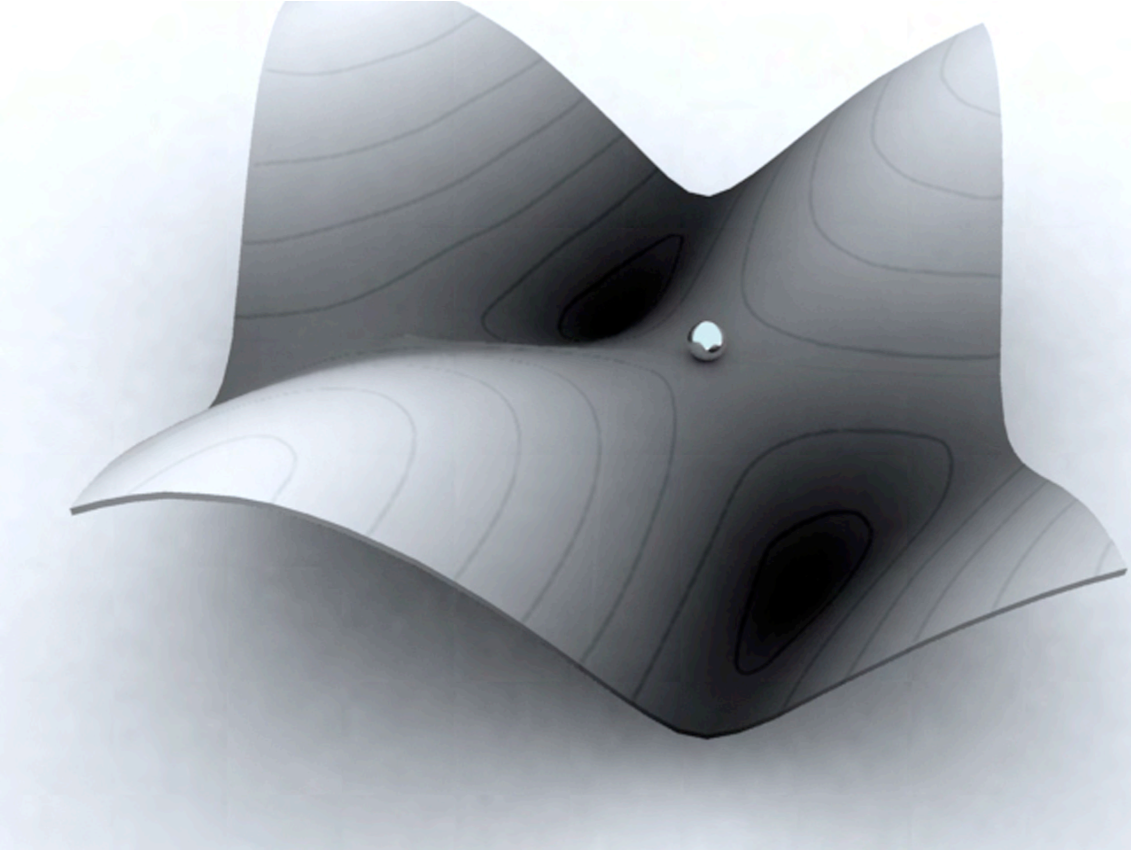

Figure 6: **System portrait**

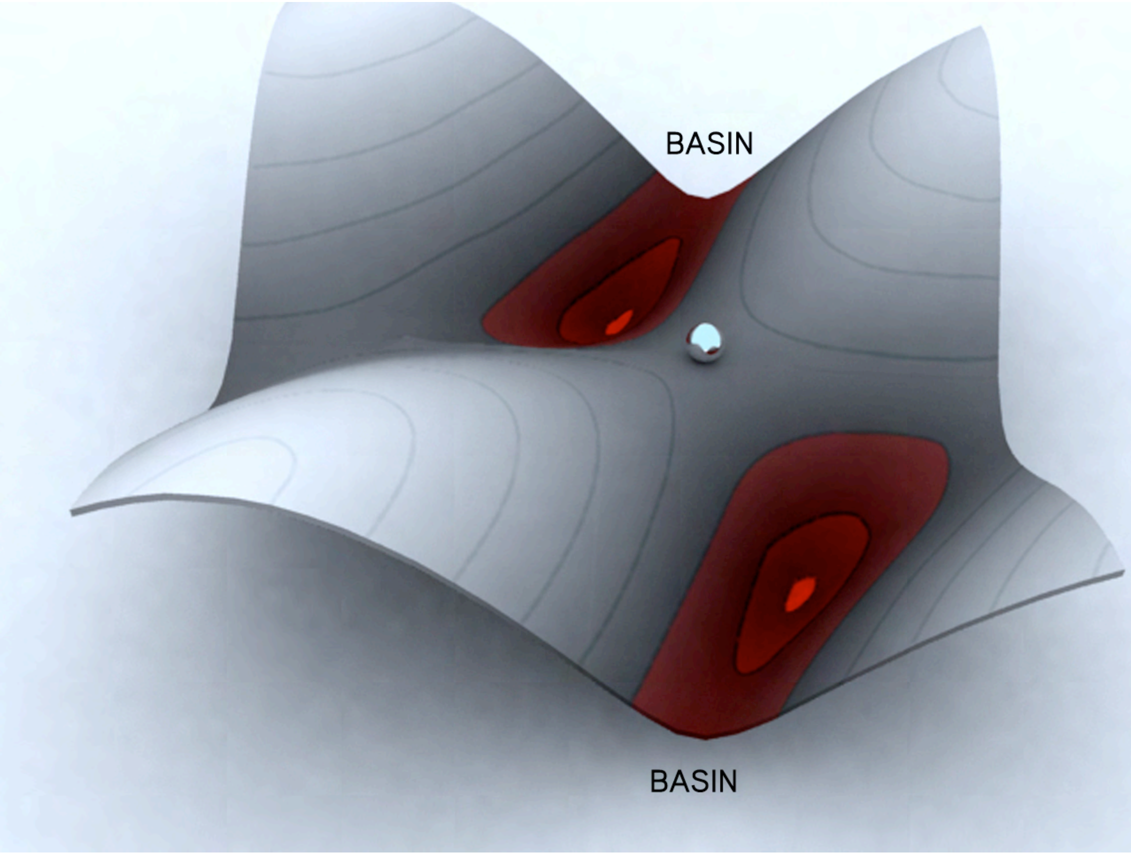

Figure 7: **System basins**

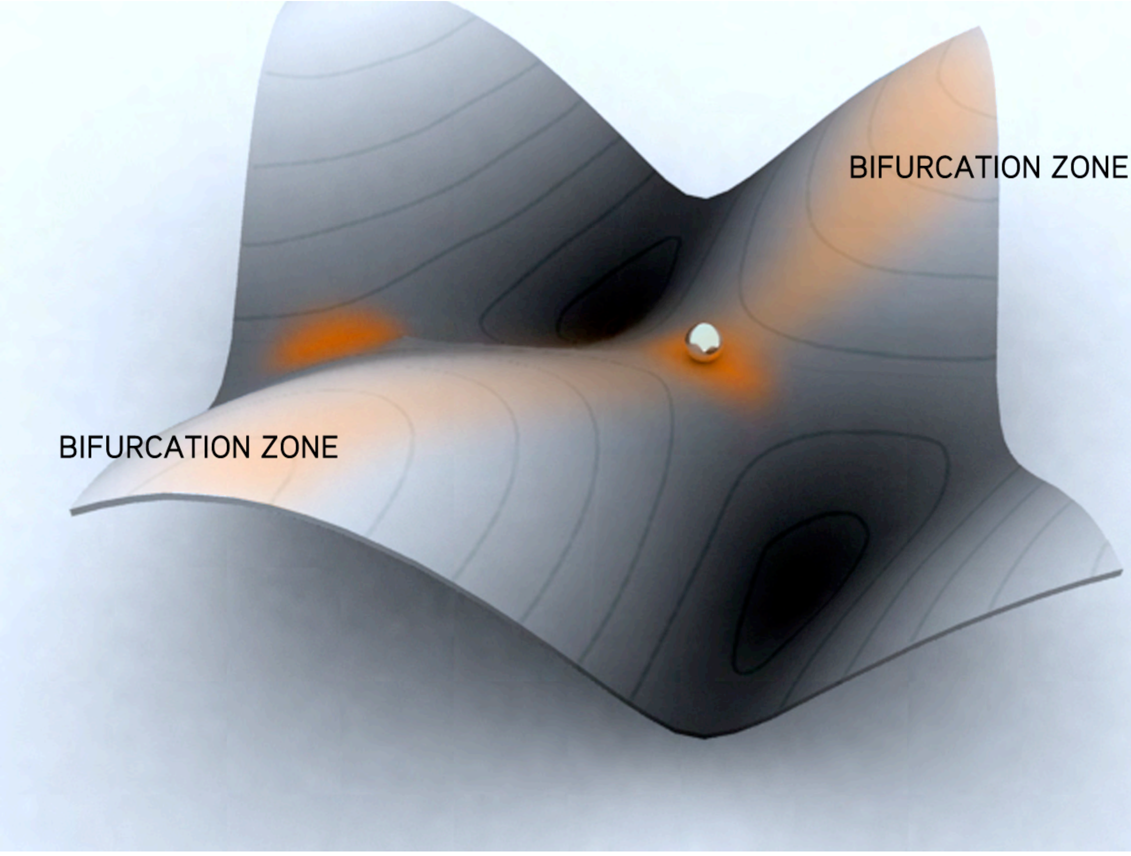

Figure 8: **Bifurcation**

Though the robot arm is useful as a pedagogical device to explain a search space, it is a highly simplified example. For more complex systems we will not be able to use a two dimensional graph. In fact every degree of freedom in a system will require its own axis; therefore for a system with n-degrees of freedom we will need an n-dimensional space to describe it.

Topological mathematics provides us with the resource to describe spaces of more than three dimensions. Topologically, a space can have an unlimited number of dimensions. The *manifold* is the mathematical 'description' of the state space; therefore the manifold describes all possible configurations of variables. A point located on the surface of that space will describe the particular configurations of each of the degrees of freedom of its component parts at any time, the movement of that point across this n-dimensional surface will describe the change in any of these potential configurations across time. This is essentially a meta-space that describes the systems potential. The specific behaviours of the system will emerge out of the constraints and tendencies of the topological space. It should be noted that there is some contention as to the status of these spaces with regards to the phenomena that they model. As Dyke notes:

> "State spaces can be called "heuristics", "models", "epistemological devices" or what ever you like. But whatever we call them, we cannot be justified in imagining a real world "process" of the successive piling up of constraints in as *necessarily* being mirrored in our successive manipulations of a matrix. The notion of a *state space* is an analytical tool *we* use to design research." (Dyke 14)

Questions of fidelity or accuracy with regards to the phenomena being modelled are of course important in an analytical sense, but at no point can we say that there is an perfect equivalence between the phenomena and the model, only that certain salient characteristics of the phenomena have been incorporated into the modelling technique and that the these characteristics shape the rate and trajectory of an object as it moves through the model. As Delanda suggests

> "(The) value of state space would be to reveal a topological isomorphism between singularities in the model and singularities in the physical system being modelled. " (Delanda 147)

6 Possibility

This account of emergence as it has been described is still highly problematic for one very significant reason. If all the potential behaviours in a system are *given* at once as on the graph, and all that is left to occur is for them to be simply selected by a point in its trajectory through the model, then we are left with a system in which *what is possible* already pre-exists. Time would only operate to make real that which has *always* been a possibility located in space.

Gilles Deleuze provides a very precise way of understanding this space of potential that accords to 'time' its properly creative function and thus opens the opportunity for novelty or newness. He achieves this via a critique of the categories; 'possible' and 'real'.

> "Every time we pose the question in terms of possible and real, we are forced to conceive of existence as a brute eruption, a pure act or leap which always occurs behind our backs and is subject to a law of all or nothing. What difference can there be between the existent and the non-existent if the non-existent is already possible, already included in the concept and having all the characteristics that the concept confers upon it as a possibility?
>
> …to the extent that the possible is open to 'realisation', it is understood as an image of the real, while the real is supposed to resemble the possible. That is why it is so difficult to understand what existence adds to the concept when all it does is double like with like. Such is the defect of the possible: a defect which serves to condemn it as produced after the fact, as retroactively fabricated in the image of what it resembles. "(Deleuze.2:211)

For Deleuze a stable topology in which *what is available to actualization already exists*, is not worth having, since all it does is make real what previously existed as a possibility, thus doubling 'like with like'.

> "That is to say, we give ourselves a real that is ready-made, preformed, pre-existant to itself, and that will pass into existence according to an order of successive limitations. Everything is already *completely given*: all of the real in the image, in the pseudo actuality of the possible." (Deleuze. 98)

7 The virtual

This state space or landscape of potential is what Deleuze would refer to as the *virtual,* with one important qualification that we will come to. The virtual is not physical and yet it is real, further not only is it real but it provides the generative space out of which physical form is developed. What is physical would be an actualisation of a particular location on this topological landscape.

As Bonta and Protevi have noted, the qualification that must be introduced, is that for Deleuze a properly virtual topology is unstable and dynamic (Bonta and Protevi 27). That is, the reservoir of potential forms out of which physical form emerges, is itself subject to variation. This is critical for Deleuze's ontology, because the stakes must not be limited to the variation in action that can take place *within the limits* of the system, what must be at stake *is the very form* of the virtual itself. A strongly emergent system is one in which this reservoir of potential is in variation with itself, so that what is available for development is itself subject to change. Weakly emergent systems would be systems in which the topology- that is the reservoir of potential forms on which actualisation processes can draw- is relatively stable and given only to local reconfigurations. This distinction between weak and strong emergence thus directly relates to type of spaces from which variation can potentially draw. It explains the limits of possible difference.

The point of understanding conceptually if not mathematically, all these features and their terminology, is that an emergent approach to design means that these specific articulations and characteristics of the virtual world become the levers and instruments, or better; the morphogenetic drives and structuring forces available to the designer. Understanding those singular zones of a systems topology- those areas of the virtual landscape in which behaviour is balanced between two different states- means that we know when and where to apply pressure to shift a systems behaviour. More importantly it promises an economy of effect since only a minimal effort is required to tip a system poised on the cusp of two different states.

8 Notes

[1] It is important to note that that this mathematical space in which variations of the objects exist is not infinite in *extension*, it is bounded and has limits, rather we should say that it is infinite in density-a bounded infinity.

[2] What emerges with a new medium or practice more than a set of techniques or methodologies is a new series of problems in which existing techniques and concepts must be recast. Just as the 'problem' of authenticity only emerges with photography and mechanical reproduction, emergence carries with it its own series of lures and traps whose effect will be felt outside of the confines of computational or digital approaches to design.

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CHANCE ENCOUNTERS BETWEEN BODY AND BUILDINGS: NEW TECHNOLOGIES IN ARCHITECTURE AND DANCE

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Abstract

The fields of dance and architecture initially seem in direct opposition – one dedicated to movement and the other to stasis. In many ways dance appears to hold the many qualities ever beyond architecture; the opportunity of flight, of 'liveness', of the ephemeral. Importing ways of thinking as well as doing from dance into architectural practice is conditioned through the shared focus on the encounters between bodies and spaces. In grappling with the impact of new technologies on the design process, new kinds of movement and spaces are being produced.

A key tactic that has emerged within both fields is that of chance. This is arguably the most radical shift that has occurred in the architectural design process. As well as the growing explorations of interactive, multi-media and virtual technologies in dance performances, has been the expansion of notational and choreographic programs that utilize unpredictability. The move toward abstracted systems in these programs endeavours to incorporate energy, force, direction and intent, opening up choreographies to undetermined movements. In this context what dance may provide for architecture, are methods that respond to the difficulty in retaining the animate body in the virtual acrobatics generated by new, generative, architectural programs.

In this paper I will be examining the transformation of the architecture drawing through generative modelling programs based in indeterminacy. The implications of these new methodologies in terms of the design process and the animate body, are viewed in relation to dance experimentation in this area. By specifically looking at the digitised body geometries of choreographer William Forsythe, I hope to open both fields to new encounters between bodies and buildings.

1 Introduction

The fields of dance and architecture initially seem in direct opposition – one dedicated to movement and the other to stasis. In many ways dance appears to hold the many qualities ever beyond architecture; the opportunity of flight, of 'liveness', of the ephemeral. They share however the key interest in the encounter between bodies and architecture. This encounter in both disciplines has shifted and been reshaped by new technologies in design and production.

While in architecture the move toward abstracted systems in these programs have meant the incorporation of multiple forms of information, choreographers have pursued the incorporation of energy, intent and force. Most importantly for both fields has been the strategy of potentiality. Indeterminacy as a creative strategy is beginning to achieve acceptance in architectural practice, a change I argue to be the most radical shift in the architectural design process. In this context what dance may provide are methods that respond to the difficulty in retaining the animate body in the virtual acrobatics generated by new, generative, architectural programs.

This paper examines the transformation of the architecture drawing through generative modelling programs based in indeterminacy. Rather than focusing on the digital programs themselves, it is concerned with the new process of thinking that these programs have instigated. I want to examine how the understanding of the design process has changed. The implications of these new methodologies in terms of the design process and the animate body are viewed in relation to dance experimentation in this area. What better way to describe the relationship between these issues than Brian Massumi's description of this new mode of architecture as 'the art of the architect is the art of the leap' (5). The leap is an act of daring, a performance not only of the stage but of the everyday. It signifies the risk of arbitrariness and the novel outcomes that this risk allows. By specifically looking at the digitised body geometries of choreographer William Forsythe, I hope to propose new incorporations of animate bodies into architecture

2 Intersections in Dance and Architecture

In order to escape the presentation of the purely tectonic elements of architecture in the drawing, it is necessary to look to other disciplines. By focusing on bodily movement, dance is a logical starting point for exploring new graphical possibilities for bringing bodies into paperspaces. Movement diagrams as well as dance scores provide alternative notational systems that can be brought into the architecture drawing.

The relationship between dance and architecture has been bound in the dichotomy of performers/audience against stage/theatre architecture, both introverted toward their own specific needs. As both disciplines in the 20th century endeavoured to break away from their historic ties, their aims began to converge. While Classical forms of Western Ballet focused on two-dimensional patterns of the body, contemporary dance has become known for exploring the physicality of the body carving and interacting with space. Modern dance can be read as an attack on the geometry of the Cartesian space, which classical ballet was contrived within. Space is reconsidered as solid and interactive. John Rajchman notes the relationship between dance and architecture as their mutual concern with gravity (52). The desire to understand it, use it and surpass it provides a shared goal. This goal of lightness and floating has been facilitated by new materials, but it is also a strategy imported by digital design programs where buildings virtually float on the screen.

3 Architecture Drawing Systems

Unsettled by technological advances, the central architectural issues of drawing, space and the animate body are in flux. For architecture, space has been constructed by the two-dimensional drawing, firmly grounded in the physical. Despite the use of three-dimensional images, they remain dictated by the same systems of hand drawings. The perspective is still that of gods or ghosts, either from up high or as if you were plastered into an interior wall. Rather than the mere replication of traditional forms, Computer Aided Design programs present the opportunity to free architecture from orthogonal geometry, with software from industrial design, aviation, film and auto design, now finding their way into architecture. What was once theoretical musing on alternative geometries and mathematics, are now architectural possibilities. Using algorithms to set up mathematical frameworks in which to generate forms does not demand a computer, as proved by Antonio Gaudi's architecture. What is now different is the accessibility and speed computers lend these complex processes to designers. What this means for the process of making architecture is an entirely new set of tools with entirely new potential outcomes.

The work of architecture in the digital domain subverts the dichotomy that has traditionally been maintained between the virtual and the actual. This distinction enforces an inability to see digital architecture as more than simply an image on a screen. However a new kind of design process is emerging, generated by these new processes of translation. In turn it is informing a new theory of design. New computer design programs have led to an emphasis on process and technique rather than the final image. With it new architecture methodologies are appearing based on organic and self-perpetuating systems.

4 Potential Acts

Amongst the various implications of these new issues for architecture, this paper will on focus on potentiality. Potentiality is also about improvisation, about indeterminacy, about chance. Inherent in these terms is the risk of the unknown. This means giving up control and giving up autonomy. The illusion of complete control is what architects stand to loose with these new programs. Brian Massumi describes these technologies as generating a 'post-heroic' architecture because the traditional role of the architect as creative genius of a finished object is replaced with a less attractive position of 'creative facilitator' (9). The focus is on process and technique rather than finished a form. Rather than the signature work of the architect, the building becomes a collaboration between the designer, data and the technology. In this new process the computer is not an imaging device, but a medium in a process of emergence. They are performative methods, based in the doing process of design rather than a static representation of forms or ideas. It becomes an art of potentiality, creating multiple possibilities rather than coming up with a single, perfect answer.

This mode of working is not limited to architectural design but is indicative of a wider, cultural shift in thinking about objects in the world. In reflecting on this current state, the writing of Giles Deleuze has shown to be particularly applicable. Deleuze describes this reconfiguration of the object, an understanding that can be used to describe this new way of making architecture:

> The new status of the object no longer refers to its condition to a spatial mold in other words, to a relation of form-matter but to a temporal modulation that implies as much the beginnings of a continuous variation of matter as a continuous development of form (19).

Deleuze declares that object making can no longer the understood simply in terms of its final product. Instead, the entire process of it's making must be considered, a process that is now based on continuous transformation.

5 Drawing Chance

The avant-garde composer and artist John Cage inspired many choreographers and performers during the 60s and 70s to incorporate potentiality and chance into their work. Cage's performance scores merge mapping techniques and informational systems, pushing the conventional assumptions of authorial control. Similarly, the contemporary dance choreographer Merce Cunningham has been known to choreograph dance sequences by rolling dice. However potentiality in choreography is not only not knowing the next move in a sequence, but what that move could be in space.

Robin Evans describes the difficulty of the architecture drawing is that unlike other kinds of drawings it occurs prior to reality (165), rather than after it like the choreographic score. Both architecture and dance drawings do not aim to represent past actions, but future ones. This means building flexibility into the performance script. Traditional ballet scores and notations present only body shapes, where teaching becomes a process of mimicry. They are formulated on defining fixed events. In contrast, contemporary choreographers have endeavoured to understand that notations must present a body that is never still, but holds multiple potentialities of movement.

In their dismissal of Cartesian space and traditional dance forms, many contemporary choreographers have drawn on different artistic disciplines to present new kinds of movement and interaction. In breaking away from traditional dance typologies, new forms of documentation are needed. New technologies in digital, spatial imaging have become central to creating systems that can document and represent the essentially live medium of dance. The most famous example is Cunningham, who uses dance notation as a creative starting point, drawing on new technologies. Cunningham was the first notable choreographer who began experimenting with integrating computer technologies into dance works during the late 1990s. He uses *LifeForms* software (now called *DanceForms*), as a generative device for exploring new kinds of movement. It is ideal for use in collaboration with live performances and as a tool for creating new kinds of movement. In his well-regarded production of BIPED in 1999 with digital artists Paul Kaiser and Shelley Eshkar, motion capture images were projected onto scrims, allowing dances to perform in real time with their avatars.

Accepting the scripting of living bodies in architecture means finding new ways of incorporating these bodies into the design process. Instead of focusing on the documentation of solid forms, to look at bodily transition and spatial transaction is to bring into the drawing process possibilities for chance and improvisation. As contemporary dancers such as Cunningham and

Forsythe utilize new technologies, the disciplines of dance and architecture start to converge. By focusing on the moving body, the interaction and overlap of technologies can bring issues of the built environment into dance practice and the body into architecture.

6 An Architecture of Movement

The geometry of movement is a choreographic tool for contemporary choreographer William Forsythe. His analytic formulations of body and space has led to several collaborations with architecture, of both theoretical and physical kinds – most notably through his friendship with Daniel Libeskind. Through his twenty year directorship of the Frankfurt Ballet and now The Forsythe Company, Forsythe has cultivated an international reputation for innovative and experimental, contemporary ballet. His interest in new ways of notating dance, coupled with a vehemence against static reproductions, has led to novel collaborations in new media and digital design. His work has often been described as ‘dance deconstruction’, although this term fails to understand Forsythe’s process. Rather than deconstructing traditional ballet forms, Forsythe is forging a new process of dance based on the body as a spatial constructor. A key part of this process is the embedding of chance into the choreographic process.

Forsythe has described his process of sculpting lines and geometries in space an architecture of movement, where the line becomes a volume, the body folding and unfolding as it inscribes geometries. Forsythe says, ‘Movement is, so to speak, living architecture – living in the sense of changing emplacements as well as changing cohesion. The architecture is created by human movements and is made up of pathways tracing shapes in space [which] we may call “trace-forms”’ (qtd. in Spier). This can be clearly understood in Forsythe’s contemporary ballet ‘Limb’s theorem’ (1990). Forsythe used Libeskind’s ‘Endspace’ drawings as scores, upon which the dancers extruded three-dimensional, built spaces. The physical dance becomes another iteration or translation of the drawing. The essentially static, planimetric nature of both the architecture and dance drawing is reconsidered as an set of spatial instigators, rather than defined parameters or representations. Libeskind wanted to create a set of drawings that were performative, open to transformation in contrast to the fixed state that conventional architecture drawings had devolved into. The ‘Endspace’ drawings are an interrogation of the architecture drawing, from which Forsythe choreographed a dance piece that interrogated the formal organizations and movements of ballet.

Forsythe draws his approach to space from the Swiss dance theorist Rudolphe Laban’s spatial geometry. Laban described the body’s kinosphere as a crystal form. It defines a three-dimensional geometry generated from the limits of the outstretched body, which mark twenty-seven points in space that tilt and rotate with movement. Based on the real limits of the body, this was defined by Laban as an icosahedron, replacing the Euclidean circle and square described by Vitruvius. Any point in this crystallized form can become the centre of gravity, instead of an original radiating axis. Using Laban’s geometry as a spatial framework, Forsythe employs algorithms to create regenerative systems. Forsythe’s calls the results ‘movement alphabets’, based on these internal movement geometries. This alphabet is designed through improvisational processes. It is as if the body were drawing formulas and equations in motion through the air. Dance theorist Gabrielle Brandstetter describes this process as:

The movement of an oscillating “dis- and re-orientation” organizes the structures as a constantly reversible process… the remembering of the order in the movement sequence, the memoria of the passing of time and space -become the generators of a vocabulary that appears like an alternating current…it is an effect that not infrequently awakens in the spectator the impression that a figure or line is growing out of the impulse of both and inward and outward mobilization (46).

This spatial geometry frees Forsythe from the traditional limitations in dance of centering the body in order to produce stability. Instead, the dancer is purposely destabilized and thrown off balance. Potentiality becomes a testing out of the multifarious possibilities of movement in the body. As Brandstetter points out, this architecture of imbalance subverts the assumption of bodily stability (46). He works with disequilibrium and distortion, seemingly contradictory themes for dance, as they are for architecture. Instead of built form, Forsythe is working with the body and space, seeing space as a plastic entity that can be both worked against and acted upon. Destabilization is used to redefine assumptions of centrality and stability, in order to generate movements that are paradoxically more intimately human to watch. To see a dancer on the verge of a fall is far more personally immersive than the incomprehensible control of the typical ballet posture. The results of this process tend toward the freakish, distorted body gestures and extreme and sudden shifts in movement, create intense and very powerful dance scores.

In terms of architecture, it is useful to look again at Libeskind's work. Forsythe has described Libeskind's work as a series of decentered spaces (qtd. in Brandstetter 49). The spaces refuse to present the traditional stability that buildings lend to the body, which anchor it in space. This can be experienced in Libeskind's extension to the Jewish Museum in Berlin. Libeskind creates spaces that purposely throw people off balance through extreme floor, walls or ceiling gradients, asymmetric windows and acute angles. The viewer must be constantly on guard, aware of their surroundings. The architecture demands active perception, where bodies must continually realign themselves. The architecture actively works against the body to extract an emotional reaction.

Forsythe understands potentiality in choreography as essentially an opening up of the geometries made by bodies in space. His design process has melded digital programs and physical improvisations, in order to generate new geometries for the moving body. At the core of Forsythe's choreographies is an algorithmic design process, which computer programs can now emulate, generating faster outcomes and documenting that process. But it is the lack of perfection, the glitches and lags and failures and falls of human repetition where Forsythe understands the art lies.

7 Conclusion

New developments in the design of contemporary architectures are being led by innovations in technology, whether it is BIM and parametric modelling programs, topological definitions of form and space or prototyping and manufacturing capabilities. This paper follows from a personal interest in what I argue to be the greatest loss risked in these digital acrobatics – the awareness of the animate body in architecture. The changes that are taking place with bodies and spaces, and in the technology of architectural drawing, will continue regardless of how the practice chooses to react. But that in parallel to the development of architectural design techniques and manufacturing, should be recognised the key question of how to incorporate the living body into these new digital and digitised spaces.

This paper has aimed to briefly map out the infiltration of chance and indeterminacy into the design process. By relating in parallel the inter-relations in the dance field and the work of William Forsythe, it proposes new relationships between the animate body, design processes and architecture. The leap into the unknown means allowing these new relationships the opportunity to create new kinds of artworks, whether dance pieces or buildings.

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THINKING BEYOND THE SQUARE: INNOVATION THEORY AND TECHNOLOGY TRANSFER AS THEY APPLY TO THE BEIJING WATER CUBE

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Abstract

The Water Cube National Swimming Centre designed for the 2008 Beijing Olympics has been hailed as a highly innovative post-millennial sports facility. Conceptually, its architecture is a cube, carved from a random, organic and homogeneous cluster of foam bubbles. Structurally, it is a mathematically rigorous steel space frame, primarily of pentagonal and hexagonal cells. Materially, it is clad inside and out with ethylene-tetra-fluoro-ethylene (ETFE) cushions whose translucent skin captures and translates water's natural transient and organic properties to a new context that is ancient, landlocked and manmade. The winning design consortium comprised the Australian architectural firm PTW, Arup (Australia) and China State Construction Engineering Corporation – Shenzhen Design Institute. This paper examines the success of the consortium in the light of innovation theory: it considers the drivers behind the collaborative effort, the structure and characteristics of the design team, and the role of technology transfer in the innovation process. Research shows that innovation in the construction industry is linked to a demand for radically new types of buildings and structures. The Beijing Games have provided such a demand as its purpose-built facilities strive to couple challenging programmatic requirements with cultural aspirations.

The Water Cube is a unique coalescence of Chinese cultural traditions, favouring axial arrangements and rectilinearity in the built environment, with current Western trends towards asymmetric organic forms and structures derived from nature. It has been achieved by the transfer of digital technology to architecture and engineering and by the application of an emergent building material, ETFE. The dynamics of the teamwork approach to design provided rich multi-cultural perspectives and diverse technological know-how that allowed for technology transfer and innovation to take place.

Keywords: Architecture, innovation, Water Cube, Beijing, Olympic.

1 Introduction

The Water Cube National Swimming Centre designed for the 2008 Beijing Olympics by the Australian architectural firm, PTW, in partnership with local architects China State Construction Engineering Corporation – Shenzhen Design Institute (CSCEC-SDI) and with engineering input from the Sydney office of Arup (Australia), has been hailed as a highly innovative post-millennial sports facility. Conceptually, its architecture is a cube, carved from a random, organic and homogeneous cluster of foam bubbles. Structurally, it is a mathematically rigorous steel space frame, primarily of pentagonal and hexagonal cells. Materially, it is clad inside and out with ethylene-tetra-fluoro-ethylene (ETFE) cushions whose translucent skin captures and translates water's natural transient and organic properties to a new context that is ancient, landlocked and manmade.

The (limited) literature on the Water Cube is fixated on how the architecture/engineering has made possible the realisation of a lightweight construction derived from the structure of water in the state of aggregation of foam (Rabagliati). This paper steps beyond the 'how' to contribute a new understanding of innovation theory and technology transfer as they apply to the Water Cube. The methodology is based on an analysis of the recognised drivers for innovation and the components of technology transfer, and is informed by a series of interviews conducted by the author with the project architects at PTW.

2 Innovation Theory

Innovation is defined by the Australian Bureau of Statistics (ABS) in its survey, *Innovation in Australian Business 2005*, as "the process of developing, introducing and implementing a new or significantly improved good or service or a new or significantly improved process" (46). The ABS research reveals that the construction industry performs poorly in innovative activities compared to other Australian industries. This accords with the scant attention paid to the workings of the construction industry in innovation literature, a review of which was completed by Christine Miller, Robert Carr and Wilfred Cheung in 2001. Literature on innovation in architecture is even scarcer and mostly comprises case studies examined individually and in isolation from a theoretical framework (Brookes and Poole).

Much innovation theory derives from studies of assembled products and explores the interrelationship between product and process innovation. William Abernathy's research on the auto industry is a well-known example. A highly valued product like a car is the result of a continuous, "fine scale" development process involving multiple inputs that are combined and transformed through a complex production process. James Utterback finds that a similar interrelationship between product and process innovation also applies to non-assembled products such as glass and steel, but that the development process differs because it is periodic and discontinuous. For example, the development of float glass technology by Pilkington was a large technological leap (104-116). This kind of discontinuous innovation is described by Philip Anderson and Michael Tushman as coming from a technology that "inaugurates an era of ferment in which competition among variations of the original breakthrough culminates in the selection of a single dominant configuration of [a] new technology" (606). Innovation is a process and technology transfer is a means by which innovation is achieved (Cooke and Mayes 11).

Architectural innovation involves both the fine-scale development of existing products and large technological leaps that transform the discipline. Mike Cook, a structural engineer with Buro Happold, describes fine-scale innovation as originating from people who are masters of their field moving "ideas forward in small steps using new tools or applying established techniques in new areas," while innovation on a grand scale comes from people "working and thinking 'at the edge' of their discipline" (in Brookes and Poole 82).

> The most important aspect of a technical innovation is the visual or experiential idea that it helps to bring nearer to fruition… without the desire to make a better expression of a particular idea, technical innovation lacks a cultural and social purpose" (Brookes and Poole 111).

3 Drivers of Innovation

The ABS survey, which is based upon an international framework provided by the *Oslo Manual, Guidelines for Collecting and Interpreting Innovation Data*, identifies three major categories of drivers of innovation: profit, market and legal-related. Respondents could also nominate "other drivers" and the Construction Industry did this at a higher rate than most other industry groups, possibly because of its ad hoc structure and the prevalent conception of building projects as "one-offs." It has been demonstrated that the drivers of innovation within the construction industry are historically strongest when there is a demand for radically new types of buildings and structures (Gann 10). The Modern Olympic Games provide such a demand.

The architectural setting of each Olympiad is important as host cities and nations strive to present a distinctive image to the world, to establish a leading status in the global order, and to project official ideologies to the local population. Olympic projects are characteristically large-scale undertakings with large budgets. The architecture is frequently progressive and technologically advanced, but may also incorporate unique elements derived from the local cultural heritage. For the international audience, recognisable features of the Olympic architecture screened by the media become symbols of the place and the time. For the local population, the physical transformation of their city through new buildings and infrastructure affects their relationship with it, often engendering city pride and fostering national identity (Orr, "Force for Federation").

The Modern Olympic Games are clearly more than just a flurry of national cultural assertiveness and international cultural diplomacy: they provide periodic occasions for symbolic architectural expression that contribute to the continuum of architectural development. The founder of the Games, Pierre de Coubertin, thought that a suitable physical setting was essential to give aesthetic and philosophical meaning to the athletic contests. He was behind the competition in 1910 for the design of "A Modern Olympia" seeking an innovative and inspirational architecture, worthy of its function and appropriate to the host city.

> It is for the architects now to fulfill the great dream, to let soar from their brains a resplendent Olympia, at once original in its modernism and imposing in its traditionalism, but above all perfectly suited to its function (qtd. in Wimmer 216).

In conceptualising the architectural setting, de Coubertin was inspired by the ruins of Olympia and by the architecture of the nineteenth-century international exhibitions. The Great Exhibition of 1851 relied for its success on the spectacular Crystal Palace to bring people together in a spirit of "peace, progress, and prosperity" (Auerbach 230). Here, the horticultural glasshouse was transformed into a magnificent and vast, yet economical, structure capable of being constructed in an amazingly short space of time: craft-based traditions were replaced by the prefabrication capabilities of modern industry. The Crystal Palace exemplifies the manner in which buildings for the international exhibitions, and later, the Olympic Games, relied upon a new ceremonial public architecture that demanded innovation in construction techniques and technologies.

Through the transfer of new materials and technologies, the Munich Olympic Games (1972) managed to create a light-hearted spirit in which architecture and nature formed a harmonious recreational landscape of flowing curves and spaces. It was an opportunity to show the world that the character of Germany had changed since the Fascist period. The jury withheld comment on the feasibility of the tent roof proposed in Behnisch & Partners' winning scheme because it was an unproven proposition that departed from architectural convention. Yet the great roof was the essence of the proposal: "an integrating element, evocative of the surrounding terrain, yet lifting off from it, like one of those manned kites in the sketchbooks of Leonardo" (Mahler 26). Frei Otto used physical models to find the natural equilibrium of physical forces and to define the desired complex forms – soap film models were used to define the minimal-surface tension structures and sprung-chain models to define cable-nets of equal stress. Research in experimental physics was transferred to architectural applications.

The Olympic imperative for innovation is enhanced when a host nation's organising elites place a high value on the staging of the Games for nation building and reform. This was as much the case for Seoul (1988) as it had been for Munich. The South Korean government, "and the USA-educated military-bureaucratic-corporate 'establishment' elite at is heart, used the staging of the Olympic Games … instrumentally to achieve a number of nationalistic, political, economic and cultural goals," including recognition as a technologically modern society (Roche 148). A strategic element in this image-making was the architecture of the Olympic facilities, whose cable domes were the first tensegrity-type domes to be realised in the world. In addition, the state-of-the-art telecommunications infrastructure developed for the Games enabled South Korea to become world leaders in the field.

The next Olympic Games will be staged in Beijing (2008) – the political, educational, and cultural center of the People's Republic of China. According to the sports historian, Professor

Fan Hong, the Olympics will be the "biggest event in China since the Communist Revolution in 1949," and will represent the fruition of a communist ideology that utilises sporting success to engender Chinese patriotism and unity (qtd. in Toy 17). China is rapidly emerging as a superpower, likely to overtake the United States as the largest world economy if current growth rates continue. Hosting the Olympics will be a milestone in the reinvention of a Communist regime in the context of a predominantly capitalist global community. The $US40 billion program to rebuild Beijing extends beyond simply preparing the city for the Olympics, to building a capital commensurate with China's ambitions.

China's long history of innovation is examined by Paul Herbig in the light of the inhibitory impact of Communism (227-229). Whereas innovation tends to flourish in competitively driven, capitalist societies that place a high value on freedom of the individual, it is relatively suppressed in collectivist societies where an authoritative political system requires submission of individuals to a dogmatic social philosophy. Through a series of cross-cultural case studies, Herbig develops an innovation matrix to chart the ways in which the cultural attributes or socio-cultural attitudes of a society in conjunction with the existing infrastructure of that society influence its ability to generate technological innovations. Under Communism, China's infrastructure has been inadequate to support innovation, a difficulty which it is rapidly overcoming. Professor Shujie Yao, at The University of Nottingham, describes China's policy to be one of pursuing "a gradual, pragmatic approach to reform, taking maximum advantage of foreign investment to build its exports and selectively importing science and technology to stimulate its own domestic development." The Beijng organisers are seeking to display China's progress through a successful Games set against the backdrop of iconic architecture. A series of architectural competitions were staged to capture the best ideas from the West and transfer them to China. To assist with the transfer of knowledge, a condition of the competitions was the inclusion of Chinese partners in the consortia (Bilmon, "Interview").

4 Water Cube National Swimming Centre

Entries for the Beijing National Swimming Centre came from a large number of high-profile international architectural companies such as HOK Sport (UK), Dominique Perrault (France), Rafael Vinoly Architects (USA), Foster & Partners (UK), Cox Group (Australia) and Takamatsu Architects (Japan). They were attracted by the enormous commercial opportunities for business profit and global market share. The ABS finds that "profit related drivers were the most frequently cited reasons driving innovation, reported by 94.2% of businesses. Market related drivers were reported by 88.9% of innovating businesses" ("Notes"). Jon Sundbo argues that in the current economic cycle, the major driving force for innovation is interpretation of the market and profiting from the sale of products on it. Unlike the period from the 1930s to the 1960s, which was driven by technological development, the market now comes first and technological development, which is running quite efficiently, will follow.

PTW is an Australian company actively engaged in the Asian market, with six overseas offices. It completed its first project in China in 1992 (Shenzhen Development Bank) and in 2000-2001 established a wholly foreign owned enterprise in Shanghai-Pudong, with branches in Shanghai-Puxi and Beijing. Fifty percent of the company's revenue in 2006 was derived from overseas operations. Like any architectural business interested in securing top-end projects and exploring off-shore markets, PTW is attracted by the prestige and exposure of Olympic projects as a means of increasing market share. PTW already has a track record of innovative pool design and expertise in Olympic overlay planning and seating bowl arrangements from previous work for the Sydney (2000) and Athens (2004) Olympics. Nevertheless, the company almost withdrew from the Expression of Interest process because of the enormous risks involved: the financial and resource-intensive demands of preparing a submission were difficult to justify given the slim chance of winning an international competition and the difficult prospect of working in Beijing on the first Olympic facility to be completed there. The hesitation of the PTW Board of Directors is supported by the ABS data, which shows the most common barrier to innovation to be high direct costs that negatively impact profit. However, the company possesses most of the characteristics identified by the ABS as indicative of innovative ability: it is a large business; it has favourable business locations across Australia and Asia; it has a diverse staff upon whose ideas, knowledge, and skills it can draw; and it is experienced in multi-disciplinary collaborative ventures.

The winning scheme designed by PTW is an orthogonal form based on the square, a traditional organizational device in Chinese city planning and architecture, and located on the significant north-south axis that runs through Tiananmen Square. It is one half of the 'yin and yang' elements of the Beijing Games. The round 'masculine' stadium (by Herzog & de Meuron), glowing red, is fire, or the 'yang', and the square 'feminine' Water Cube with its baby-blue hue, is water, or the 'yin'.

The restraint of the square shape posed an architectural challenge. Its monumental unbroken box form, 177 square metres by 31 metres high, demanded an innovative treatment of façade, fabric and structure to give it unique character. Starting with the idea of water and its qualities of translucency, the team considered the architectural applications of ETFE. This product was originally developed for the aeronautics industry and its transfer to the construction industry is recent. A wave of global interest in the architectural applications of ETFE was generated when Nicholas Grimshaw used it for the huge Eden Project conservatories (2000). The appealing property of ETFE is that the resin can be spun into a thin, light, elastic, durable, transparent film that has self-cleaning and structural properties (Woyke). PTW is using the material for the first time because it meets a number of aesthetic, environmental and engineering requirements. The risks on a project of this scale are high but overcome in this case by the Chinese commitment to innovate and by a strategic reshuffling of personnel and a commercial arrangement between the ETFE manufacturer, Vector Foiltec, and CSCEC.

The use of ETFE for the Water Cube is an example of the transfer of an available technology to a new application to achieve innovative aesthetic, experiential and functional solutions. The bubble concept was not simply applied as a pattern of circles of different diameters to the surface of a conventional structure, but became the basis for a radically new approach integrating aesthetic, environmental and structural agendas into an "insulated greenhouse" concept.

5 Teamwork: cross-disciplinary and cross-cultural collaboration

Innovation theory emphasises the essential role of teams and examines structures for effectiveness and efficiency and the spectrum of expertise and personal qualities that members should combine (Von Stamm). Mike Davies, from Richard Rogers Partnership, claims that his firm's most important design weapon is its strong and robust team of highly creative and completely differently skilled individuals who work constructively together. He says, "You have to have concept-makers, movers, developers, doers, providers, polishers and finishers" (in Brookes and Poole 22). The facilitation of teamwork at PTW appears to be extremely important to the company's success. PTW's operations are informed by a concept of integrated practice and a collaborative and cross-disciplinary team approach to design projects. It has developed a corporate structure diagram resembling a flower in which the central stamens, representing the Directors, are surrounded by concentric circles of Executive and Support staff. The individual design teams are the petals of the flower. New petals can be added as multi-disciplinary teams are formed (Bilmon, "Export").

The PTW architectural staff working on the Water Cube combined the talents of experienced senior design architects such as Associate Director Mark Butler and Principal Director John Bilmon with those of younger, Australian and overseas-trained, highly digitally-literate practitioners. Complementing this staff was the multi-disciplinary and cross-cultural collaboration with Arup (Australia) engineers and local Chinese architects, CSCEC-SDI. The dynamics of this team of local and international architects and engineers was crucial to the unique final design. The team split into four groups to workshop design principles, cultural values, and environmental and structural concepts for the project and quickly identified a range of possible seating bowl arrangements and developed design criteria for the envelope cover: the building should reflect the time and the place, be responsive to the immediate environment and its position as one of two gateway buildings; it should embody the concept of water in one of its forms; it should reflect ideas in traditional Chinese architecture and be culturally appropriate; and it should be a contemporary building – a cathedral for the Twenty-First Century – embodying the values and aspirations of China, testing materials, and expressing form in the most dynamic way.

Cutting-edge international practices frequently turn to nature for inspiration for design innovation. David Kirkland (Nicholas Grimshaw & Partners) says "biomimicry is set to transform the way we live on Earth," while Mike Davies (Richard Rogers Partnership) says that "nature programmes … are a huge resource of concepts and ideas contributing to the next building" (in Brookes and Poole 23 & 53). Many of the early proposals favoured by the PTW team were fluid, organic forms derived from nature, such as curvilinear roofs resembling petrified waves of water. But to some members of the cross-cultural team these curvilinear forms seemed inappropriate for a country whose temples, monuments and ancient cities are based on the geometry of the square. Members of the CSCEC-SDI cohort produced a conceptual model of wire mesh bent into a box acknowledging Chinese architectural traditions. Once the box form had been accepted, other team members seeking an innovative interpretation of tradition again turned to nature, particularly water and bubbles, for a solution to the treatment of the cube's façade. It was the close relationship between the architects and engineers within the multi-disciplinary team, and the diversity of their educational backgrounds, that made possible a creative leap from Frei Otto's explorations of soap bubbles as film-like structures to an examination of the bubble connections in foam – the subject of nineteenth-century scientific research by Professor Weaire and Dr Phelan. Advanced computer software and iterative analysis techniques were employed to model the structural geometry of foam, which was then rotated and carved, producing a non-repetitive system: it breaks with modern conventions of standardisation by comprising 22,000 structural elements, 12,000 nodes and 4,000 different cladding panels.

In the Water Cube, innovative architecture is an outcome of a coalescence of Chinese cultural traditions, favouring axial arrangements and rectilinearity in the built environment, with current Western trends towards asymmetric organic forms and structures derived from nature. Kenzo Tange previously recognised the role of tradition fused with the modern in his own architecture for the Tokyo Games(1964). "The role of tradition is that of a catalyst, which furthers a chemical reaction but is no longer detectable in the end result" (Kultermann 9). This has been born out again in Beijing. For those attending the Olympic swimming events, the luminous, thermal, acoustic and kinetic environment of the Water Cube will stimulate the senses and enhance the perception of metaphorically inhabiting the nation of China.

6 Conclusion

The innovative design of the Water Cube combines fine-scale development in terms of the architectural application of ETFE and the geometrical possibilities of the space frame, with large leaps in conceptual thinking about architectural form and digital technology by a team of people working and thinking at the edge of their disciplines. The drivers for this innovation included the common desire by the consortium to optimise profit and market share for their respective companies, enhanced by the international profile afforded by the Olympic Games. It has been demonstrated that the drivers of innovation within the construction industry are historically strongest when there is a demand for radically new types of buildings and structures.

This paper has argued that the Olympic Games act as a driver for innovative architecture because host nations strive to couple challenging programmatic requirements with cultural aspirations. In the particular case of the Water Cube the propensity for innovation has been enhanced by the meeting of two cultures; Chinese traditions and Western technology. The box-like form represents a break in an era of ferment focused on structural forms derived from nature: the organic paradigm has been challenged by a multi-cultural project team designing a culturally-specific building for China. It has been achieved by the transfer of digital technology to architecture and engineering and by the application of an emergent building material, ETFE. The dynamics of the teamwork approach to design provided rich multi-cultural perspectives and diverse technological know-how that allowed for technology transfer and innovation to take place. The roles of teamwork and collaboration in creative endeavour and their interplay with special drivers such as mega-events, cultural imperatives, and unusual programmatic briefs, merit further investigation to identify and understand conditions likely to produce innovative architecture.

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THE ROCKET-BAROQUE PHASE OF THE ICECREAM VERNACULAR: ON REYNER BANHAM'S CRITICISM OF ARCHITECTURE AND OTHER THINGS

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Abstract

Throughout his trans-Atlantic career as a critic and commentator, Reyner Banham turned his attention to a vast range of objects, places and activities. This is especially true of his writing in the 1970's and 80's, after he was invited by *New Society* to write (according to Mary Banham) on 'almost any subject that intriuged him'. Mary Banham notes that 'From boyhood Reyner Banham's interests had been very wide indeed, his curiosity particularly aroused by the unexpected and the incongruous and most particularly by anything with wheels and/or an engine,' and his writing is indeed marked by a respect, concern, and fascination for technical matters, in architecture and elsewhere. But the essays from this period, ranging as they do from 'reviews' of the potato crisp to the bolo tie, the clipboard to the first Star Wars movie, also serve to raise a series of questions about architectural criticism. Banham turned his specifically architectural sensibility to a startling array of non-architectural, technological and practical things, but what criteria did he use to evaluate these? How did these criteria differ from those he used in his more conventional architectural criticism in the same period? And perhaps most importantly, how was Banham able to reconcile practical, technological, formalist, programmatic and historical issues, whether in a building or a Gulfstream caravan, in his arrival at aesthetic judgement? This paper will examine selected essays from Banham's critical oeuvre to open the question of how his criteria for judgement shifted according to the nature of the object he was examining, and what this might mean more broadly for the theory and practice of architectural criticism in relation to technology.

1 Introduction

In his address to the 1964 conference of the American Institute of Architects and American Collegiate Schools of Architecture teacher seminar, Reyner Banham quipped that 'history is… my academic discipline. Criticism is what I do for money' (Banham 1965: 91). Now while this may have been a throw-away line, played for laughs, it provides a fitting introduction to this paper, since the distinction between the scholarly, rigorous, academic practice of history and the essayistic, journalistic, opinionated and rhetorical practice of criticism lies at the centre of my concerns here. The distinction, or polarisation, between a highly theorised and arcane critical discourse published as long essays in academic journals, and short accessible journalistic articles in glossy commercial magazines, has dominated architectural theory for the past thirty years. It can be held at least partly responsible for what is widely seen as a present malaise in the culture and practice of architectural criticism. As Susanne Stephens notes, ‘the absence of well-thought-out standards for evaluation, a weak cultural context for debate, and the critic’s need to write for several audiences with different needs and levels of knowledge are significant barriers’ (Stephens 1998: 68). The present paper represents new work in a larger project that seeks to understand the widespread contemporary belief in a state of crisis in architectural criticism. The larger question here, then, is what Banham’s work could continue to offer, nearly twenty years after his death, to architectural criticism in the present day.

If we accept judgement and evaluation, alongside interpretation, as key aspects of the value and purpose of architectural criticism, then how does an architectural critic derive and determine their criteria for judgement? How, especially, does a critic like Banham do this given the extraordinarily broad range of items that he evaluates – whether ‘conventional ‘high art’ architecture, the styling of household appliances, or the latest science fiction puppet series on television’ (Whiteley 1990: 188). In this context Banham provides a useful test case – as one of the most prolific and vociferous critics of the twentieth century, he opens both the question and the process of architectural criticism precisely by including it as one part of a much broader critical practice, on a continuum with popular culture criticism and what would later come to be called design criticism. His oeuvre thus allows us to pick out the commonalities, and distinctions, between various modes of critical work. Two interrelated themes immediately emerge: the significance Banham places on the social aspects of function and human use, and the common thread formed by his thoroughgoing interest in technology. As Romy Golan has noted, ‘Banham is one of the best reads, ever, on architecture. Yet at the same time few have shared his fixation with technology’ (Golan 2003: 401). Banham himself noted, in the foreword to the first anthology of his critical writing published in 1981 as *Design by Choice*, that ‘if the tone and style change, [from one publication to another] it should be clear that one thing does not – my consuming interest, through thick and thin, hardback and limp, in what happens along the shifting frontier between technology and art’ (Banham 1981: 7).

2 Banham the engineer

In this context, much has been made of Banham’s background and education in engineering – he undertook an apprenticeship in the engine division of the Bristol Aeroplane Company during the second world war (Whiteley 1990: 188). In much of the commentary on his writing the implication has accordingly been that he was not only theoretically concerned with, but actually understood, the way that mechanical and technological things work. Peter Hall writes that Banham ‘started from his absolute engineer’s knowledge of what things were like and how they really worked which made him impatient with – and contemptuous of – any theory that did not spring from the deep soil of experience’ (Hall 1996: xiii). Romy Golan speculates that Banham ‘probably would have liked to be described as the smartest engineer to have written about architecture’ (Golan 2003: 401), while Mary McAuliffe writes that

> One of his most enduring themes, influenced by an engineering apprenticeship… was the emancipation, abundance, and pleasure offered by twentieth-century technology… Banham urged architects to discard their artistic pretensions and run with the “fast company” of scientific and engineering experts (McAuliffe 2000: 269).

Banham’s engineering training was later balanced by an opposite extreme, when he studied for a PhD under the supervision of Nikolaus Pevsner at the Courthauld Institute of Art in London, whilst concurrently working as a journalist for the *Architectural Review*. His doctoral thesis was published in 1960 as *Theory and Design in the First Machine Age*, and it became the book that made his reputation. In this text he was concerned with the historiography as much as with the actual history of the Modern Movement, attempting to unearth and re-evaluate the legacy of early modernists such as Bruno Taut and Filippo Marinetti, and in the process questioning the monolithic and self-enclosed version of Modern architectural history that had been written by ‘the triumvirate of grandstyle architectural historians’ represented by Pevsner, Siegfried Giedion, and Henry-Russell Hitchcock (Golan 2003: 401).

It would be too easy to say that architecture provided the middle ground that allowed Banham to bring together his interests in technology and art, but nevertheless there is something in the complex functionality of architecture that surely provided a foil for Banham’s concern with both use and symbolic expression. He chose as his critical subjects a truly wild profusion of things, places and products, but as Walter Vanstiphout notes, his work has several key common threads.

> From the admiration for car designers of Detroit, to the analysis of ice-cream-cart art, the evocation of power stations, the execration of the Getty Museum, the historiography of the motel, the archaeology of the sheriff's star, the anthropology of the bolo tie, the survey of Frank Lloyd Wright, all the way to the celebration of air shows, Banham's critique of design was always founded in a strong commitment to the people who were using and adapting and living on the land (Vanstiphout 1998: 2).

Banham was an amazingly prolific critic. Aside from his twelve published books, Whiteley counts over 750 magazine articles or reviews Banham published between 1950 and his death in 1988 (Whiteley 2002: 328). Banham is most closely associated with the weekly journal *New Society*, to which he was a regular contributor for twenty-four years, producing a colossal 235 essays in a column entitled 'Society and Design'. But between 1958-1965 he also wrote regularly for the left-wing journal *New Statesman*, and between 1956-1964 contributed the 'Not Quite Architecture' column to *Architects' Journal.* Less well known is his work for a host of other art, design, and architecture journals, and his early regular contribution to *Art News and Review*, for which he reviewed art exhibitions, before turning to the architectural and technological subjects with which he is most associated.

3 The Banham Legacy

In recent years the examination of Banham's legacy has continued apace. This has been assisted by the two anthologies of his criticism, Penny Sparke's 1981 collection *Design By Choice* and *A Critic Writes*, released after Banham's death, in 1996. In addition, any recent work on Banham (including this paper) is indebted to Nigel Whiteley's authoritative *Reyner Banham: Historian of the Immediate Future,* published in 2002. Reviews of that book have noted the political aspect of Banham's practice, and the way that towards the end of his career he came to be 'outflanked' by both sides of the political spectrum, 'on the right, by traditionalists who found his preoccupation with *Barbarella* and corporate logos unseemly, and on the left, by a more socially conscious generation for whom his delight in the "aesthetics of expendability" seemed an extended apologia for mindless consumerism and a culture of waste, superficiality, and environmental irresponsibility' (Katz 2002: 799).

In the context of this small body of key literature, it is worthwhile to briefly examine the way these different works curate and order the Banham oeuvre. The *Design by Choice* anthology is divided into two sections, the first devoted to 'Twentieth-Century Architecture – History, Theory and Criticism' and the second to 'Pop Culture – Theory and Design'. This may seem a rather rigid categorisation going against Banham's own synthetic and inclusive practice, which looked to break down hierarchical barriers between 'high' and 'pop' culture. But this division is nevertheless interesting for the contrast it sets up, between strictly and conventionally 'architectural' criticism, for instance the canonical essay on Stirling and Gowan's Faculty of Engineering Building at Leicester University entitled 'The Style for the Job', and the essays which attempt to assimilate and understand popular culture, such as 1955's 'A Throw-Away Aesthetic', in which was derived a conceptual armature and methodology for much of Banham's later design criticism.

The later anthology *A Critic Writes* has a much lighter curatorial touch on the part of the editors, with very little critical commentary or contextual information, and the essays arranged chronologically. This means that the full breadth of Banham's interests are allowed to sit in happy juxtaposition rather than in thematic clusters. In turn, the title of Whiteley's book plays cleverly on the intertwined temporality of history and criticism in Banham's oeuvre. If history is a critical approach to the past, then criticism is a historically-informed approach to the present which will, in turn, contribute to the writing of buildings and projects into the historical record. One might very well say then that any critic is a historian of the immediate future, but the thing that makes this such an appropriate description of Banham's work is his attention to pop culture, to the passing parade of 'noisy ephemeridae' (as he put it in an early essay on car design entitled 'Vehicles of Desire') that makes up the everyday commercial vernacular. In some ways his writing itself was a contribution in the spirit of this transience, and Banham was clearly well aware of this when he wrote that

> The splendour (and misery) of writing for dailies, weeklies, or even monthlies, is that one can address current problems currently, and leave posterity to wait for the hardbacks and PhD dissertations to appear later… the splendour comes, if at all, years and years later, when some flip, throw-away, smarty-pants look-at-me paragraph will

> prove to distil the essence of an epoch far better than subsequent scholarly studies ever can (Banham 1981: 7).

This temporality of the various modes of Banham's writing has also been commented upon by Penny Sparke, who writes that '[m]any of his articles are 'essays' for his books – particularly his architectural pieces – but the others, on a cross-section of mass culture, serve to translate the ephemeral values within this area of culture into an equivalent language which adequately describes them.' The magazine essays thus have some of the transience and apparent expendability of the things they discuss. Magazines themselves are consumed and then abandoned in the same economy as many of the other items of pop culture that Banham celebrates, unlike books – and architecture – which are designed and intended for longevity. The essays also employ a very distinctive mode of writing, an exuberant, impudent and rollicking polemical style, which swings along at helter-skelter pace. In this Golan notes the influence of Fillipo Marinetti, who 'gave Banham the prose stylist an irrestistable model for an exhilarated and iconoclastic way of writing', as well as the broader disposition of both Futurism and Dada, in 'the way both aimed to touch every aspect of life' (Golan 2003: 402). The space limitations inherent to writing for magazines mean that many ideas are touched upon without being fully developed, but this too is part of the pleasure of this mode of writing – it is a *hors d'oeuvre* rather than a main course.

4 Design criticism

Much of Banham's written oeuvre has come to be understood as design criticism, and indeed a large part of his significance as an historical figure derives from his contributions to the then nascent discourse of design studies. But this too opens a significant question in the present context – what is the distinction between design criticism and architectural criticism? Does this imply that the criteria which architectural criticism might bring to bear in judgement of an object are different from those of design criticism? And what might these respectively be?

In order to approach this question, it is worthwhile to look a little more closely at some of Banham's writing, and to do so through Whiteley's brilliant analysis of Banham as a design critic. He explains that for Banham, the function of a thing and its signification or symbolic expression are not divided but inextricably linked through human use, which is to say the way it is consumed within a specific social context. This is distinct from a more objectival concept of use, a 'quasi-ergonomic' one 'by which modernist designers tended to mean the graspability of a handle or pourability of a spout, for example' in that use itself becomes something *culturally* meaningful. Whiteley gives as a case study the article 'Shades of Summer', published in *New Society* in 1967 (Whiteley 1997: 26). In this essay Banham analyses a particular brand of sunglasses pitched at the surfer-girl market and known as 'Boywatchers'. He finds that their functions fall into three categories, the 'prime function' being 'to keep the hair tidy, the secondary function… to conceal eye movement while studying form (hence the name) and, in extreme circumstances only, to shield the eyes from glare' (Banham 1967: 959). Such an approach, aside from its amusing and lateral analysis of a consumer item in terms of the actions, identity, and subculture of a particular slice of society, makes no distinction at all between the form of the sunglasses and their signifying function. In fact the signifying function, the meaning of the object, is only ever revealed through its social use, not through a formalist analysis of the thing in itself. Further, Whiteley argues that Banham's mode of critique recognised the crucial role that design plays in a postmodern society, in the fashion-conscious construction of identity.

5 Functional considerations

In attempting to understand the commonalities and distinctions between Banham's design and architectural criticism through the vehicle of technology, and particularly its inflection of 'function' and 'use', it is also worthwhile to revisit his larger conception of architectural theory as a whole. In the conference address mentioned at the beginning of this paper, Banham makes a series of broad observations about the state of the art, including the argument that there *is* no discipline of architectural theory, or not any longer, and certainly not in the architecture schools, where the term becomes simply a term for anything that won't fit anywhere else.

> The category "theory of architecture" having become vacuous, empty of formal content and devices, has been used as a sort of general purpose carrier-bag or hold-all, into which you stuff sociology, computer programming, and anything else which cannot be taught at the drawing board but which you feel architects ought to know (Banham 1965: 93).

But more pointedly, Banham argues that it is precisely in response to a functional brief, provided by a client, that the architect's actual creative work occurs. In everyday practice architects do not, or not commonly, invent and motivate projects on their own, either funded by themselves or 'sold' entrepreneurially to an investor. Banham notes that architects, like lawyers or engineers, thus make a professional life of standing ready to be 'propositioned' by a client, they 'depend upon someone coming forward with the proposition in one hand and the money bag in the other' (Banham 1965: 94). His point here is that the interesting and valuable and *critiquable* aspects of architectural practice are reactive to a specific programmatic task provided from outside, and to ignore this in favour of the elements of architectural practice which are either generic (not specific to the task at hand) or autonomous (somehow particular to architectural practice independent of its fulfilment of a task) is to miss the point at both ends of the scale. Banham goes on to make a strong case for the primacy of functional concerns in architectural criticism.

> It is impossible to discuss the building without discussing what it is for. Above all, to treat utility as an affliction, as something that should be set on one side in discussing a building, is to leave out the reasons why the building was created in the first place and the performance that society expects of it. If you leave out the fact of utility, you leave out the "why" of architecture as a human activity; yet a great deal of architectural writing appears to (and has to) support this dichotomy of method (Banham 1965: 92).

From this he continues on to argue that the critic of a given building needs to have a thorough and expert knowledge of the brief in order to say anything usefully specific about it. Perhaps more controversially, he also argues that it is necessary to have direct knowledge of the architect's intentions, and that criticism should concern itself with the 'biography' of the architect in the professional situation, and thus of the entire 'life' of the project from the point at which the task is accepted.

6 The limits of architecture

In the last essay he wrote before he died, Banham sought those things that distinguish architecture from other types of design or manufacturing process. Describing the arcane aesthetic conventions of architecture as a 'black box', he argued, radically, for it to be understood within much more highly circumscribed boundaries. This was explicitly an argument against the colonising tendencies of architectural discourse, the 'vulgar cultural imperialism that leads the writers of general histories of architecture to co-opt absolutely everything built upon the earth's crust into their subject matter' (Banham 1996: 297), just as it was an argument for architecture to be seen as a process rather than a product. More than this, his argument hinges on a specific historical and geographically located lineage.

> Recognising the very straightened boundaries of architecture as an academically teachable subject, we might deceive and confuse ourselves less if we stopped trying to cram the whole globe into its intellectual portfolio. We could recognise that the history of architecture is no more, but emphatically no less, than what we used to believe it was: the progression of those styles and monuments of the European mainstream, from Stonehenge to the Staatsgallerie, that define the modest building art that is ours alone (Banham 1996: 297).

In this conception, it is precisely drawings, in the strictly middle-Italian sense of *disegno*, that distinguish architecture as a practice and as an art. This would immediately exclude those design practices that do not employ drawings, such as those based on patterns, or on direct, applied adjustment at the time of manufacture. As an example Banham describes the case of ice cream vans, which he describes as 'the biggest invisible objects in residential Britain', the design and manufacture of which were, at the time and place of his writing, dominated by a single company. He describes the way that this firm operates entirely without drawings or 'design' as such, but nevertheless produces remarkably sophisticated 'styled' objects, drawing inflections from popular culture such that there is an identifiable 'Rocket-Baroque phase', influenced by the aesthetic of the space race and of Batman. The point here is that even constructions like this might, in the kind of omnivorous discourse prevalent at the time and continuing even more extremely today, be taken as architecture, but that this would be a disservice both to architecture and to ice-cream vans. In Banham's schema, his ice-cream van manufacturer has a working process closer to artisan masons working on a gothic cathedral, than to the drawn at the board processes of architecture. And even though both artefacts must be understood in their respective highly encoded cultural and social contexts, the evaluation of architecture must always be relative to that past architect, their intentions, and the drawings that result from them.

7 Conclusion

To return to Banham's quip with which I began this paper, that 'history is my academic discipline, criticism is what I do for money', it is precisely through criticism of the everyday ephemera of popular culture than Banham reads history in the present moment. Thus the idea of the 'throw-away line' also becomes curiously appropriate – in Banham's terms it is precisely those things we consume and then toss aside that define our contemporary culture, and in his attempt to make journalistic writing as current and disposable as the things that he wrote about, Banham also approached a kind of durability, even timelessness. This method continues to hold currency today - Walter Vanstiphout, has extended the list of 'Banham's urban gizmos' to include such present day items as 'the Powerbook, the condom dispenser, the cellphone, the methadone van, the mobile sound system, and the freight container. In these and other gizmos one sees contemporary life' (Vanstiphout 1998:4). This archaeology of the present, particularly inflected through the technology that permeates every aspect of life, continues to reveal Banham's work as an enduring model for critical practice.

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