UTOPIA COMPUTER

The »New« in Architecture?

Nathalie Bredella, Chris Dähne,
Frederike Lausch (Eds.)

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The critical concern of the book “Utopia Computer” is the euphoria, expectation and hope inspired by the introduction of computers within architecture in the early digital age. With the advent of the personal computer and the launch of the Internet in the 1990s, utopian ideals found in architectural discourse from the 1960s were revisited and adjusted to the specific characteristics of digital media. Taking the 1990s discourse on computation as a starting point, the contributions of this book grapple with the utopian promises associated with topics such as participation, self-organization, and non-standard architecture. By placing these topics in a historical framework, the book offers perspectives for the future role computation might play within architecture and society.

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Introduction

"'There is no security'—to quote his own words—'against the ultimate development of mechanical consciousness, in the fact of machines possessing little consciousness now. A mollusc has not much consciousness. Reflect upon the extraordinary advance which machines have made during the last few hundred years, and note how slowly the animal and vegetable kingdoms are advancing. The more highly organised machines are creatures not so much of yesterday, as of the last five minutes, so to speak, in comparison with past time. Assume for the sake of argument that conscious beings have existed for some twenty million years: see what strides machines have made in the last thousand! May not the world last twenty million years longer? If so, what will they not in the end become? Is it not safer to nip the mischief in the bud and to forbid them further progress?… .'"[1]

This quote about machine consciousness was written at the end of the 19th century by Samuel Butler. In *Erewhon. Or Over the Range* (1872) the protagonist discovers in his quest for colonial expansion an unknown land called Erewhon—an ananym of "nowhere." But Erewhon is not nowhere, it is a not-yet-colonized land where the hierarchies of western society are rearranged and imagined anew.

In reference to Charles Darwin's theory of evolution from *On the Origin of Species* (1859), Butler developed a concept of evolution in relation to machines, conceptualizing a mechanical life that is subject to constant evolution, potentially becoming "man's next successor in the supremacy of the earth."[2] This one might say rather dystopian view of the increasing importance of machines in human society leads to Butler's utopian idea of a machine-free society: Erewhon. Both dystopia and utopia, of course, collapse

1 Samuel Butler, Erewhon. Or Over the Range (London: Trübner & Co., 1872), 189.

2 Cellarius [Samuel Butler], "Darwin Among the Machines," The Press, June 13, 1863. Accessed March 03, 2020. http://nzetc.victoria.ac.nz/tm/scholarly/tei-ButFir-t1-g1-t1-g1-t4-body.html.

in Butler's novel, neither being the home of absolute horror nor absolute joy, as he demystifies the complex relationships between man and machine. Butler's Erewhon is at odds with the promises of industrialization. Whereas in England, machines are commonly used and regarded as a civilizing force, in Erewhon machines are potentially dangerous and therefore rejected. The protagonist of *Erewhon* faces several problems because he wears a mechanical watch; the Erewhonians fear that machines could one day develop into independent creatures and rule over humans.

In Erewhon, some one hundred years before its discovery by the protagonist, the chapters that make up the "Book of the Machines"[3] talk about a civil war that was fought between the machinists and anti-machinists. It ended with the destruction of many mechanical inventions, treatises and engineers' workshops, while some objects remained in museums as exponents of the past. In the "Colleges of Unreason," research into these formerly existing machines is regarded as a "curious antiquarian study, like that of some long-forgotten religious practices among ourselves."[4] The protagonist translates the "Book of the Machines" for his readers, informing them of the supposed danger of the rapid development of machine consciousness—what we would today call artificial intelligence. Even though machines are made to serve, they serve only according to their conditions and humans must operate them according to the rules of use: "How many men at this hour are living in a state of bondage to the machines? How many spend their whole lives, from the cradle to the grave, in tending them by night and day? Is it not plain that the machines are gaining ground upon us, when we reflect on the increasing number of those who are bound down to them as slaves, and of those who devote their whole souls

3 Butler developed the three chapters about the "Book of the Machines" from articles he had published previously, such as "Darwin among the Machines" (see fn. 2). Tim Taylor and Alan Dorin, Rise of the Self-Replicators: Early Visions of Machines, AI and Robots that Can Reproduce and Evolve (Cham: Springer, 2020), 19–22.

4 Butler, Erewhon, 187.

to the advancement of the mechanical kingdom?"[5] Just as animals and humans have evolved over millennia via natural selection, self-regulating and self-acting machines will become more intelligent by the same mechanism, thus confronting the reign of humans.

With Butler's Dystopia/Utopia Machine in mind, this edited volume will reflect on the notion of "Utopia Computer." Before we develop this notion further, we need to dwell for a moment on the word utopia. It is understood commonly as nowhere, a fictional place where things are better, or, as Butler has so convincingly explained, where they are inverted, reordered and rearranged. Utopia is not necessarily a fictional place, but a not-yet-discovered—and in Butler's case a not-yet-colonized—place where society is organized according to different values, rules and laws. It provokes surprise, and occasionally the incredulous shaking of a head, in the Western observer as a representative of the supposed norm, or rather, of the dominant. For the philosopher Gilles Deleuze, the term utopia describes a political call to philosophy to bring about different and new concepts of existing. Deleuze, in *Différence et Répétition* (1968), adds a third layer to nowhere and erewhon: the "now-here." It is from the erewhon—the displaced, the disguised, the modified, the always re-created—that "emerge inexhaustibly ever new, differently distributed 'heres' and 'nows'."[6] Connected to a present and a milieu, developing out of the midst of things, the utopian presents an absolute deterritorialization: something different emerges that is not yet realized and that can only be realized "by betraying itself."[7] The now-here is a push in a new direction without a goal; it frees us from oppressive and limiting concepts. Utopias envision an impressive, never-before-seen world in which the present and the future are simultaneously visible: reality provokes criticism of existing conditions,

5 Ibid., 200.

6 Gilles Deleuze, Difference and Repetition (New York/NY: Columbia University Press, 1994), XX.

7 Gilles Deleuze and Félix Guattari, What Is Philosophy? (New York/NY: Columbia University Press, 1994), 100.

out of which, with all constructive imagination, a playful-experimental counter-image of a better world is created. Thus, there are two moments in this alternative life model: a rather dystopian, negatively connoted deconstructive moment, which critically diagnoses the current condition, as well as a positively connoted constructive moment, which highlights the potential for change in a future society.

The future is lost to us, the cultural scientist Aleida Assmann wrote in 2013, the past will not let us go and the present pours into a sea of data technologies, which do not produce ideals or utopian visions but scientific models and calculations. In a recent conversation with Ann-Katrin Günzel about the exhibition "Critical Zones," Bruno Latour and Peter Weibel reject the concept of utopia and emphasize instead the down-to-earth and the present with all its problems and potentials. According to both, the illusion of utopia is toxic because there is no other world to discover or to conquer. Instead, we must "land on earth," face the actual localized situation, and map and understand its "critical zones."[8] Their reasoning recalls Deleuze and Guattari's understanding of utopia as a virtual image which emerges amid actual things and introduces new concepts. Using the notion of minor architecture, Jennifer Bloomer offers a perspective of utopia within architecture that works within the conventions of existing architectural language towards subversive ends.[9]

In this issue we look at the advent of the computer. What is a computer to begin with? It is an electronic and digital machine that can be universally programmed. While a classic machine of the industrial age—to which Butler refers—has a specific function, the computer is a universal machine that can simulate any other machine via programmes, i.e. software. A computer processes data, converts it into numbers and follows a binary logic, according to a programmed algorithm. When we speak about

8 Bruno Latour and Peter Weibel, "Utopien und Critical Zones," interview by Ann-Katrin Günzel, ZKM Karlsruhe, September 19, 2020, video, https://zkm.de/de/utopien-und-critical-zones.

9 Jennifer Bloomer, Architecture and the Text: The (S)crypts of Joyce and Piranesi (New Haven/CT: Yale University Press, 1993).

the introduction of the computer in architecture we must distinguish between different concepts: the computer is a tool to process and analyse large amounts of data, to draw or model forms, to animate or render them; the computer is a thinking machine, capable of artificial intelligence and pattern recognition; the computer is a medium for collaborating, exchanging and distributing information; and the computer is a virtual machine, creating environments such as the internet and simulated models of spatial interaction. The title *Utopia Computer* almost presumptuously encompasses all these different applications, responding to the use of computer as a buzzword for the so-called "digital revolution" or "digital turn" in architecture.

If we go back to the period from the 1960s up until the 1990s, we detect an exhilarating euphoria about the potential of computers within architecture. What was fascinating about the computer and what hopes were projected onto the new medium? Buckminster Fuller's World Game, Gordon Pask's belief in an architecture that can learn via feedback loops and Frei Otto's form-finding experiments bore witness to concepts of participatory planning procedures, self-optimizing design processes and non-standard architectural structures made possible or more accessible and easier to execute thanks to the computer. These ideas gathered momentum in the 1990s when planning processes were reconceived as gameplay and architects explored virtual games to generate collective and interactive urban planning solutions. Algorithm-based computer software and parametric design fostered the idea of a self-organizing architecture, one emerging from the interplay of parameters and able to offer "optimized" answers to internal and external constraints. Architects thought that the architectural environment could respond automatically and flexibly to the changing needs and desires of users and society through smart and connected objects. These utopian ideas—user participation in planning processes, self-optimisation or self-organisation and responsive architectures—were meant to come true with the help of the computer and the internet.

For some, the launch of the Internet marked the creation of a new place, cyberspace, where society and architecture could work differently—a true utopia in the sense of erewhon, formerly nowhere and now discovered through digital media. In the *ANY* issue on "Electrotecture: Architecture and the Electronic Future" (Nov/Dec 1993), a collage of text fragments and images confronts the viewer with the following:

"When the world is wired, nothing remains the same."

"In cyberspace, the real is hyperreal and reality becomes virtual. In this space that is no place and yet is not everywhere, what does it mean to build?"

"When speed reaches a certain point, time and space collapse and distance seems to disappear. The very conditions of spatio-temporal experience are radically transformed. At this point, does architecture finally become immaterial?"

"What happens when the grid becomes the net?"[10]

The introduction of cyberspace through the computer seemed disruptive for architecture. Traditional spatial categories such as public/private, outside/inside and surface/depth no longer make sense in cyberspace.[11] At the same time, the architecture in some virtual environments offers few surprises. Referring to the massive multi-player online role-playing game "Habitat," which has been available since 1986, the media theorist Allucquére Rosanne Stone states that cyberspace is a "space of desire" because conventions such as gender can be broken down in the form of opposite-sex or asexual avatars. However, architecture appears in "Habitat" in the form of standardised houses and typical monuments.[12] This example shows that what is supposedly new can turn out to be very conventional. This is why, in the subtitle of this publication, we have marked the "New" in architecture with a question mark.

This compilation of case studies critically examines the utopian potential of digital technologies and the euphoria in architectural

10 "Electrotecture," ANY, no. 3 (Nov/Dec 1993): 8–9.

11 Mark C. Taylor in "Electrotecture. Architecture and the Electronic Future," ANY, no. 3 (Nov/Dec 1993): 49.

12 Allucquére Rosanne Stone in "Electrotecture. Architecture and the Electronic Future," ANY, no. 3 (Nov/Dec 1993): 44, 53.

discourse associated with the advent of the computer. This critical view resists a positivistic or enthusiastic appraisal of the computer, but at the same time, it does not reflect a pessimistic warning like that of the anti-machinists in Erewhon. What new architectural practices and processes were actually made possible by the computer and what was just a dream, a utopia in the sense of nowhere? What new forms and spaces were created with the help of the computer and what remained conventional, perhaps re-dressed but not rearranged as erewhon? What new liberating subjectivities and possibilities of collaboration were created by the computer and what remained illusion, a speculation that found no now-here?

Besides euphoria, the introduction of the computer in architecture provoked fear and rejection as well. We do not want to join in the lamentations that the computer undermines the (supposedly) ingenious creativity of the (mostly male) architect-artist, or that virtual architecture is causing good and solid craftsmanship to disappear. Instead we want to point to the fact that technological developments, especially at the turn of the millennium, were part of neoliberal shifts in politics and the economy. Smart houses or smart cities, for example, collect and analyse private and public data and help process this data, which is then used to generate behavioural predictions and gain knowledge about sustainable urban planning, enabling economic decision-making. The use of computers in architecture cannot be detached from larger social and economic developments such as datafication, surveillance capitalism and ideas about human improvement through social and technological control.

The publication *Utopia Computer. The "New" in Architecture?* is based on a workshop we organised at the Berlin University of the Arts from November 15–16, 2019 as part of the series *Forum Architekturwissenschaft*. Taking the 1990s discourse as a starting point, the workshop centred critical and historical reflections on interconnectedness in the post-war period and its participatory effects, about self-organization and its potential for optimization, and about non-standard architecture and its capacity to adapt itself to its environment. Three themes were discussed during the conference. The first, "Subjects and Societies," dealt with the effects of digital technologies on society and thus on designers, those involved in the planning and construction process, as well as users of buildings. Presenters in this section concentrated on the organisation of intellectual labour, which was meant to be improved by computers, automation and the internet, which would supposedly give people more time for creative and collective endeavours. But computer technology also brought with it new, sometimes dystopian, forms of control, hierarchy and technological dependencies that operate with and through architecture.

"Organism and Organisation," the second theme, focused on the changes in the design process that have occurred as a result of digitalization, especially in relation to the increased interest in natural growth processes. Here it became apparent that the potential of the computer to deal with the complexity of design, i.e. the computer's ability to manage countless parameters and calculate numerous variants, is often based on a view of the design process as a pure and objective search for the most optimal solution and for applicable rules of control. Comparing design to natural processes threatens to reduce the organism to its function and performance. This significantly changes the idea of what constitutes creativity, from free, intersubjective association to the production of variants with the help of the computer. With a view to theoretical approaches that capture the idiosyncratic aspects of computer-based design, we discussed strategies of participation and anarchism connected to the use of the computer.

The last part, "Data and Form," looked at how architectural forms and form generation are transformed through digital design tools and the use of large amounts of data. The comparison with the 1960s made it clear that experiments with "programmed architectures" at that time had a large socio-political component—for example, the participatory and democratic aspects of computer-aided design were foregrounded, while in the 1990s and to this day, aesthetic and material-related aspects dominate. The formal references in today's digitally produced structures to their historical-visionary predecessors are manifold, but only a few provide direct answers to important environmental and social issues.

For this publication, we decided to rearrange—in the sense of erewhon—the topics in order to burst the neat framework of three distinct themes and to multiply the connections between them. We start with Hélène Frichot's "A Dirty Theory for a New Materialism: From Gilles Deleuze to Jennifer Bloomer" which brings us back to the theory frenzy of the 1990s. She reminds us that alongside the mainstream discourse about digital design another existed: feminist architects and theorists were pointing out the necessity of critically assessing "the material and socio-technical implications of computationally informed architectures." In "Prerequisites for Self-Organization: The Re-emergence of Colin Ward," Grayson Daniel Bailey addresses one of these implications: the ideological positioning of architectural subjectivities in cybernetic theory. Drawing on Colin Ward's anarchist theory, he proposes a "transition from cybernetic other-organization to anarchic self-organization." The pitfalls of cybernetic strategies, when it comes to questions of how to manage multiple, undetermined and changing goals without patronizing subjects or converting them into objective structures, is discussed by Marcus Bernardo, reporting from the field of practice in "Unmanageable Utopias." The nexus of freedom-control—how to experience freedom while being immersed in a controlled environment?—is also central to Juan Almarza-Anwandter's "About the Current (and Future) Implications of the Process of Digitalization in Our Everyday Experience: A Fourfold Critical Approach." He highlights the increasing dominance of "protocols of interaction" in architectural experience due to the present development of interactive and ubiquitous technologies such as Augmented Reality, the Internet of Things and Domotics.

Joseph L. Clarke's "The Art of Work: Bürolandschaft and the Aesthetics of Computation" brings us back to the 1950s and considerations of how to organise intellectual labour in large companies. He shows us that the utopia of "radically open, non-gridded, and non-hierarchical, early Bürolandschaften" was driven by information processing and cybernetic methods, which were ultimately transformed with the advent of personal computers into "rigid rows of identical cubicles." The flexibility and adaptability of Bürolandschaften is echoed in what Erik Hermann, in "Houses of Ice: Raster Utopias and Architecture's Liquid Turn," describes as "real time probabilistic design environments." Looking at the work of Italian architects Leonardo Mosso and Laura Castagno Mosso in the 1960s, he presents a "pixelated utopia" in which mutable, fluid models are able to adapt to changing conditions in real time. Both papers are contextualized by two interviews, conducted by Corinna Studier with (intermedia) artist Kurd Alsleben about his contribution to Bürolandschaft and by Arianna Borrelli, Nathalie Bredella, Mads Frandsen and Julius Winckler with computer artist Frieder Nake, whose computer-generated works, which were some of the earliest manifestations of computational art, made their first public appearances in three small exhibitions in 1965.[13] Staying in the realm of computer and cybernetic artworks and their potential to develop and test utopias, Cezara Nicola discusses the artistic endeavour "La Plissure du Texte 2" in "Virtual Artistic Spaces: Roy Ascott's LPDT2, Cybernetics and Beyond." She focuses on notions of "distributed authorship" and "moist media" introduced by Ascott, and reflects upon the impact of virtual architecture design on contemporary artistic production. In "Making Sense without Meaning: Christopher Alexander and the Automation of Design" Pablo Miranda Carranza discusses the computer as an "army of clerks," which for Christopher Alexander was the danger inherent in the use of computers. Taking a close look at the programs and code that Alexander used in "Notes on the Synthesis of Form," he analyses whether and how architecture begun conforming to this "army of clerks." That the conception of the computer was not just based on an operational ideology is emphasised by Gregory E. Cartelli's "Machines, Fabrics, and Models: ARTORGA and Biology's Cybernetic Utopia."

13 The interviews were conducted as part of a seminar and exhibition taught by Arianna Borrelli (Wissenschaftsgeschichte TU Berlin) and Nathalie Bredella (Institut für Geschichte und Theorie der Gestaltung, Universität der Künste, Berlin).

He introduces the reader to the 1950s collaborative project ARTORGA, an attempt "to retain both biological complexity and organic matter in the conception and construction of organizational structures" that are often overshadowed by the importance placed on information theory and operations research. The connection between biology and cybernetics in analyses of the built environment is also the topic of Kaman Lam's "C. H. Waddington's Biological Science of Human Settlements 1963–1978." In it, she reveals the influence of developmental biology (epigenetics) on ekistics, the quest to find a science of human settlements from the late 1950s to the early 1970s. Nathalie Kerschen expounds the problems of the myth of the "animal-machine," a concept that resonates with contemporary bio-inspired computational approaches and architectural projects, in "Towards a New Understanding of the Animal." She argues that we need to restore the "animal-machine" anew as a "living being" within its *Umwelt*.

The publication closes with Donal Lally's "All that Is Solid Melts into the Cloud." With the help of a "theory-fiction," he reminds us that the Cloud—the data storage system floating in the sky—is a "techno-utopian fantasy," an illusion that makes you forget the massive energy consumption, use of rare earth minerals and land consumption data centres require. Lally reveals the material side and the dirtiness of digitalisation. In this respect, the computer is not nowhere. It is right here, it is material, it has material effects—which brings us back to Frichot's insistence on materialism.

Returning to nowhere, erewhon and now-here, we would like this publication to contribute to (re)discovering some fictions, some hidden territories, some alternative thoughts related to the introduction of the computer in architecture. They point to a critical evaluation of the field of machine-thinking, which has been developing since the post-war period, and is currently associated with utopian promises. Knowing the beginnings of computer use, the hopes and dreams associated with it, and the different, sometimes alarming directions in which these dreams have developed, we can decide now-here whether we want to prevent those that have proved harmful and stand up for those that have not taken place (yet).

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HÉLÈNE FRICHOT

A Dirty Theory for a New Materialism

From Gilles Deleuze to Jennifer Bloomer

This essay returns to the 1990s when architecture was about to launch into a period of experimentation with computational procedures and form-finding adventures. At the same historical juncture an architectural thinker-practitioner, whose work has maintained an undercurrent of influence amongst feminist architectural theorists and practitioners, was unsettling architecture's status quo. Cognizant of the digital turn, Jennifer Bloomer sought to disturb the allegorical house of architecture by venturing questions about disciplinary assumptions. A return to the work of Bloomer directs us toward the importance of critically assessing the material and socio-technical implications of computationally informed architectures. To reclaim this other story, I conclude by introducing a dirty theory for a new materialism.

"The last thing the hero wants to know is that his beautiful words and weapons will be worthless without a bag, a container, a net." Donna Haraway[1]

In his anxious late-career essay "Postscript on Control Societies," originally published in French in 1990, Gilles Deleuze introduces the aesthetic figures of the mole and the serpent in order to describe a shift from the shadowy containment of disciplinary societies to the bright slippery surveillance of societies of control.[2]

1 Donna Haraway, Staying with the Trouble: Making Kin in the Chthulucene (Durham: Duke University Press, 2016), 118.

2 Gilles Deleuze, "Postscript on Control Societies," in Negotiations (New York/NY: Columbia University Press, 1995), 177–182. See also Gilles Deleuze, "Control and Becoming," in Negotiations (New York/NY: Columbia University Press, 1995), 169–176.

Contemporary societies of control are characterized primarily by the rapid development of information technologies and attendant processes of computation, the likes of which Deleuze could only have had the vaguest presentiment. This essay returns to the 1990s, a moment at which architecture was about to launch into a period of exhilarated experimentation with computational procedures and form-finding adventures, or what at the time was simply called "digital design." At much the same historical juncture, an architectural thinker-practitioner whose work has maintained an undercurrent of influence among feminist architects and theorists was introducing another version of the mole figured as a devious female practitioner. The mole, or mole-ster, as described by architect and theorist Jennifer Bloomer, seeks to disturb the allegorical house of architecture and thereby architecture's disciplinary status quo. Bloomer was one of the first architectural thinkers to introduce the work of Deleuze to an anglophone architectural audience in advance of the eager uptake by digital architects of Deleuze and Félix Guattari's concepts, such as the fold, the virtual, and the diagram. Inspired by Deleuze and Guattari's "minor literature," Bloomer introduced a minor architecture as a means of resistance to oppressive forces in the discipline.[3] What I argue is that a return to Bloomer's work reveals an anticipation of what would come to be called "New Materialism" and more specifically, "Feminist New Materialism," which alerts us to the importance of critically assessing the material and socio-technical implications of computationally-informed architectures. In the 1990s at least, it would appear that matter was taken too readily as secondary, as passive in relation to the wonders of digitally-imagined form. Bloomer's work offers a valuable counter-narrative. To reclaim this other story, I introduce a dirty theory for a New (Feminist) Materialism, including a conceptual allegiance with the environmental humanities and intersections with the feminist post-humanities.[4]

3 Jennifer Bloomer, Architecture and the Text: The (S)crypts of Joyce and Piranesi (New Haven/CT: Yale University Press, 1993), 173–175.

4 See Cecilia Åsberg and Rosi Bradotti, eds., A Feminist Companion to the Posthumanities (Cham: Springer, 2018).

A dirty theory for a New Materialism will turn out to be somewhat at odds with the notion of "Utopia Computer" and ambitions for the "new" in architecture, the themes organizing the collection in which this essay is included. Utopia, by definition, is no-where and no-time, a non-place-time we might nevertheless be under the illusion we virtually inhabit today via our immersion in networked digital information technologies, amid environments ubiquitously organized by Big Data. In that we are nowhere and everywhere interconnected, and yet moving further apart—becoming morcellated "dividuals," mere units of information—it could be argued that we inhabit the non-place and no-time that is Utopia, only perversely. As Bloomer, a central character in the story I present here, already commented in 1993 "despite the closure of space and time in the Modern world, there is no nearness."[5] Our technologies have enabled us to grow further apart. Utopia, in being no-where and no-time, is also that place toward which we endlessly approach, but never arrive. It is a temporal zone that is out of time in both senses: it has, arguably, run out of time as a useful or applicable concept, and it is out of time in that it is anachronistic, not of our present time. Utopia is a figure that first emerges in literature and philosophy as a parable. There is Thomas More's island of Utopia in *Utopia* (1551), Samuel Butler's *Erewhon* (1872), and William Morris' *News from Nowhere* (1890), where wage slavery and marriage have been abolished, to name the best-known literary examples, making Utopia a fictional or imaginary construction, a location for make-believe (or even for making beliefs). The literary effects of "Utopia" often lean toward parody or are deployed for the purposes of critique. Yet the concept and promise of Utopia can also allow us to speculatively imagine other possible worlds. That Utopia is a fictional construction makes it no less powerful. As for "Computer," it is that instrument we are daily plugged into, a device for computation, for the working out of problems at speeds and levels of

5 Jennifer Bloomer, Architecture and the Text, 186.

complexity that the meagre, fleshy, embodied human mind cannot manage. What does it mean to place these two terms in conjunction? What promise or what threat is promulgated? Is it parody, critique, or a speculative leap into a future being tested by the concept of "Utopia Computer"?

Rather than commencing with the emergence of cybernetics in the post-war period, which is one obvious place to begin when it comes to the promise or threat of "Utopia Computer," this essay tucks itself into the voluptuous folds of the 1990s. I return to the concept of the "fold,"[6] which was popularized at a moment when architectural students and designers were beginning to experiment with computational techniques and technologies. The fold, the promise of infinite folds upon folds, enabled through increasingly sophisticated computational procedures and permutations, with early inklings of the future of powerful parametric processes, was becoming all the rage in the 1990s. The fold, or folding in architecture, is usually attributed to the architect Greg Lynn, who edited a 1993 edition of *Architectural Design* (*AD*) called *Folding in Architecture*, which was so popular that it was re-released ten years later with a new contribution from Mario Carpo called "10 Years of Folding."[7] Between the first and second editions of *AD* Profile number 102, *Folding in Architecture* a convenient timeline can be mapped. Here I note parenthetically that Carpo has more recently edited an *AD* reader called *The Digital Turn 1992 to 2012*, with an introductory essay now called "20 Years of Digital Design,"[8] for time has been inexorably passing. When we look at the contents page of *The Digital Turn*, Carpo notably does not include such thinkers as Claire Robinson, present in both editions of *Folding in Architecture*, in fact women—except for those grouped into studio formations such as FOA, or ShoP—are barely present at all. Greg Lynn does not manage much better in his 2014

6 Hélène Frichot, "Deleuze and the Story of the Superfold," in Deleuze and Architecture, ed. Hélène Frichot and Stephen Loo (Edinburgh: Edinburgh University Press, 2012), 79–95.

7 Mario Carpo, "10 Years of Folding," in Folding in Architecture, AD Design Profile 102, ed. Greg Lynn, revised edition (2004): 14–19.

8 Mario Carpo, "20 Years of Digital Design," in AD Reader, The Digital Turn 1992–2012 (London: Wiley and Sons, 2013), 8–14.

collection *Archaeology of the Digital* in which Peter Eisenman's name dominates.[9] It's important to draw attention to these lacunae, to ask: who is represented, who is not? These omissions form something like folds of erasure that require unfolding so that other voices might be represented too.

In 2004, in the revised edition of *Folding in Architecture*, Carpo asserted that "Folding in Architecture is now a classic—not a timeless one, however, but time specific."[10] Rendering it, perhaps inadvertently, an anachronistic classic, for a classic that is not timeless makes no temporal sense. *Folding in Architecture* expressed, in Carpo's words, the "quintessential architectural embodiment of the new digital technologies that were booming at the time." "Obviously," Carpo added, "the nineties started angular [i.e. the train wrecks of deconstructivist architecture] and ended curvilinear."[11] With this simple statement Carpo reveals the ways in which the convoluted dialogue between architectural practice and theory is prone to fads, to "new" ideas that are consumed and then discarded, from Derrida's deconstruction to Deleuze's compellingly fluid folds, to a flurry of interest today in the promise of overcoming carbon form.[12] What Carpo also draws attention to is a distinct emphasis on form over matter. Shards and subsequently folds are formally explored with little concern for their material substantiation. Instead, the articles collected in *Folding in Architecture* introduce a "topological" avant garde, advancing projectively to succeed the torturous collisions of Derridean-derived deconstructivist architectures, spearheaded by the ever-present paternal figure of Peter Eisenman tropologically turning from one tendency to the next.[13] According to Carpo, Deleuze's theoretical influence would have gone unnoticed if it were not for Peter Eisenman, who in turn introduced the writings of Deleuze to his student

9 Greg Lynn, ed., Archaeology of the Digital (Montreal: CCA, 2013).

10 Carpo, "10 Years of Folding," 14.

11 Ibid.

12 See for instance *Log* 47: Overcoming Carbon Form.

13 See Bloomer's critique of the notion of the "cutting edge." Jennifer Bloomer, "The Matter of the Cutting Edge," Assemblage, no. 27 (August 1995): 106–111.

Greg Lynn.[14] Carpo's reading habits, it would appear, are highly selective, and his gender bias means he overlooks the earlier work of such figures as Bloomer. Again, a blindness is at work here, coupled with a challenge to rewrite women and minorities back into architecture.

The fold, "le pli," concept and method, is signed by the French philosopher Gilles Deleuze, and derived from his small book *The Fold: Leibniz and the Baroque,* published in French in 1988 and translated into English in 1993, the same year in which the first edition of *Folding in Architecture* appears. Deleuze's *The Fold* introduces such concepts as the "objectile," attributed to the architect Bernard Cache, a former student whom Deleuze acknowledges. Cache's experimental digital projects, which often manifested in the convenient form of pavilions, can be found in the pages of the ANY (Architecture New York) series. The inflections of the processes of folding, unfolding, refolding, im*pli*cating, ex*pli*cating, com*pli*cating persisted during the 1990s, discovered here and there in design projects, both speculative and realized, and in the pedagogical spaces of design studios. As theorists such as Rajchman explain early on, the fold in French is "le pli," and "le pli" lends itself to words such as "expliquer," "impliquer," "compliquer," likewise in English: explicate, implicate, complicate—actions of folding and unfolding. It is in the act that the fold becomes generative, things are complicated and they can be explicated. All the while, much of the milieu in which acts of folding are undertaken is implicated, things and relations get taken up in the dynamics of folding. A kind of infectious spread of folding takes place in the 1990s. Architectural projects resulting from the formal logics of the fold in this period, whether knowingly or not, engaged in the accompanying discourse and are the result of an image-based contagion. The formal characteristics of the fold catch on.

Suffice to say, as the "digital" is on the threshold of exploding into architectural experimental test-sites, so too is the name (a

14 Mario Carpo, The Alphabet and the Algorithm (Cambridge/MA: MIT Press, 2011), 6–8.

shibboleth of sorts) Deleuze, as well as Deleuze and Guattari. As architect Todd Gannon notes, we all had a "well-worn" copy of *A Thousand Plateaus: Capitalism and Schizophrenia* "lying around our studios," back in the day, when we were under the "sway" of Deleuzianisms.[15] Jason Payne, another architect-theorist, likewise makes light of "reading Deleuze, Georges Bataille, and the Marquis de Sade."[16] Through the late nineties and into the new millennium, citations of Deleuze's name diminish, as though no longer required as a theoretical prop. In fact, his death in November 1995 sits right in the middle of the timeline I have described. Like his compatriot Derrida before him, and Foucault, and Barthes, and so on and so forth, Deleuze simply went out of fashion. As Greg Lynn remarks in his 2013 introduction to *Archaeology of the Digital*, "Following the very tight alignment of postmodern architects with theorists, there has been a schism between design and history/theory that roughly corresponds to the emergence and integration of digital media in the architectural field."[17] Lynn goes so far as to say that a theory vacuum emerged in the wake of Deleuze.

Often overlooked by architectural thinkers who do venture further into the discourse of the time is that the fold is also a concept discussed in Deleuze's monograph on Michel Foucault. Simply entitled *Foucault,* the work appeared in French in 1986, a couple of years prior to the French edition of *The Fold*, *Le Pli*, and was then translated into English in 1988, therefore making it available earlier than Deleuze's 1993 English edition of *The Fold*. In Deleuze's *Foucault*, the fold relates to a problematics of power organized around the control of language, labour, and life.[18] Moving sideways, during the same period that Deleuze's *Foucault* was published and translated in the mid-1980s, power relations, in

15 Todd Gannon, Graham Harman, David Ruy and Tom Wiscombe, "The Object Turn: A Conversation," Log, no. 33 (Winter 2015): 73.

16 Jason Payne and Sanford Kwinter, "A Conversation Between Sanford Kwinter and Jason Payne," in From Control to Design: Parametric Algorithmic Architecture, ed. Tomoko Sakamoto, Michael Meredith and Albert Ferré (Barcelona: Actar, 2008), 219.

17 Lynn, Archaeology of the Digital, 11.

18 Frichot, "Deleuze and the Story of the Superfold," 79–95.

institutional settings as elsewhere, are what philosopher of science Donna Haraway would describe as "practices of domination and the unequal parts of privilege and oppression that make up all positions."[19] We need to hesitate here and think about the kinds of discourse that were circulating during the rise of the digital in the 1990s. What looms forward for those in the discipline of architecture, and what is pushed into the background? The history of the digital and the exhaustion of Deleuze (and other thinkers for architecture) very much depends on where you are looking, and which stories you choose to tell. In architecture, for instance, it is more convenient for the fold to be a tool through which formal explorations rather than relations of power are explored.

Now, to complicate this folded spatio-temporal architectural journey, because folds are composed of smaller folds, as well as larger macro folds (all the way to infinity, even), as promised I want to introduce another figure. When we remain on the shimmering surface of (architectural) discourse, especially during the long 1990s and into the new millennium, we might too readily assume (as does Carpo) that it was Greg Lynn and his mentor Peter Eisenman who introduced Deleuze to an architectural audience. And what a popular theme the fold must have been, to be featured in 1993 and then re-issued in that seductively high-gloss magazine *AD* ten years later. What I want to draw attention to is that in the early 1990s something else was afoot: a forceful undercurrent, a liberatory murmur from underground, a gesture of creative resistance.

In 1993, concurrent with the first edition of *Folding in Architecture*, Jennifer Bloomer's *Architecture and the Text: The (S)crypts of Piranesi and Joyce* was published. *Architecture and the Text* is a highly complex and sophisticated, as well as humorous and joyful, work that took eleven years to accomplish and was punctuated by events including child-birth, folding clothes, general housekeeping, and all those reproductive labours we are

19 Donna Haraway, "Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective," Feminist Studies 14, no. 3 (1988): 579.

not supposed to mention in proper academic discourse. In her work Bloomer often makes reference to the daily tasks of ironing sheets, making soup, making costumes for kids, because daily life is messy and it is dirty and we need to fold this consideration into our spatial and material architectonic considerations too.[20]

In *Architecture and the Text* Bloomer not only wilfully reads Giovanni Battista Piranesi's etchings through the literary tactics and word-play of James Joyce's *Finnegan's Wake*, to astonishing effect, but introduces a complex assemblage of thinkers to architecture: Walter Benjamin, the two "Jacks": Jacques Derrida and Jacques Lacan, Gilles Deleuze and Félix Guattari, and Michel Serres. To this list feminist thinkers such as Luce Irigaray, Hélène Cixous, Alice Jardine and Donna Haraway can be added. In sly asides, Bloomer makes critical short shrift of Peter Eisenman and Mark Wigley. Greg Lynn is perhaps not yet on her critical radar.

Stating that Bloomer is an underground figure is of course misleading; she was a shining light of her time, burning bright, running intellectual circles around her peers with her profound intelligence and capacity to knit ideas together and make them *matter*. While her textual play produces delightful "mise en abyme," signifiers collapsing into other signifiers in an endless play of signification, the material weight and what matters for her remain ever present. As I argue in my recent book *Dirty Theory: Troubling Architecture*, Bloomer performs a material-semiotics. By material-semiotics, I mean the concept introduced by Donna Haraway, who in her work on situated knowledges explains that signification and material relations operate in entangled matrices and ought not be hewn apart. Haraway writes: "Feminist embodiment, then, is not about fixed location in a reified body, female or otherwise, but about nodes in fields, inflections in orientations, and responsibility for difference in material-semiotic fields of meaning."[21] A material-semiotics is a powerful way of

20 Bloomer, Architecture and the Text. Bloomer, "The Matter of the Cutting Edge," 107.

21 Haraway, "Situated Knowledges," 588.

acknowledging that we make sense amid material and relational constraints. This alerts us to our socio-technical, material-environmental, architectural-relational ecologies, an acknowledgement of a New Materialism that challenges the predominance of form or idea over matter and material relations.

So now we have our timeline in place, the halcyon years of the 1990s book-ended by the two editions of Greg Lynn's *Folding in Architecture*, 1993, and 2004, and then an interference pattern, a "moiré" of sorts composed of two different patterns. Bloomer, I propose, is the pattern that disturbs and unsettles things, shifts appearances, produces a shimmering effect, and pre-empts a growing fascination in "vibrant matter" and "thing power"[22] and (feminist) New Materialism. With witch-like presentiment Bloomer anticipates our contemporary turn toward environmental matters of concern, material matters, their flows and effects, and the ways in which we have made such a bloody mess of things.

It is by learning from Jennifer Bloomer that I will (when I get to the conclusion of this essay) sling-shot us (like a rocket) forward in time, near to where we are today, to argue that Bloomer's work pre-empts some contemporary theoretical and practical orientations including New Materialism and more broadly the domain of the environmental humanities in relation to architectural studies. My tactics will be dirty, close to the ground, groping blindly, sometimes like a mole, which means that by subterfuge I will also introduce to you my dirty theoretical orientations. What you can assume is that my methods are dirty, as my aim is to trouble the status quo in architectural theories at their intersection with practices.[23]

But let's step back carefully, again, into the 1990s. As I have written elsewhere, a distinct shift in orientation can be discerned between the first and second edition of Greg Lynn's *Folding in Architecture*.[24] In 1993 the emphasis is clearly on the novelty of form. Specifically one can see a wilful shift being undertaken as

22 See Jane Bennett, Vibrant Matter: A Political Ecology of Things (Durham: Duke University Press, 2009).

23 See Hélène Frichot, Dirty Theory: Troubling Architecture (Baunach: AADR, 2019).

24 See Frichot, "Deleuze and the Story of the Superfold," 79–95.

→

theoretical allegiances move from a formal interest in shattered, post-collision fragments to smooth curvilinearity and what came to be rather disparagingly described as "blobitecture." As media and cultural studies theorist Luciana Parisi explains, "The new centrality of generative algorithms (but also cellular automata, L-systems, and parametricism) in digital design has led to the construction of various topological geometries and curvilinear shapes that have come to be known as blob architectures."[25] Yet there is also a shift in the formal understanding of folding, from planar folds, such as those found in Peter Eisenman's Rebstock Park project in Germany and his Alteka Office Building in Japan, with their distinctly planar, folded experiments, like paper planes made out of paper. Both projects are featured in *Folding in Architecture*. Such planar experiments are followed by a thickening of materials, heading toward voluptuous folds as of baker's dough, fatly folded and refolded, much like Greg Lynn's speculative "Embryological House," emerging in fits and starts. Then, over the following ten years (enough time for the story to be reformulated), an early fascination in curvilinear and folded form gives way to other conceptual justifications.

Following the initial fascination with formal expression, by the 2004 edition of *Folding in Architecture*, the immaterial information recognized in the fold is divulged. Actually, Lynn informs us, it was really only ever about the calculus (not the form), and how the calculus delivers the opportunity for us (digital architects) to fold our way all the way to infinity.[26] Those messing with digital procedures in the day will remember some of the well-documented dilemmas of the moment, the problem of authorship: if the software is generating endless, equally adequate forms, who am I in the process? And in any case, I'm not the author of the software I am obliged to use. Then there is the "stopping problem" discussed by Brian Massumi: if the software is spewing out a

25 Luciana Parisi, Contagious Architecture: Computation, Aesthetics and Space (Cambridge/MA: MIT Press, 2013), 15.

26 Lynn, Folding in Architecture, 11.

seemingly unending list of possible forms, all equally valid, which do I choose?[27] What are my aesthetic criteria of judgement? All of which is to say that the fold as motif, as instruction, as concept, leads us from a supposedly innovative formal play to a recognition of the potential of calculus-based software in design processes, from the French curve to software and plug-ins named after insects and animals.

While it would be tempting to offer up at this interstice a long lesson on Deleuze's discussion of the fold, and how it was greedily taken up by architectural thinkers and practitioners in the 1990s, I will proceed instead directly to the distinctly less joyful essay by Deleuze, "Postscript on Control Societies," written in 1990 (very convenient for our folded chronology), where the worrisome concept of the "superfold" is introduced. Here too we see the fold as a material-semiotic construct, one side facing material manipulation, the other directed at the management of information or data, including the noopolitical management of populations as clusters of "dividuals." Well before architectural actors are over their digital enjoyments, before they have even half-way begun, Deleuze is already offering up his presentiment of the ominous controls wired into bright digital futures. So much for Utopia Computer. The superfold as concept organizes his vision, his presentiment, his speculation on what is to come (the places and times we now inhabit). As I have written in *Deleuze and Architecture*: "The story of the superfold is one that can be told in the wake of the exhaustion of the material and conceptual procedure of folding as a technique used in architecture."[28] Today, however, I would revise this statement to assert that the superfold describes a milieu that in fact anticipated our digital architectural design advances. For Deleuze, the superfold displaces a former classical sense of the infinite as that which raises relations all the way to infinity (here we are to imagine the interior spaces of a Baroque church), and in

27 Brian Massumi, "Strange Horizon: Buildings, Biograms and the Body Topologic," AD, Hypersurface Architecture II (1999): 12–19.

28 Frichot, "Deleuze and the Story of the Superfold," 131. See also Eugene Galloway, "Computers and the Superfold," Deleuze Studies 6, no. 4 (2012): 513–528.

its place introduces an unlimited finitude wherein "a finite number of components yields a practically unlimited diversity of combinations."[29] This begins to sound very much like a parametric architecture: near endless, though not infinite, re-combinations of elements prescribed by parameters, combinatory play, a bit like word play.

To characterize his superfold, which attends to the transformation of disciplinary societies into control societies, Deleuze notes a crucial shift from the animal figure of the mole, blind underground creature of dark institutional corridors, to the serpent, slippery figure of the bright spaces of surveillance and control. Spatial infrastructures are allocated to each animal totem: where the mole moves through the disciplinary spaces of containment, or sites of confinement, the serpent offers the false promise of slippery, fluid freedom of movement, right up until the moment your digital pass-card (or passport) no longer allows you, the "dividual," access to healthcare, schooling, housing, passage across the borders between nation-states, or the right of refuge from war and oppressive political systems.

Particular to this transformation, Deleuze observes that "it doesn't depend on the barrier but on the computer that is making sure everyone is in a permissible place, and effecting a universal modulation."[30] Now, even though "A snake's coils are even more intricate than a mole's burrows,"[31] it is not as though the blind mole of disciplinary societies is better than the all-seeing serpent of control societies, that's not the point. In fact, by the conclusion of the essay, Deleuze remarks: "It may be that older means of control, borrowed from old sovereign societies, will come back into play, adapted as necessary."[32] What Deleuze stresses in 1990 (the publication date of the original French edition) is that we are at the beginning of something new, and this new era is what many have subsequently called the new information age, or the age of Big Data, and its management on the scale of populations

29 Gilles Deleuze, Foucault (Minneapolis/MN: University of Minnesota Press, 1986), 131.

30 Deleuze, "Postscript on Control Societies," 182.

31 Ibid.

32 Ibid.

and how they often unwittingly think together, producing devastating large-scale effects (think the proper names Trump, Brexit, Bezos, Zuckerberg). Such is the promise and the threat of Utopia Computer. What we will require are weapons, new and old, of critical reflexivity and creative resistance. What we need to deploy are feminist intersectional weapons, calling on the powers of a differentiated multitude that is critically attuned to the places where power relations are most oppressive, whether in politics, in the discipline of architecture, or in everyday life.

By felicitous coincidence the animalistic aesthetic figure of the blind underground mole crops up in Bloomer's *Architecture and the Text*, and on at least one occasion she features a serpent (she also incants the "one-eyed trouser snake"), as part of her bestiary of "Undesirable Beasts."[33] It's good to include relations with non-human others, they get us closer to environmentalities, opening different points of view onto environmental relations. Beast, Bloomer explains, is any animal except "man," which means it is a category that includes "women, blacks and other others."[34] In fact, she argues, this is a category that includes the majority of beings on the planet, after which she adds: "Writing the feminine is mole work, writing on the wall."[35] According to the approach of the mole, what architecture "looks like" hardly matters, it's about how it feels and what it does to subjects and how relations come to be forged as well as undone.

In *Deleuze and Architecture* we tactically open with an important essay by Australian architectural historian-theorist Karen Burns, who points to the crucial counter-narrative of another history of architectural and distinctly feminist thinkers introducing Deleuze to the discipline of architecture in advance of such players as Greg Lynn and Peter Eisenman. Burns writes: "I offer here a counter-history, retrieving a more diverse, architectural

33 Bloomer, Architecture and the Text, 182.

34 Ibid.

35 Ibid., 198.

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Deleuzianism from the archives as well as offering an account of how the plurality of the period has been gradually expunged."[36] Her project is to restore the multiple gathered voices, especially the voices of women thinkers and practitioners who are marginalised again and again. Jennifer Bloomer looms large in Burn's genealogy.

Bloomer, delightfully, does not pull punches when it comes to the pater familias architect Eisenman. Of his Carnegie Mellon Research Institute she says that less than being a successful project of deconstruction (as claimed) it remains "solidly within the tradition of architecture as metaphor."[37] He misses the lesson that he himself is aiming to deliver, rather paternally, to us; he gets stuck in his own signifying loops forgetting to critically acknowledge the societal impacts of architecture. Contrariwise, Bloomer's preferred emphasis, extremely Deleuzo-Guattarian in its orientation, pursues not a question of meaning but a matter of use: "It is about how it works. Not concerned with what it means or what it looks like but what it does."[38] Bloomer has what she calls a "bone to pick" with the alliance of architecture with discourses of deterritorialization and dissemination that "all comes out as a style." She proposes: "'What does it look like?' is not the same question as 'How does it work?' or 'What is the itinerary?' or 'What constitutes the assemblage?'"[39]

Across Bloomer's work there is scattered a great many sly references to the uses (as distinct from the abuses) of a careful reading of Deleuze and Guattari. She is the first to reclaim their minor literature for a minor architecture, inspiring Jill Stoner's 2012 book *Toward a Minor Architecture*. Bloomer spends time with material handicraft, specifically, the permutational patterns of the patchwork quilt. She speaks of the smooth and the striated, and of processes of becoming. Importantly, and as Burns

36 Karen Burns, "Architecture, Feminism, Deleuze – Before and After the Fold," in Deleuze and Architecture, ed. Hélène Frichot and Stephen Loo (Edinburgh: Edinburgh University Press, 2012), 15.

37 Bloomer, Architecture and the Text, 185.

38 Ibid.

39 Ibid., 32–33.

has argued, she does not depend on Deleuze (and Deleuze and Guattari) as her sole authority, but populates her texts with a multiplicity, a true cacophony of voices and positions to tell her tales of the forgotten, undervalued, overlooked spaces and often-silenced subjects of architecture. She has worked, for instance, on women's shelters, she has dedicated herself to the challenges of the homeless, and of hospices for people with HIV/AIDS.[40]

Furthermore, before we risk dispelling Bloomer as some kind of goody-two-shoes, big jugs luddite—certainly she complains about email, but who doesn't!?[41]—we find many of the tropes that became popular with the so-called "digital turn," a "trope" being that figure of speech that turns us from one sense and/or direction toward another. Bloomer draws on Reimannian spaces, on topology, on Klein-like tubes within tubes, in fact, this is how she figures the live human body and the fits and starts of embryonic development. She touches on Virtual Reality, she speaks, notably, of "codes [that] take the form of apparatuses, or machines, which contain within themselves the ghost of architecture."[42] In coding and decoding, we simultaneously code ourselves, she suggests. I would add, we render our "dividual" effects as so many complex, entangled intersecting codes, and these are not solely our constructions, but also composed by the way in which Big Data, social media, and platform technologies increasingly pre-empt our desires at a molecular level. Cautions might be issued: if you don't take care of the code, the code will take care of you, it will finish you off. Overcoded, our very thoughts determined in advance, what hope have we of thinking otherwise? The promise and the threat of Utopia Computer is that we no longer even know how to think for ourselves.

Here is where I will take up my slingshot and propel us toward times and places closer to our own. In conclusion, I want to argue for what a careful rereading of Bloomer, and many of her companion

40 See Jennifer Bloomer, "Abodes of Theory and Flesh: Tabbles of Bower," Assemblage, no. 17 (1992): 6–29.

41 See Jennifer Bloomer, "Architecture and the Feminine: Mop-Up Work," ANY: Architecture New York, no. 4 (January/February 1994): 8–11.

42 Bloomer, Architecture and the Text, 146.

thinkers and practitioners, offers us. Thinking with Bloomer, I propose, leads us toward the environmental humanities where it intersects with the (feminist) post-humanities, emerging research domains that engage in an intersectional thinking of environment, decolonization, difference *and* relationality, and human and non-human encounters. The environmental humanities proffer methodologies that are less about narrative per se than dedicated to storytelling, the story being that which is passed along, from one storyteller to the next, dog-eared and handled, a little grubby as it passes through busy hands. Accompanying the environmental humanities is "New Materialism" and also Feminist New Materialism, introduced by both the feminist philosopher Rosi Braidotti and by Manuel de Landa—another go-to thinker for digital architects in the day.[43] In the flurry of excitement to leap on the digital bandwagon, to achieve (deceptively) smooth surfaces and liquid forms, we left behind a great deal of important thinking, as though inadvertently deciding to allow our machines to do the thinking for us. Already in her 1985 "Cyborg manifesto," Donna Haraway (who is neither a technophobe, nor a technophile) remarks that our machines are becoming disturbingly lively, while we are becoming frighteningly inert![44] Can we slow the great machinic assemblage down, or have we gotten too caught up in its gears?

Bloomer's work from the early 1990s demonstrates how storytelling must be anchored to relevant problems, ones that ground us. Her ethos is shared by the environmental humanities, which likewise stresses the importance of paying close attention to environmental problems, with the aim of telling and even performing stories that reveal the complex interrelationships to be found in our local environment-worlds. Bloomer's ambivalent figure of the mole-ster follows the materials and thinks close to the ground, demanding that we feel our way with care. Here too, an attention

43 See Rick Dolphijn and Iris van der Tuin, eds., New Materialism: Interviews and Cartographies (Ann Arbor/MI: Open Humanities Press, 2012).

44 Donna Haraway, "A Cyborg Manifesto: Science, Technology and Socialist Feminism in the Late Twentieth Century," in Simians, Cyborgs, and Women: The Reinvention of Nature (London: Free Association Books, 1991), 152.

to the liveliness of materials places her work in the company of (feminist) New Materialists. The digital snake, by contrast, takes us on a slippery ride, offering smooth passage, but for whom and at what cost? The mole-ster, meanwhile, works away in the dark, digging up the dirt, undertaking the unglamorous labour, because the answer is not always to reveal things to the brilliant light of day. A violence can be wrought in the stories we tell, and the stories we steal, and so ethical care must be taken. Still, we urgently need to "resist, reclaim, speculate"[45] by way of other stories, deploying counter-genealogies to frame other approaches to the promise or curse of Utopia Computer. Inspired by Bloomer, who is unafraid of mixing her thinking with the dirt and remaining open to productive if risky contaminations, the dirty tactics of "dirty theory"[46] throws dirt into the hegemonic machine of kingmakers, it offers up counter-narratives to disrupt the status quo, it seeks to introduce noise and grit into the system, to disrupt architecture, which must be troubled. A dirty theory for a (Feminist) New Materialism, situated in the midst of the burgeoning domains of the environmental humanities and the (feminist) post-humanities, offers a counter-narrative to what might end up being the empty promise of Utopia Computer.

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45 See Isabelle Doucet and Hélène Frichot, "Resist, Reclaim, Speculate: Situated Perspectives on Architecture and the City," Architectural Theory Review 22, no. 1 (2018): 1–8.

46 See Frichot, Dirty Theory.

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Prerequisites for Self-Organization

The Re-emergence of Colin Ward

Underneath specific examples of cybernetic policies in built space, the ideological positioning of "system" and "agent" affects how architectural production in general is organized. Building from an initial connection between cybernetic and anarchist theory in the writing of Colin Ward, this essay uses the two orientations toward non-hierarchical systems to examine a reconstituted architectural field. The conditions of Ward's system-oriented anarchism, and its unprivileged arrangement of system goals, help to examine how architectural subject positions can transition from cybernetic other-organization to anarchic self-organization.

As with almost all dimensions of social and economic life, the proliferation of agencies born from the "democratic revolution" (as defined by political theorists Ernesto Laclau and Chantal Mouffe) has slowly generated a complete instability in terms of architectural self-conception as it relates to objects and systems.[1] In the expanded sphere of agency, one which transitions from focusing on stable hierarchies—objects and structures—into the culmination of hegemonic practices, the spatial role of architecture moved from generating isolated projects into the manifestation of distributed urban effects. Architectural historian Manfredo Tafuri wrote about the turn of urban development in the 18th and

1 Ernesto Laclau and Chantal Mouffe, Hegemony and Socialist Strategy: A Radical Democratic Politics (New York/NY: Verso, 2014).

19th centuries: "It was no longer a question of giving form to single elements of the city, nor even to simple prototypes. The real unity of the production cycle having been identified as the city, the only suitable role for the architect was as organizer of that cycle."[2] Tafuri's 19th century architects concerned themselves with understanding and directing the distributed agency of the urban system, just as the contemporaneous politician began to understand and direct the distributed agency of the enfranchised public.

Thus, architectural organizing systems can be read as an environment in which architectural and political objects perform their functions, construct subjectivities, and induce affects in the constructed subjects. Within this schema, the architect—assumed provider of architectural production—is not caught up in the urban web, but somehow is extracted and external, pushing and pulling production cycles on some imaginary meta-structural plane. A true organizer above being organized. Of course, this is fiction. Instead, we are enmeshed in the ideologies of systems thinking, just as all other disciplines, professions, peoples. And in this enmeshment, Tafuri makes his more fundamental claims against architecture: we serve the ideology of capitalism; we are not organizers outside of the system, but subjects and production agents within it.[3]

The increasing ebb of political agency in novel forms of democratic, socialist and totalitarian practices—each reacting to the power of a partially enfranchised public sphere—has transformed itself from an arborescent structure balancing the mass of public sentiment against the operations of governance into an unfolded environment of meanings and materials. Laclau and Mouffe describe the hegemonic turn of the "democratic revolution" as the unfolding of a malleable common political meaning based on antagonisms within the public sphere, rather than among concentrated sovereignties, but the outcome of the hegemonic turn has manifested different forms of ideological contestation than

2 Manfredo Tafuri, Architecture and Utopia: Design and Capitalist Development (Cambridge/MA: The MIT Press, 1979), 107.

3 Tafuri, Architecture and Utopia, 165.

democracy, socialism or totalitarianism.[4] Instead, the competitive and cooperative field of agency, unable to be coordinated further by structural organizations, has reformed the hegemonic site of contestation as one which focuses on the derivative cultivation or manipulation of recursive agencies within a system.

The development of cybernetics in the post-war era and the system-focuses of Colin Ward's anarchic theories take on particular significance as visions in which social, technological and architectural relations occur under the conditions of enmeshed and competitive agency. Just as the 18th century spelled a turn in the architectural vector toward the expanded urban system, computational organizations define the emergent field in which social and architectural production has already started: a field accelerated and deconstructed into vectors beyond that of democracy, totalitarianism and socialism, into the negotiation of the system-agent relationship via two main ideological frames: anarchism and cybernetics.

As an architect, urban theorist and anarchist, Colin Ward covered a myriad of topics in architectural discourse since the early 1970s in his work. Although only briefly touching on the topic in his 1973 book *Anarchy in Action*, the optimistic link that Ward makes between cybernetics and anarchy traces an early connection between technological, architectural and anarchic organization. In the essay "Harmony Through Complexity" Ward writes, "Anarchy is a function, not of a society's simplicity and lack of social organization, but of its complexity and multiplicity of social organizations. Cybernetics, the science of control and communication systems, throws valuable light on the anarchist conception of complex self-organizing systems."[5]

In almost all of Ward's urban writing, the interaction between "agent" and "system" is of central importance, whether it is the unconsidered social spaces of children in the city or the role of allotment gardens in reforming shared spaces of collaboration and negotiation within a neighbourhood. Between the spaces of

4 Laclau and Mouffe, Hegemony and Socialist Strategy, 138.

5 Colin Ward, Anarchy in Action (New York/NY: Harper & Row Publishers, 1973), 50.

the individual and the social (system), Ward poses cybernetics as a possible vehicle for anarchist thought and organizational strategizing at a time when cybernetic ideology had not defined itself entirely, before its potential was tied to material mass-market logics or coercive organizational outcomes.

Ten years prior to *Anarchy in Action*, the first prominent application of cybernetic policies in architecture took place with the inclusion of the cyberneticist Gordon Pask on the design team for Cedric Price's Fun Palace. Moving the Fun Palace's deconstruction of architectural programming into the realm of cybernetic policy, Pask wrote later that architecture was "only meaningful as a human environment. It perpetually interacts with its inhabitants, on the one hand serving them and on the other hand controlling their behaviour."[6] Cybernetics from thereon understood the utility of architectural design as a form of social engineering, with the architect taking on the role as the most prominent social engineer. The potentials of architectural work, regardless of the architect's professed intentions or artistic applications of style, were becoming the material systems through which individuals could qualify and quantify system goals. When Pask notes the system effects of architecture, he is outlining an interior condition within architectural production that already centres the built environment as producing material economic and social conditions which both "serve" and "control" in terms of organizing bodies and stored economic value. As seen in figure 1, the efficacy of the Fun Palace's cybernetic plan either lives or dies by its ability to foretell, calculate and limit the programmatic actions of the users streaming through space (fig. 1).

Jumping to 2005, the year Zaha Hadid Architects' BMW Central Building opens in Leipzig, Germany, the evolution of socially engineered space has been wholly internalized by architectural offices as one of the discipline's main proprietary offerings. Well beyond the abstraction of cybernetic policy in the Fun Palace, the organization

6 Gordon Pask, "The Architectural Relevance of Cybernetics," Architectural Design 39 (1969): 494.

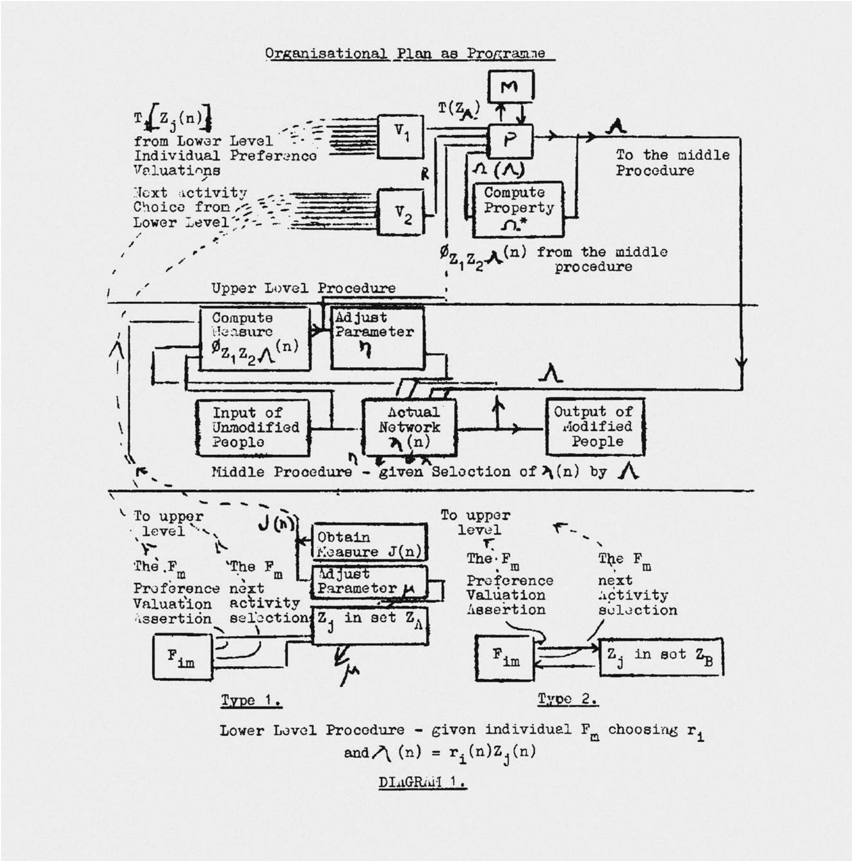

Fig. 1: Cybernetic diagram of the Fun Palace program by Gordon Pask. Source: Cedric Price fonds, Canadian Centre for Architecture

of complex operations in the BMW Central Building offers a refinement of form and material practice, all of which aims to "have a wide range of activities happening together in one space. There's a mix of blue- and white-collar areas, which prevents an exclusive domain from being established."[7] Complex architectural coordinations are achieved through a flattening and homogenization of the

7 Hans Ulbrich Obrist, Zaha Hadid, The Conversation Series 8 (Cologne: Verlag der Buchhandlung Walther König, 2007), 64–65.

human agent who bends to consensual materializations of control. These read as solely formal demonstrations of Gilles Deleuze and Félix Guattari's conception of the non-hierarchical smooth spaces of nomadic agency, in contrast to the hierarchically organized and static organization of striated space.[8]

Yet, as Deleuze and Guattari themselves would attest, "smooth spaces are not in themselves liberatory. But the struggle is changed or displaced in them, and life reconstitutes its stakes, confronts new obstacles, invents new paces, switches adversaries. Never believe that a smooth space will suffice to save us."[9]

Douglas Spencer describes the momentum of emergent discourses in architecture as moving "towards the affirmation of the emerging cybernetic environment, with its transcategorical forms of knowledge, its entrepreneurial orientations, its celebrations of networked mobility and its promises of self-transcending immersion. Even if unwittingly, it came to serve as the vanguard for the spacing of a neoliberal subjectivity."[10]

In addition, Harun Farocki's *Die Schöpfer der Einkaufswelten* (The Creators of Shopping Worlds) shows how the smooth space of consumer culture develops in the mundane aesthetics and architecture of everyday consumption alongside the projects of the pseudo-avant-garde.[11]

As the cultivation of cybernetic tendencies was happening in architecture, a neoliberal hegemony was simultaneously forming elsewhere, in the economy and in a technocratic understanding of society. In reaction to computer graphics researcher Loren Carpenter's crowd-produced pong experiment, the documentarian and creator of "All Watched over by Machines of Loving Grace," Adam Curtis, has stated: "Carpenter saw it as a world of freedom with order. But I suddenly saw it as the opposite—like

8 Gilles Deleuze and Félix Guatarri, A Thousand Plateaus: Capitalism and Schizophrenia, trans. Brian Massumi (London and New York/NY: Continuum, 1992), 474–500.

9 Deleuze and Guatarri, A Thousand Plateaus, 500.

10 Douglas Spencer, The Architecture of Neoliberalism: How Contemporary Architecture Became an Instrument of Control and Compliance (London: Bloomsbury, 2016), 45.

11 Harun Farocki, Der Schöpfer der Einkaufswelten, dir. Harun Farocki (Berlin: Harun Farocki Filmproduktion, 2001), video.

old film of workers toiling in a factory. They weren't free—they looked like dis-empowered slaves locked to a giant machine screen."[12] Extended by 30 years, social media companies—platforms outside of traditional control structures and lynchpins of the contemporary market—attempt to escape the critique of cybernetic systems, and their derivative forms of manipulation, with cynical pontifications on the lack of hierarchical control, i.e. "free speech." The streams of cybernetic organization and market logic, rather than anarchist practice, have intertwined. Ward's optimism seems misplaced.

In Deleuze's "Postscript on the Societies of Control," the inherent link between control operations within neoliberal economies and cybernetic systems analysis and construction can be easily parsed. Architecturally, the society of control accompanied the transition from Le Corbusier's Plan Voisin to Zaha Hadid Architects' Kartal Pendik Masterplan. Deleuze writes, "Enclosures are molds, distinct castings, but controls are a modulation, like a self-deforming cast that will continuously change from one moment to the other, or like a sieve whose mesh will transmute from point to point."[13] In this context, cybernetics was not the emergent new condition which might reform anarchist conceptions of organization, as Ward thought, but rather a vehicle for the control impulses which were in action well before the tool. Direct design application, and the differentiation of classes in urban structures as within the Plan Voisin, gives way to algorithmic thinking, protocological functions which can either act as points of derivative control or points of mass negotiation—the ideological underpinnings of cybernetics or anarchism.

In this regard, the difference between Ward's anarchist perspective and the perspective of architecture in general is one which

12 Carpenter's pong experiment at the SIGGRAPH '91 conference used two-sided paddles distributed among the audience, which aggregated the movements of pong bars on the respective sides of the crowd. The outcome was a crowd-controlled game, with the speed and distance of bar movement controlled by the distribution of paddle orientations. See Katherine Viner, "Adam Curtis: Have computers taken away our power?" The Guardian, May 6, 2011. Accessed August 10, 2019. https://www.theguardian.com/tv-and-radio/2011/may/06/adam-curtis-computers-documentary.

13 Gilles Deleuze, "Postscript on the Societies of Control," October 59 (1992): 3–7.

depends on an orientation toward protocol. The anarchist view of organization includes itself within a field of protocol and agency, while cybernetics and the architectural discipline do not. Anarchy involves, and architecture applies—the two strains of "non-hierarchical" systems thinking begin to seem much farther apart than in Ward's initial optimism.

However, the connections which Ward made between cybernetic policy and anarchist practice were not naïve or foolish. In fact, while not actively internalized in cybernetic thinking thus far, Ward's writing nevertheless provides an open avenue for true-ing cybernetics or at least co-opting its logics. Inverting Ward's description of anarchism and cybernetics, one can postulate that *Cybernetics is an operative mechanism, not of a society's complexity and liberation, but of its divisional control and manipulated consensus. Anarchism, the theory of organization without coercion, throws valuable light on a humanist conception of complex cybernetic systems*.

Fundamental to describing any negotiation between anarchist and cybernetic practices, differences among their systems goals must first be laid out: (1) hierarchical value sets vs. equally negotiated values, and (2) constructive versus cooperative operation. First, the hierarchical values of cybernetics starkly prevent any possibility of liberation. The goals of a cybernetic system are various, but the primary goals—hierarchically privileged—are: (a) immediate gains, (b) stability, (c) survival. Even within this set, preferences are made and survival—the propagation of the system itself—represents the most immanent value. While a variety of subsidiary goals are constantly evaluated, their success is inherently tied to the success of the hierarchically privileged goals.

Within a cybernetic analysis of office management, the contentedness of employees is certainly a value, but only in terms of its effect on the continuation of the office, the stability of the office system and its immediate profitability. In the case of labour organizing against management (a situation in which the happiness of employees is often in direct contrast to the goals of management), hierarchically privileged goals determine a course of action: either the employees are subdued and replaced (allowing a decrease in office stability in order to maintain survival and protect immediate gains), or the employees are bargained with (allowing a decrease in immediate gains in order to maintain stability and ensure survival). At any point, even with a distributed set of values within a cybernetic system, the hierarchically privileged values are what determine courses of action. Within any cybernetic policy, advocating for a termination of the system itself is untenable, as this represents the core antithesis of cybernetics itself: to be controlled rather than to control. In 2020, this was demonstrated by the reaction from local and federal governments against Black Lives Matter protests: when the survival of the system itself is even mildly threatened, the system responds with either overbearing cruelty or incremental sacrifices.

The maintenance of these hierarchically privileged goals marks out another avenue in which coercive action must be internalized in order to produce the conditions for stability, system propagation and immediate gains. Within the Ur-cybernetic model of capitalist production—a network form of cybernetics which overcomes environmental unpredictability by consuming its environment both figuratively and literally—Laclau and Mouffe describe the dynamic between labour-power and the production cycle as a relationship that requires domination in order to extract enough labour-power, which underpins the entire cycle of labour and commodity valuation.[14] In order for capitalist production to be maintained or evolve at all, they argue, domination must exist. Any structure of hierarchically privileged goals must follow suit. If system propagation is dependent on agents within the system, and system propagation is the ultimate form of system validation, the attempted domination of agents is inevitable, since their freedom or equality are only valued in their effect on increasing or decreasing system propagation. In the end, cyberneticist Stafford Beer's economic policy Cybersyn is widely remembered as a prototype of failure because it couldn't propagate as a system, even

14 Laclau and Mouffe, Hegemony and Socialist Strategy, 68.

if its limited implementation was an attempt to avoid traditional styles of economic domination.[15]

In contrast to hierarchical value sets, anarchism involves a set of unprivileged values which are not capable of being completely incorporated into the system—namely the values outlined by the Russian anarchist Pyotr Kropotkin in *The Conquest of Bread*: liberty, equality and solidarity.[16] As Justin Mueller describes, regarding the interaction of qualitative "values" in anarchism: "Rather than a fixed value-slope or hierarchy, these values form a continuum wherein each idea is meaningfully constituted only in association with the others."[17] In effect, there is no final resolution to any negotiation among these values. Instead, the values are constantly repositioned within an infinite horizon of ethical action. The philosopher Simon Critchley characterizes the ethical tenets of anarchism as "not so much organized around freedom as around *responsibility*, an infinite responsibility that arises in relation to a situation of injustice."[18] The expectations of the anarchist system can never be met, just as any teleological project—be it a final system or successful revolution—is incapable of sustaining itself, regardless of how flexibly cybernetic it might be. Within anarchist theory, the lack of terminal stability or guarantee that the state will survive is not a hindrance because system survival as a goal provides only the imperative to find sufficiently coercive forms of system propagation. Similar to the Lacanian and otherwise post-structural agreement that there is no "meta-language" and that all negotiation of the subject and discursive meaning takes place on the same plane, anarchism is a system orientation in which there are no "meta-goals" and all evaluation takes place without priority.[19]

15 Eden Medina, Cybernetic Revolutionaries: Technology and Politics in Allende's Chile (Cambridge/MA: The MIT Press, 2014).

16 Pyotr Kropotkin, The Conquest of Bread (London: Penguin Classics, 2015), 120.

17 Justin Mueller, "Anarchism, the State, and the Role of Education," Anarchist Pedagogies:-Collective Actions, Theories, and Critical Reflections of Education (Oakland/CA: PM Press, 2012), 16.

18 Simon Critchley, Infinitely Demanding: Ethics of Commitment, Politics of Resistance (New York/NY: Verso, 2012), 93.

19 Jacques Lacan, Écrits: A Selection, trans. Alan Sheridan (London: Tavistock Publications, 1977), 311.

The second core difference between anarchist and cybernetic practices concerns constructive versus cooperative operation. Cybernetics constructively "builds up" system architectures and the derivative relations within, while anarchism, as Ward describes, is a process of "uncovering." While cybernetics has a system-view of agent and process units, which interrelate on a blank substrate overseen by an external meta-agent (the cyberneticist, the architect, etc.), anarchism in Ward's explanation is exactly the opposite. Anarchism is the recognition of a rich substrate which already exists, and anarchic practice is about negating coercive control structures and creating forms which preserve the freedom and equity of agents and processes there within. Ward describes this condition as, "A society which organizes itself without authority, is always in existence, like a seed beneath the snow, buried under the weight of the state and its bureaucracy, capitalism and its waste, privilege and its injustices, nationalism and its suicidal loyalties, religious differences and their superstitious separatism."[20]

In stark contrast to the construction of decentralized and layered control networks, as seen in Beer's Viable System Model, the anarchic process does not operate on the positivist structuring of an interactive system, but rather in an unconstrained negative operative model. Instead of decentralized systems ordered around information attenuation and feedback, with the aim of achieving hierarchically privileged goals (system propagation), anarchic process is a practice of limiting the exertion of control and allowing unintentional emergence.

Whereas second-order cybernetics models jump from "organized" to "organizing" systems and focus on streaming data and object sets in order to attain a comparably stable relation among them, anarchism focuses on the limitation and negation of those control methods through the unresolved negotiation among anarchic values and the unconstructed space which separates the system

20 Ward, Anarchy in Action, 18.

21 Heinz von Foerster, Understanding Understanding (New York/NY: Springer Verlag, 2003), 283–286.

and the agent.[21] Ward builds his theories of anarchism on a lineage of classic and early 20th century anarchists, most notably from the foundations set by the German revolutionary Gustav Landauer and the Russian cartographer and evolutionary theorist—the anarchist prince—Pyotr Kropotkin. In Ward's writing the contemporary conception of a systems and process-oriented anarchism is produced as an uncanny mirror image to the network organizations of cybernetic theory in which cooperation is present.

Ward's theories of anarchism specifically stem from Landauer's positioning of the "State" as "not something which can be destroyed by a revolution, but… a condition, a certain relationship between human beings, a mode of human behavior; we destroy it by contracting other relationships, by behaving differently."[22] Landauer's conception of the "State" as something other than a continuous totality precedes both the work of Antonio Gramsci on hegemony and Laclau and Mouffe. What he contributes to a critique of cybernetics is the shift in understanding the "State" as a "state"—a momentary measurement of an emergent system. The "state" of the system is evaluated within cybernetics in terms of how it relates to its internally hierarchical goals: stability, immediate gains, survival. It is thus treated less as an autonomous object than as a system image which must continually be developed. While cybernetics develops the "state" through reinforcement and construction, Landauer's concept of resistance through "state" construction is cybernetic in method and *revolutionary* in practice.

Kropotkin's contribution to Ward's synthesis of contemporary anarchism comes in two forms: faith in the emergent intelligence of the masses, and a scientific understanding of social and biological evolution through the combination of competition and mutual aid. In *The Conquest of Bread* Kropotkin remarks, "Give the people a free hand, and in ten days the food service will be conducted with admirable regularity. Only those who have never seen people

22 Gustav Landauer, "Weak Statesmen, Weaker People!," in Revolution and Other Writings: A Political Reader, trans. Gabriel Kuhn (Oakland/CA: PM Press, 2010), 214.

23 Kropotkin, The Conquest of Bread, 60.

hard at work, only those who have passed their lives buried among documents, can doubt it."[23] Although, as a classical anarchist and the father of anarcho-communism, Kropotkin approaches the formation of anarchist society from a severely modernist point of view, this faith in the masses and faith in the bottom-agent once "uncovered" from its restraints is central to both contemporary anarchism and any rejuvenated cybernetic policy.

The second central concept from Kropotkin comes through his book *Mutual Aid: A Factor of Evolution*, which revises the often misconceived evolutionary process of "survival of the fittest," claiming that mutual aid among species within a community and environment was a central feature of the evolutionary process.[24] Contesting the analogies of the capitalist market and its suggestion that cut-throat competition produces elevated results, Kropotkin's focus on mutual aid provides a scientific basis for the theory of anarchism's "uncovering." If mutual aid and beneficial mass organization is already rooted in environmental and biological practice, any object-network system will unavoidably include mutual aid; every evolving system involves solidarity.

Ward's anarchic processes thus take on an understanding of relation rather than structure, and produce a set of anarchic conceptions in which the interplay of relations can avoid authoritarian rule. First, there is a clear understanding that anarchism, as a relation-based distributed system-network of processes, agent, and objects, is fundamentally in opposition to coercion. Already historic cybernetic policy fails in this regard, because it bases most of its methods of system propagation on feedback in order to coercively stabilize an acceptable environment. Instead of a myopic cybernetic model on stability, an anarcho-cybernetic model must start to provide ways of validating or escaping the system.

In order to facilitate an environment without coercion, Ward's anarchism operates on two shared foundations: free association and modes of legitimation/delegitimation (fig. 2). Free

24 Pyotr Kropotkin, Mutual Aid: A Factor of Evolution (Boston/MA: Extending Horizons Books, 1914).

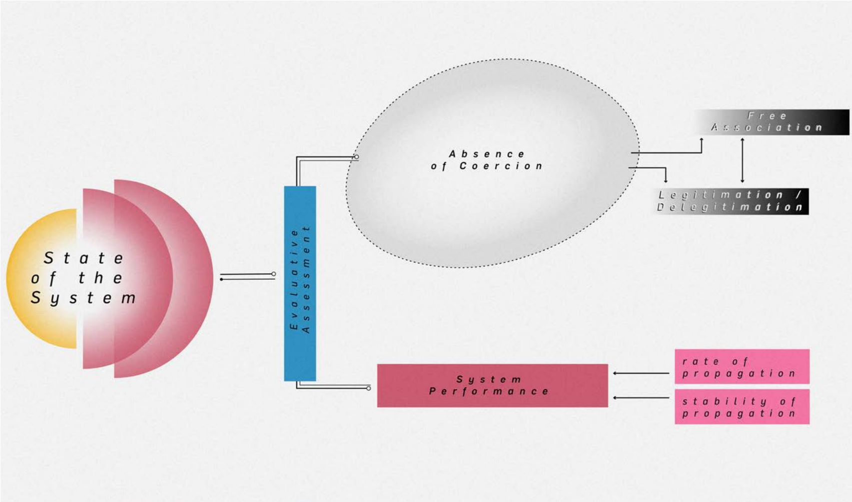

Fig. 2: Evaluative differences between traditional cybernetic and anarchic values. Source: image by author

association, which Kropotkin notes was formed by the first federations of corporations in Europe, is an open logic which resists being subsumed by active or derivative control systems. "What is of importance to us," Kropotkin writes in *The Conquest of Bread*, "is this: The agreement between hundreds of capitalist companies to whom the railways of Europe belong, was established without intervention of a central government to lay down the law to the divers[e] societies; it has subsisted by means of congresses composed of delegates, who discuss among themselves, and submit proposals, not laws, to their constituents. It is a new principle that differs completely from all governmental principle, monarchical or republican, absolute or parliamentarian. It is an innovation that has been timidly introduced into the customs of Europe, but has come to stay."[25] Ward makes a similar argument regarding international postal agreements, in which states freely associate on a transnational level, a rare example of international anarchic unity which has recently been questioned by the US government.[26] But the point is that one may withdraw

25 Kropotkin, The Conquest of Bread, 127.

26 Ward, Anarchy in Action, 53–54.

from these free associations, regardless of whether it is in one's personal interest or not.

Importantly, modes of legitimation and delegitimation provide a constitutive check on the propagation of a system or its characteristics. While Beer and Pask (and cybernetics in general) each conveniently ignore the possibility of interior antagonisms within cybernetic policy, the absence of antagonisms—agents and processes which actively or intentionally degrade the mechanisms of the system—only makes cybernetics more utopian and idealistic than any form of anarchism. The general reaction to a lack of antagonisms in cybernetic policy has been speculation about how cybernetic systems can react in order to negate the antagonistic source: search, augment, and destroy. This idea is central to the Marxian crisis-theory of capitalism.[27]

However, anarchism prioritizes the ability of agents and processes to delegitimize a portion or entirety of a system based on bottom-level acceptance. In this way, Ward's enthusiasm for a potential anarchic and cybernetic overlap is merited. The inclusion of anarchic principles to validate cybernetic processes and outcomes, and the ability of free association and modes of delegitimation within a system is an infusion of distributed agencies which are held to standards beyond that of survival and stability.

In *The Architecture of Neoliberalism*, Spencer notes that, "What architects want from complexity are rules of governance. Organizational truths located in an irrefutable materialism. The 'laws' of natural systems and the 'orders' of complexity."[28] Architects want meta-planes from which to organize the systems they create, even as Tafuri's critical declarations remain. In architectural production, the potential for radical contestation through the understanding of, interaction with, and implementation of complex systems is already present, but the discipline is currently incapable of divesting from its imaginary role outside the control system. Instead of continuing to propagate our own versions of derivative coercive networks via the standard ideology of

27 Karl Marx, Theories of Surplus Value (London: Lawrence & Wishart, 1951), 368–402.

28 Spencer, The Architecture of Neoliberalism, 67.

cybernetics, or creating alternative control methods, the interlacing of anarchic principles with cybernetic processes as described by Ward suggests an alternative potential in our work as organizers, researchers, and architects.

Concluding *Anarchy in Action*, Ward reminds us that "Anarchism in all its guises is an assertion of human dignity and responsibility. It is not a programme for political change but an act of social self-determination."[29] This practically rhymes with the ethical declarations of the contemporary architectural studio, but remains entirely distanced from the material practices of the discipline. Architectural production already operates inside a cybernetically-composed system, one which depends far more on the differences of zeros and ones in market algorithms than it does on the "phenomena" of space or the interest of the users it internalizes. Gentrification, the maven and harlot of urbanization, is not a confusing aberration or the effect of a system which spontaneously displaces populations and values or devalues land, but a central characteristic and sign of systemic success. The capacity of architects to ignore the role of their profession is profound, and certainly deserves an in-depth critique, but for the moment this feigned confusion can be tied to the architectural subject position and its assumption of system overview—the very assumption of the cyberneticist.

The connection between cybernetic and anarchic outcomes in architectural production requires a reorientation of field and repositioning of the architect as internal to the machinations they assume to oversee. This strain of thought has emerged in the last decade of architectural discourse, as seen in the organization The Architecture Lobby and in the writing of Spencer, Peggy Deamer, and Manuel Shvartzberg.[30] However, the focus on architectural labour hits a wall when it solipsistically generates its own criteria for what architectural labour comprises, without addressing

29 Ward, Anarchy in Action, 137.

30 Particularly, Deamer's organization and contribution to *The Architect as Worker* (2015) comes to mind, along with Matthew Poole and Manuel Shvartzberg's organization of *The Politics of Parametricism* (2015).

the larger systems within which it operates. Throughout *The Art of Inequality: Architecture, Housing, and Real Estate*, the authors show how entrenched the architectural discipline is in systems of value and how little agency it has to negotiate the conditions of that value, regardless of the "architectural" labour involved.[31] Further, it is important to remember that in all of the outcomes of contemporary architectural production, "Value, the [one] thing they have in common, is not a measure of their usefulness."[32] This condition does not change with an emphasis on "interdisciplinary" action, nor does it change through collaborations with non-profit organizations. Creating antagonisms which allow for freer forms of negotiation, popular legitimation and popular delegitimation will come through reconceiving and possibly abolishing the architect's position within the system. Architectural objects in specific locations calcify and store capital, and thus are assumed to create value, even while the value that they have calcified comes from a generational and collective heritage of labour and habitation. Kropotkin remarks, "Who, then, can appropriate to himself the tiniest plot of ground, or the meanest building in such a city, without committing a flagrant injustice? Who, then, has the right to sell to any bidder the smallest portion of the common heritage?"[33]

There is no internal escape within the current cybernetic (control) paradigm. Only an external escape, which must extricate the architects from their privileged position as overseers and dissolve them into mere agents being organized. If architectural production is to be socially and systemically positive in view of the values it so chronically vomits out into ineffectual prose, there must be a better conception of how the system can work agonistically, without a hierarchical privileging of economic value. Perhaps then the architect might realize that most "architectural" decisions are made by client developers and state officials, and

31 Reinhold Martin, Jacob Moore and Susanne Schindler, eds., The Art of Inequality: Architecture, Housing, and Real Estate (New York/NY: The Temple Hoyne Buell Center for the Study of American Architecture, 2015).

32 Prole.info, The Housing Monster (Oakland/CA: PM Press, 2012), 8.

33 Kropotkin, The Conquest of Bread, 78.

that free association is also beneficial to the professionals who design beautiful client presentations for decreasing returns. Rather than continuing the work of Pask by internalizing sub-systems of analysis and control within the building, the digital model, or in geometric algorithms, the only positive reaction of architectural production to the current conditions of cybernetic ideology is to actually come to terms with the system we are in—one which contains no meta-planes and one in which there is no neutrality. If we are participants of the cybernetic model called "Empire" as supposed by Michael Hardt and Antonio Negri (as well as their anarchist opponents in the radical French journal *Tiqqun*), we cannot focus on encoding fluid conditions into private-public-commercial space within the urban centre, nor to endeavour toward the end of robotic labour, but rather on the acceptance or abandonment of the system positions we hold.[34] The real question is whether the architectural discipline truly wants responsibility within the immanent cybernetic ideology and whether they want the market to change at all.

Comfortingly, even if the discipline does not want to change, there is still the possibility of uncovering antagonisms (and developing forms of Mouffe's "agonistics") which traditional cybernetics does not recognize.[35] Ward himself accepts the limits of discipline while proposing another path: "I do not subscribe to this view [that architects can internally reform the system in which it participates]: architects, like teachers, are victims of 'role-inflation' and we cannot expect more of them than that they do their job competently, though in the course of doing so they may very well become 'anti-architects' in the same way as some very competent and thoughtful teachers become 'de-schoolers'."[36]

Cybernetically there can be no problematization of position once internalized—and the architect is thoroughly internalized—but

34 Michael Hardt and Antonio Negri, Empire (Cambridge/MA: Harvard University Press, 2000). Tiqqun, This is not a Program, trans. Joshua David Jordan (Cambridge/MA: The MIT Press, 2011).

35 Chantal Mouffe, Agonistics: Thinking the World Politically (London: Verso, 2013), 9.

36 Colin Ward, "Introduction," in Vandalism (London: Van Nostrand Reinhold Co., 1974), 14.

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anarchically, the anti-architect is capable of contestation. In the face of dualling system ideologies, any progress toward political "emergence" in architectural production must come through the re-emergence of Colin Ward and his frustratingly optimistic vision of the anarcho-cybernetic project.

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MARCUS BERNARDO

Unmanageable Utopias

This essay proposes, through a case study, a utopian project based on cybernetic reasoning. The case involves self-organized families trying to solve their housing problems by occupying idle land in a large Brazilian city. The essay will analyse three cybernetic strategies thought to alleviate the groups' problems: Stafford Beer's Team Syntegrity, the use of analogically-computed interactive topological models and self-organization strategies. Three cybernetic concepts will be introduced to analyse and discuss self-organization, collective control and the use of indeterminate models in design.

Introduction

The holistic thinking of the counterculture movement that began in the 1960s did indeed imagine a different utopian society immersed in new technologies. However, the technological products of this junction between engineering and other areas of knowledge were mostly incorporated for mainstream purposes.[1] Interconnectedness, productive autonomy and the adaptability of new technologies were key in the imagination of a more plural and collectively managed society. Nevertheless, the impact of these technologies in the opposite direction is undeniable. Many new technologies have trivialized social relations, reinforced control mechanisms and failed to effectively manage the problems of society.

My contribution to this discussion is to present the results of my study on collective space planning, which supports the hypothesis

1 Fred Turner, From Counterculture to Cyberculture: Stewart Brand, the Whole Earth Network, and the Rise of Digital Utopianism (Chicago/IL: University of Chicago Press, 2010), 3–4.

of the anthropologist Mary Catherine Bateson that the "tragedy" of the cybernetic revolution was the abandonment of its systemic reflections in favour of the amenities of uncritical automation.[2] We live in a society organized by systems whose implementation is primarily based on cybernetic principles. During the Cold War, the institutional implementation of these principles had a predominantly negative impact on urban development in the United States,[3] and on political control in the Soviet Union[4] and China.[5] However, within the field these implementations have been widely criticized. Indeed, Norbert Wiener had already warned about these impacts in the field's early years in his book *Cybernetics*: "That [communication] system which more than all others should contribute to social homeostasis is thrown directly in the hands of those most concerned with the game of power and money."[6] There were attempts to develop different, critical approaches, such as those cyberneticist Stafford Beer conceived for Chile's economic management system. Called Cybersyn, the Chilean initiative was theoretically a top-down attempt to build a factory coordination system led from the ground up by workers, but in practice it became a way to distribute factories between the government's political allies.[7] After the successes and failures of this project, Beer brought his critical reflections to the field of social organization in a series of lectures he called "Designing Freedom," published in 1974. If Bateson was right, some of these abandoned reflections can bring light to the problems we are currently witnessing.

2 Mary Catherine Bateson, "How to Be a Systems Thinker," interview by John Brockman, dir. Nina Stegeman, Edge, April 17, 2018, video, 42 min. Accessed September 15, 2021. https://www.edge.org/conversation/mary_catherine_bateson-how-to-be-a-systems-thinker.

3 Jennifer S. Light, From Warfare to Welfare: Defense Intellectuals and Urban Problems in Cold War America (Baltimore/MD: Johns Hopkins University Press, 2003).

4 Slava Gerovitch, From Newspeak to Cyberspeak: A History of Soviet Cybernetics (Cambridge/MA: The MIT Press, 2002).

5 Susan Greenhalgh, "Missile Science, Population Science: The Origins of China's One-Child Policy," The China Quarterly 182 (June 2005): 253–276.

6 Norbert Wiener, Cybernetics: or Control and Communication in the Animal and the Machine, 2nd ed. (Cambridge/MA: The MIT Press, 1961), 161–162.

7 Eden Medina, Cybernetic Revolutionaries: Technology and politics in Allende's Chile (Cambridge/MA: The MIT Press, 2011).

The methodology used for this field study involved first searching for situations where collective organization for space planning was happening, and then conducting participatory observations and laboratory experiments to discuss cybernetic strategies in context.

A self-organized settlement

The situations I found to be illustrative of the cybernetic principles I will examine are situated in Belo Horizonte, a city of almost six million people in Brazil with a history of strong occupation movements and large informal settlements. One reason for the number of occupations is that the housing deficit is high, but the amount of vacant land and buildings is even higher. Housing is a multidimensional problem that involves politics, power, economy, technology and other fields. Given this situation, the university where this project was conceived, like many other universities in the area, studies and supports these occupation groups to understand what can be improved within this unbalanced context. This ongoing research made it possible for me to access different initiatives undertaken by collective organizations and create cybernetic experiments around them, one of which I discuss here.

The selected case study involves around 200 families, who, in collaboration with activists, are trying to solve their housing problems by occupying idle land. Their problems cannot be addressed either by state housing policies or by the real estate market. The size of their families or their activities exceed the capacity of the state apartments, and their income is not sufficient for the available housing on the market. The situation they face consists of parcelling the recently occupied land and planning its infrastructure, then building.

The occupation is overseen by a bigger group that has already acquired other land over the past eight years. Most informal settlements in Brazil occur through spontaneous self-organization, but organized occupations are also significant; in Belo Horizonte alone, twenty-four of them involve more than fifty thousand people.[8] To outline this organization process briefly, over time the organizations have gradually established decision-making authorities: plenary assemblies are used to discuss collective matters and elect semi-autonomous committees for specific tasks. These committees manage everything, from the search for proper land to occupy to a scoring system to record participation and manage the sequence of land distribution. Each committee decides most things autonomously, meets with others, and calls for plenaries when they think an issue needs to be discussed with the whole group. If poor decisions are made autonomously by a committee, they can be dissolved by a plenary vote. After any new occupation, a committee is established to plan the settlement's infrastructure and the subdivision of the land. Only after that does building commence. Once the occupation is consolidated, the organization remains strong so long as there are collective claims and actions to carry out. Organizing can become less pronounced and sometimes dysfunctional after public amenities are provided to the new settlement.

In earlier occupations, the settlements were designed solely by the technical committee elected for that purpose. Designs were repeatedly presented in assemblies for discussion and approval and, once approved, implemented. Assigning lots to families was the final step, as the generic subdivision of land drastically simplified design requirements. However, this parcelling process also led to problems later, when some residents were given plots other than those they had imagined.

In this occupation, the committee tried to enact a collective planning process. The first attempts were made at a meeting at a local school. Committee members divided the family representatives into nine groups of around 20 people. Each group developed a proposal which was voted on at the end of the session. Observing from the outside, the chosen proposal did not appear any better than those previously prepared by the committee in isolation. The problems with the allotments had not seemed to be resolved, as the design plan continued to include generic lots.

8 Rafael Reis Bitterncourt, Cidadania autoconstruída: o ciclo de lutas sociais das ocupações urbanas na RMBH (Belo Horizonte: UFMG, 2016).

These solutions did not look very different from the ones provided by the state either, since they did not address the specific needs of each family. In order to resolve this issue, the planning committee studied how to enable the subdivision of blocks of land into plots proportional to three types of family size, and had to decide what criteria would be used to determine this.
According to two previous and significant studies on the socio-spatial structures of favelas in Belo Horizonte, it is clear that much more can be considered when it comes to the proper division and distribution of land and infrastructure than family size. According to this research, during its formation, the built space of the favela grows to accommodate relations between neighbours, the compatibility of their activities, the diversity of their family structures, mobility requirements, domestic production and commercial activities, and many other factors. Sometimes, for example, a group of neighbours changed the access routes to their houses to avoid another group. The creation of alleys also served to connect interdependent houses, like those of young families and their elderly parents. Most houses were continually transformed through the construction of walls, alleys, and rooms to avoid convivial problems and accommodate new family members and work initiatives, like a hair salon, a mechanic's workshop, or a vegetable garden.[9] If all of these parameters could be considered in the planning process, conflict could be avoided, diversity fostered, and the families could be supported to coexist in a more stable situation than in the favelas. How to design with all these variables collectively?

Cybernetic analysis of the situation

In his aforementioned lectures, Beer warned that the survival of purposeful social organizations depends on their ability to adapt their responses to their dynamic context and to maintain their

9 Cidade e Alteridade, Direito Fundamental à moradia adequada: "novos olhares sobre os impactos e efeitos das políticas públicas de assentamentos e reassentamentos em aglomerados urbanos de Belo Horizonte" (Belo Horizonte: UFMG, 2015).

purpose.[10] For this adaptation to keep pace with the environment, decision-making processes cannot rest at the top of hierarchies, as the ability to make decisions towards the top diminishes in typical pyramidal administrative structures.[11] He states that the network pervasion can aggravate this problem if there is no change to administrative structures.[12] For an organization to be effective, its communication structures must enable different degrees of autonomy.[13] Thus, problems should be solved, whenever possible, by smaller groups, with a decreasing number of pertinent questions as the group becomes larger and its scope more general. Nonetheless, the second problem, stated clearly by Beer's research fellow Gordon Pask, is that this decision-making structure is too complex to be designed; it must be self-organized to create a context-efficient organization.[14]

Beer and Pask's statements can be evaluated in the context of the occupations in Belo Horizonte. In the occupation assemblies, the higher the number of people involved, the greater the number of issues to be discussed, but there is less capacity to discuss all these issues comprehensively. As questions accumulate, speaking time gets too scarce to engage in effective collective decision-making.[15] I observed that this scarcity promoted three types of economy: (1) the economy of the number of problems to be discussed, using the ideology of needs, which discerns between personal desires and "important basic needs"[16]; (2) the economy of the complexity of the problems discussed, using generic solutions that can be adopted from the

10 Stafford Beer, Designing Freedom, Massey Lectures vol. 13 (New York/NY: Wiley, 1974), 6.

11 Ibid., 73.

12 Ibid., 26.

13 Ibid., 70–72.

14 Gordon Pask, "My prediction for 1984," in Cidoc Cuaderno 1014: Interpersonal Relational Networks, ed. Heinz von Foerster (Cuernavaca: Centro Intercultural de Documentacion, 1971), 4, 8–12.

15 Gordon Pask, "The limits of togetherness," in Information processing 80, ed. Simon Lavington (Amsterdam: North-Holland, 1980), 1001.

16 Ivan Illich, "needs," in The Development Dictionary: A Guide to Knowledge as Power, ed. Wolfgang Sachs (London: Zed Books Ltd, 1992), 95–110.

establishment of standard needs; and (3) the economy of the debate about the problems, which reduces all the voices of the collective to one voice through voting or unanimity—a viable route only when the discussion involves generic solutions that concern everyone. What the case study indicates is that assemblies have a structure that, at best, flattens individual issues and directs collective decision-making only to the problems that affect all participants. There is no opportunity to discuss problems that are specific to individuals but would be better solved collectively due to their relational nature. However, at worst, assemblies as a form of organization can also be used to prioritize the individual issues of those who have more informally-established power, as explained by the feminist political scientist Jo Freeman: "the idea of 'structurelessness' does not prevent the formation of informal structures, only formal ones… [and] …becomes a smokescreen for the strong or the lucky to establish unquestioned hegemony over others."[17]

The problems that arise from the economies mentioned above affect the solutions generated in the assemblies and influence how the committees are formed to implement these solutions. We saw that these committees split tasks according to functions, such as a purchasing committee, communication committee, design committee and so on. This subdivision allowed the committees to implement solutions already decided in the assembly and adapt them as needed in an autonomous way. Conversely, this subdivision did not help overcome the problems that resulted from adopting simplified solutions, since it siloed essential aspects that needed to be discussed together in order to adopt new solutions. Ultimately, the subdivisions made in the assemblies, instead of forming autonomous groups according to what concerned each of them, split the issues affecting everyone into parts and distributed them among the groups.

The project committee's attempt to subdivide residents into nine non-specialized groups to design separately was a step forward,

17 Joreen Freeman, "The Tyranny of Structurelessness," The Second Wave 2, no. 1 (March 1, 1972): 1.

yet the design method being used was the same as one that might be used by an architect designing alone. Consequently, the nine groups could not work on the project in parallel, but only in competition for the best idea to solve the problems of a homogenized group, composed of supposedly generic families.

Cybernetic strategies in the context of the occupation

As a result of the above analysis, I thought three cybernetic strategies to assist dwellers in their planning efforts:
(1) The first strategy uses principles from Beer's Team Syntegrity meeting protocol. As an alternative to general assemblies, Team Syntegrity focuses on problem-solving groups that adhere to the issues raised individually: in the first stage, participants interested in a general theme meet and, to start a discussion, any of them can visibly write, for example, on a whiteboard or poster, the issue they want to discuss.[18] Other participants may freely join or leave this discussion, and may also start other independent discussions. In the second step, topics are selected for discussion in groups of five people. Each person participates in two topics as an active discussant and in two topics as a critic. Consequently, small groups can meet separately at the same time, while at every meeting, each participant relates information from the other three groups in which they have participated. To foster the integration of groups, people are organized like the edges of platonic geometries,[19] each person connecting two nodes that represent the topics they address. This organization protocol guarantees the possibility of simultaneous parallel work, and, after many rounds of meetings, it foments integration between

18 Allena Leonard, "Team Syntegrity: a New Methodology for Group Working," European Management Journal 14, no. 4 (August 1995): 407–413.

19 Platonic forms are ideal for performing the protocol, but a number of variations have already been obtained to suit different numbers of people. More information can be found in: Marcus Bernardo, "Integrating parallel conversations in an institutionalized society: Experiments with Team Syntegrity online," Technoetic Arts: A Journal of Speculative Research 19, no. 1–2 (2021): 61–69.

topics.[20] In tests I conducted online with architecture students, it seemed that the process favoured personal expression, not only because of the small size of the discussion groups but because it brought together participants with information from other groups with which the other participants were unfamiliar.

If we were to apply the same strategy to the settlement design, the families would freely articulate their spatial desires in the first stage. Clustering around their shared interests, groups of families would discuss the form they would like the settlement to take. Instead of finding topics, we would raise "spaces of interest" in a decentralized manner, for example, different types of houses, parks, quiet streets, busy streets, stores, schools, workshops, riverside spaces and so on. For the next stage, interrelated groups would be formed to design the spaces. The design could start with the spaces inside each house, which could be discussed by each family as an interrelated group of individuals, and in the next step, groups of families with common interests could plan the design of small neighbourhoods. The presence of common or conflicting interests between these groups would connect or separate them the same way as the topics were integrated by the multiple roles of participants in Team Syntegrity. Similarly, each person would participate in the design of different spaces and pass information between groups. However, for this design process to work, it would be necessary to use design tools that make it easy to adapt the group's different solutions synchronously, which leads to the second strategy.

(2) The second strategy involves the use of analogically-computed interactive topological models as an alternative to traditional deterministic blueprints. Topological models, in general, are not defined by the geometry of their parts, but by how these parts relate to each other: their connectivity, adjacency, enclosure, overlap, etc. If instead of drawing spaces using specific geometrical forms, we think of them as a collection of disks connected by elastics, we can maintain specific desired configurations while

20 Leonard, "Team Syntegrity: a New Methodology for Group Working," 407–413.

varying their geometry to create a wide range of forms. Each family could assemble their houses by connecting disks of various sizes, up to an amount of land proportional to the size of the family. Houses would join together around streets, patios and other shared spaces composed of donated areas. Flexible tubes would represent linear elements like streets, walkways or pipes. Designing this way, parallel solutions would automatically adapt to each other by varying their geometry when joined.
To achieve this model, I first tried different strategies using the software Grasshopper and its physical simulation plugin Kangaroo to make a digital model. Grasshopper is a visual programming environment that runs within Rhinoceros 3D, a computer-aided design application. The software is used to create processing paths where inputs, like the number of houses and their configuration, can be varied to produce different outputs, for example different neighbourhood projects. Accordingly, a processing path was created to output an interactive graphic where houses were represented by disks behaving as if they were tied by elastic strips. This worked, but I could not process the agglomeration of more than forty houses without creating errors in the physical simulator. Consequently, the next step was to try physical models. I found in screw-nuts an accessible hexagonal form that gives a snap to movements when joined with latex strips. This form provides some stability to the model if a specific positioning is desired, but automatically adapt its form to maintain its configuration. The interactive model generated is easy to reproduce in the context and capable of automatically and simultaneously processing the same information as the digital model, without the computational limits of digital serial computers. After some tests with screw-nuts, I designed a 3D printed version that is not as accessible, but is easier to attach to elastics (fig. 1).
One disadvantage of this physical model is that, once all the spaces are connected, it is hard to manipulate the model to suit all families simultaneously. Two hundred family representatives around it would form a circle with a diameter of 20 meters. For the parallel design process to work in its analogue version, I would need to subdivide and detach areas for groups of neighbours

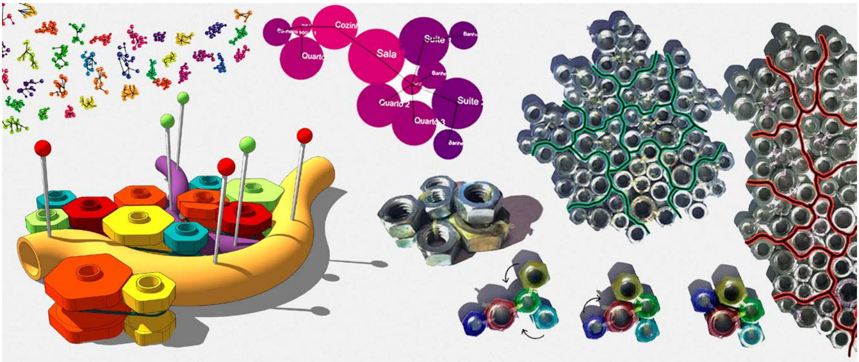

Fig. 1: On the top left, digital experiments with discs agglomerated by forces of attraction; on the right, experiments made with screw-nuts and rubber bands; on the bottom left, the digital representation of a version developed for 3D printing. Source: image created by the author

to design details separately, after fitting the agglomeration to the land geometry. A recurrent subdivision would be needed to entwine the parallel designs, every new subdivision embracing the borders of the last subdivision (fig. 2).

(3) The third strategy uses self-organization to perform the necessary actions for implementing solutions, as an alternative to integral coordination through a consensual deterministic project. Centralized coordination through deterministic design is not necessarily an efficiency tool but a workforce control feature,[21] as it a priori defines the solutions to be adopted and does not employ the decision-making power of the workers involved in construction. There are non-mapped trees, terrain accidents, and underground rocks in the occupied land, not to mention the changing relationships in the neighbourhood and a host of other factors that need to be taken into account when implementing a solution. These features are too complex to capture, process, and deterministically model, even using the parallel processing strategies mentioned. Given this situation, there is no sense in using deterministic models when the inhabitants are managing the building of the houses and infrastructures on their own. The same

21 Pedro Fiori Arantes, The Rent of Form: Architecture and Labor in the Digital Age, trans. Adriana Kauffmann (Minneapolis/MN: University of Minnesota Press, 2019), 101–109.

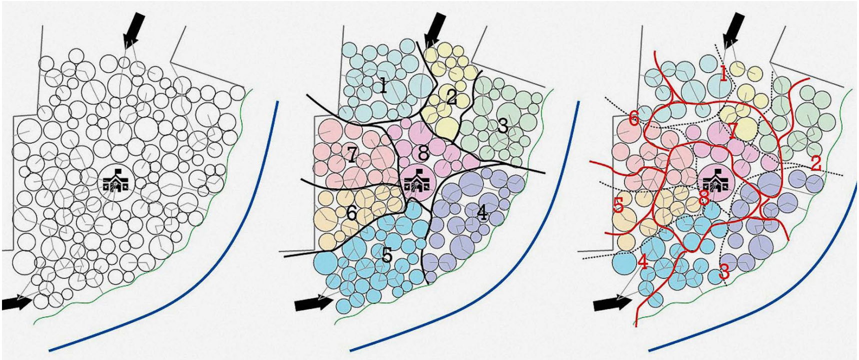

Fig. 2: Illustration of how a parallel settlement design process could be achieved. From left to right: agglomeration adapted to the geometry of the land; the subdivision of groups by area; new subdivision done in a way that does not coincide with the previous division. Source: image created by the author

cybernetic reflections applied to the first strategy can be used here to devise an alternative strategy to centralized coordination. While Team Syntegrity can attenuate the variety of issues to be collectively resolved, its use for opposite purposes can amplify the variety of individual responses to a complex context through autonomous self-organization.

Working this way, models and meetings could be used as tools to imagine settlement possibilities and for planning abstract rules to guide their realization by self-organized autonomous groups. In the case of the subdivision of land, residents—keeping plot areas and street axes collectively organized—may negotiate on-site as to the best form for their plots and implement together any infrastructure they deem necessary.

Analysis of strategies

If in the 1960s there was a utopic dream of a society immersed in cybernetic technologies, today's dream society might be immersed in cybernetic strategies. Three cybernetic principles can be used to analyse and discuss the impact of these cybernetic strategies on today's utopic imagination. The first is about self-organization, the second about collective control, and the third about indeterminate models:

(1) The use of the word "self-organization" to describe some events in this essay calls for a better understanding of its potential meaning. The subdivision of any observed phenomenon into parts organized in a way that behaves like this phenomenon is what the cybernetics pioneer William Ross Ashby calls a "system."[22] Accordingly, a system is an abstract machine that reproduces a phenomenon. The more conditionality the system has between its parts—the more organized it is—the fewer the possibilities of what could happen, and the better the phenomenon is known to uncertain observers who calculate probabilities based on what they have already seen.[23] As a result, we depart from a phenomenon observed as one entity that changes its states to a phenomenon observed as a machine that can have its parts manipulated. Ashby explains that the same phenomenon can be divided and organized in many ways that reproduce its behaviour, and that the observers are the ones who decide how to do it depending on the goals they want to achieve.[24] In the same way, the description of how some systems move from independent parts to connected parts, i.e. how they organize themselves, is a second-order observation of the same kind as the first, namely the organization of the organizational process.[25] In this context, Ashby states that greater or lesser organization, in itself, is neither good nor bad, nor is any type of organization. An organization can only be good according to an observer's criteria. Depending on the criteria we use, we can imply that disorganization can be better than bad organization,[26] as it at least carries the possibility that good organization might emerge. This is where self-organization comes into its own—when we relinquish control to achieve something beyond our control capabilities.[27] Nevertheless, as Ashby just stated, an emergent organization does not mean a good organization. Therefore, Ashby alerts designers that it is

22 Ross Ashby, "Principles of The Self-organizing System" in Mechanisms of Intelligence: Ashby's Writings on Cybernetics, ed. Roger Conant (Seaside/CA: Intersystems Publications, 1981), 55.

23 Ibid., 53–54.

24 Ibid., 54–55.

25 Ibid., 62–63.

26 Ibid., 59–61.

27 Pask, "My prediction for 1984," 9.

crucial to understand what kind of organization tends to consolidate in these fomented indeterminate processes.[28]

In light of this reasoning, we can view the group I observed as self-organized, in the sense that it started with disorganized people and ended organized into committees with specific roles. However, even though this process of organization was not predicted, it happened in a context that came out of traditional organization formats, such as the general assembly and specialized subdivision. This organization made the group capable of accomplishing many tasks, but if they continue with it, further possibilities of organization will be reduced. As I previously described, their organization implies a series of economies in the design process. In this sense, the imagined strategies can generate an alternative context that fosters different self-organization which might be better for settlement planning and implementation. The criterion for "better" here is specific: increase personal expression through the integration of decentralized decision making. The first reason for this criterion is the previously quoted statement from Beer, that a form of organization that balances centralization and decentralization will more likely succeed in achieving the group's goals. Nevertheless, one more significant reason can be mentioned, and this is about control and freedom.

(2) Engineer and philosopher Jean-Pierre Dupuy refers to a conjecture that helps us to understand the necessary balance between individual and collective control. He calls it the Heinz von Foerster postulate. The postulate suggests that when new possibilities for the interrelationship between individuals in an observed society emerge, each individual's sense of control over their future increases, while the path of society as a whole becomes more unpredictable. Furthermore, he affirms that the same is true in reverse. For those inside a system composed of trivial relations, there is no individual control or freedom within the fate of a whole that conducts itself autonomously to a predictable

28 Ashby, "Principles of The Self-organizing System," 65–67.

future.[29] This is another way of saying that system control depends on recognizing patterns of behaviour. Accordingly, for any amount of collective control to exist, some trivialization of relations is necessary. This is a second reason to think that even true collective control must have a degree of indeterminacy. In this case, control must be balanced with non-modelled self-organization, not just for efficiency but also for freedom and diversity.

This strategy is already used to increase the efficiency of Artificial Intelligence, to give machines a specific scope to autonomously search for solutions.[30] Moreover, it is also used in Toyotism, giving workers a certain amount of autonomy to produce goods and achieve their productivity targets.[31] The same strategy can be used by agents that are not organized by companies but organize themselves to achieve a shared collective goal that has some complexity.

The group I studied implements some control, which is achieved by distributing roles and adopting protocols. Despite creating some limits, these controlled relations also provide the predictability necessary to allow integrated actions that compensate for any limits by performing tasks that individuals alone could not achieve. Therefore, balance comes from a limit bringing its opposite: freedom. Accordingly, maintaining balance can also mean that these organization protocols aligned with the group consensus can seek to foster its opposite wherever possible: decentralized decision-making. It can also mean that the trivializations caused by these protocols, like stipulating specific activities and subdivisions into groups, can focus instead on making room for diversity and personal expression to emerge.

29 Jean Pierre Dupuy, "Que reste-t-il de la Cybernétique à l'ère des sciences cognitives," in Seconde Cybernétique et Complexité: Rencontres avec Heinz von Foerster, eds. Evelyne Andreewsky and Robert Delorme (Paris: Editions L'Harmattan, 2006), quoted in David Chavalarias, "The unlikely encounter between von Foerster and Snowden: When second-order cybernetics sheds light on societal impacts of Big Data," Big Data & Society (January–June 2016): 1–11.

30 Paul Horn, Autonomic computing: IBM perspective on the state of information technology (New York/NY: IBM T.J. Watson Labs, 2001), 13. Accessed September 15, 2021. https://homeostasis.scs.carleton.ca/~soma/biosec/readings/autonomic_computing.pdf.

31 Ricardo Antunes, The Meanings of Work: Essay on the Affirmation and Negation of Work (Chicago/IL: Haymarket Books, 2014), 38–39.

(3) The third reasoning comes from the cybernetician and design theorist Ranulph Glanville and throws light on how the way we model control can support this balance between organization and indeterminacy. Glanville says that since design models are not meant to be used for prediction, like scientific ones, they can be indeterminate, leading not only to one result but a range of satisfactory possibilities. While in the sciences this brings uncertainty, in design this is not a problem but an advantage, as all these possibilities provide more choices. Accordingly, architectural models do not need to be determinate; they can simply help filter out the possibilities we do not want to choose. Filtering a range of good possibilities can help groups move from unmanageable situations to more restricted and achievable ones.[32] The topological model can exemplify this reasoning in the context of the occupation. Once determined, the configuration of a space (a house, for example) and the manipulation of its form is restricted to the range of forms that attend to that configuration. When a whole neighbourhood is configured, there is a great range of possible arrangements of its parts that can be easily manipulated without changing their configurations. This restricted model can make the situation manageable through manipulation. The organization of the whole protocol into steps and division into groups is a restriction that can filter out undesirable situations and leave room for autonomous decisions and self-organization.

Discussion

The aim of this article was to introduce some cybernetic principles that might shed light on the unfortunate transformation of the utopian 1960s' technological imagination into a dystopic one, and to suggest that an alternative utopia can focus on spreading cybernetic strategies (rather than cybernetic machines). I imagined a strategy of integrated parallel processing in the

32 Ranulph Glanville, "Designing Complexity," Performance Improvement Quarterly 20 (2007): 75–96.

collective planning of settlements by their occupants. This strategy was inspired by the alternative approach an existing group took to solving housing problems and managing urban space. This group has resisted many forces and regulations to create an experimental space for collective land management directly by inhabitants. Accordingly, the cybernetic analysis I conducted has no intention of disqualifying this collective organization, but departed from it for the purpose of a utopian thought exercise. As a collection of exercises, my research is not meant to be applied in the context of the actual occupation because it was not developed there (if it was, it would involve many more aspects than those mentioned here).

Despite not directly applicable to housing, the results can yield insights about what we do in the realm of exercises and imagination: the architecture school. Design exercises imagine a society in order to develop and provide instruments and strategies that can be used to benefit that society. Therefore, one venue for further research is to test and develop these alternative practices of collective and parallel design in the context of architects or architecture students designing together.

Although this essay used only one case study in its analysis, thanks to the work presented by researcher Grayson Daniel Bailey at the Utopia Computer workshop, I found echoes with far greater studies linking architecture, cybernetics and anarchism. The anarchist writer and architect Colin Ward brought many other examples of cybernetic strategies for self-organized town planning. The concept of social self-organization, and insightful cybernetic approaches to it, can be also found in the work of the philosopher and economist Cornelius Castoriadis.

Bailey's text highlighted the pre-requisites of self-organization, which motivated my inclusion of Ashby's arguments about the dependence of self-organization on its wider context. Moving forward, the discussion can progress by making an inversion, and asking, based on which pre-requisites do we want our design strategies to unfold? If design strategies are to be built on top of over-descriptive digital models, they will require trivial behaviour from inhabitants and a lot of processing effort. Another study at the conference, presented by Donal Lally, showed how big data storage and processing is not just a significant effort involving matter, energy, and precarious labour, but is already impacting urban planning. He discussed plans by the city of Dublin to use the heat generated by a large data centre to warm houses. This system will also manage heat distribution using artificial intelligence when shortages occur. In other words, upon the structure built for processing big data, self-organization strategies will grant digital computers the space to tackle complexity. If we compare this to the cybernetic strategies analysed, we can see that both use self-organization to deal with complexity; however, the indeterminate processes, or decision spaces, are left to be carried out by different agents.

These cases bring back into our imagination the utopia Beer advocates in his aforementioned "designing freedom" lectures: a space where collective organization works by and for the individual's freedom,[33] remaining complex and unable to be managed by datacentres, universal models or large computers.[34] However, in order for this to happen, the reflections of Ashby about the role of the observer in defining goals must be considered.[35] As we can infer from Heinz von Foerster's postulate, from the moment that goals are assigned to objects rather than subjects, the world risks becoming an oppressive automaton. This problem seems to be aggravated when adaptive technologies are used to meet the goals that their creators set for the people they serve, rather than interlinking these subjects' goals. The failure of past cybernetic experiences in Chile[36] and the Soviet Union[37] show that the general distrust for the undetermined subject can turn into a technocratic reliance on objective structures, even when they project a dystopian destiny.

33 Beer, Designing Freedom, 87–100.

34 Ibid., 42–43.

35 As explored in depth in second-order cybernetics and radical constructivism.

36 Medina, Cybernetic Revolutionaries.

37 Gerovitch, From Newspeak to Cyberspeak.

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JUAN ALMARZA ANWANDTER

About the Current (and Future) Implications of the Process of Digitalization in Our Everyday Experience

A Fourfold Critical Approach

The current development of interactive and ubiquitous technologies such as Augmented Reality, the Internet of Things and domotics has tended to close the perceptual gap between the analogue and the digital through a radical process of merging both domains. The distinction seems to be definitely blurred. The following text explores the implications of this process through a model of interpretation based on four main points which allows me to critically conceptualize this paradigmatic shift from a broader metahistorical perspective. It addresses some of its potential consequences in social, cultural, and political terms, referring also to specific implications in the domain of architecture from a phenomenological perspective.

In the last ten years, the exponential development and everyday normalization of technologies such as Augmented Reality (AR), the Internet of Things (IoT), domotics, and others seem to have blurred the distinction between analogue and digital. If, in the mid-1990s, the digital revolution was still utopianly conceived as a form of replacement or overcoming of the analogue,[1] these

1 As exposed by Nicholas Negroponte in his book *Being Digital* (New York/NY: Coronet, 1995).

novel technologies render such utopian narratives obsolete: they close the gap between the analogue and the digital through a radical process of *merging*, specifically at the level of the phenomenology of sensory perception. Certainly, seen from an optimistic-progressive perspective, this current reorientation of the utopian goals of digitalization entails and fuels a wide array of expectations. But it also has some specific implications, particularly in terms of its incidence in fundamental concepts like personal freedom and self-determination. The following text constitutes a brief analysis of these implications, in the form of a critical model of interpretation based on four basic points that will help us to conceptualise the process of digitalization from a broad and encompassing perspective. These four points are:

(1) In historical terms: the irruption of the digital as a form of transition from *Titanic* to *Daimonic* forms of technology.

(2) In terms of the phenomenology of perception: the notion of *blurring* the limits between reality and fiction.

(3) In terms of its implications within the domain of social and political forms of control: the idea of *protocol of interaction.*

(4) Finally, a critical approach on the notion of *self-organisation* by machine-learning algorithms, confronted with the praxis of the implementation of ideological-normative principles of social organisation.

These four points will constitute, in turn, a theoretical basis for addressing some specific implications of the digitalization process in the ambit of the phenomenology of architectural experience.

From Titans to Daimons

Commenting on the recent imprisonment of Julian Assange, the philosopher Slavoj Žižek provided some statements on the press which are worthy of deeper analysis. Žižek said: “All our lives today are somehow regulated through digital media. So it’s absolutely crucial to know who controls this digital media. This is the greatest threat to our freedom… We are not even aware of it as we don’t experience it as unfreedom. It’s not like the old days of the police state, where you look over your shoulder and see a man following you. You feel totally free, but your every move is registered and you're subtly manipulated."[2] Žižek's words can be summarised into a single statement: we are experiencing the shift from visible to invisible forms of social control. The "old days of the police state" were based on the use of entirely analogue systems of surveillance, from hidden microphones to secret agents disguised as normal citizens. Such analogue interphases had the irreducible character of visibility. You could eventually find the microphone and cut its cables, or discover and kill the agent. But the shift to the digital has implied a gradual process of dematerialization and the effective invisibilization of such physical interfaces. And this is highly functional to any form of social control.[3] The secret agent is now in our pockets, in our cell phones via GPS tracking, and, according to Žižek, we do not realise this. Here we arrive at the first point that I would like to propose as a form of conceptualisation of this process: from a broad historical perspective, the change from the analogue to the digital is essentially the paradigmatic displacement from *Titanic* to *Daimonic* forms of technology. What does this mean?

The innermost *telos* of technology, understood as the instrumental embodiment of *tékhnē* in concrete historical and material forms, is the overcoming of the limitations imposed by nature (*physis*) on the sphere of human experience. In specific terms: the dominion over time and space on a global-planetary scale, the aim of achieving an "absolute state" in the forms of ubiquity and instantaneity. This is the inherent teleological character of technology, and it is particularly recognisable in the exponential development of speed in transportation and communication technologies. The final goal or *telos* of this process is the overcoming of the human condition itself, as it is posed in the programmatic goals of transhumanism.[4]

2 Slavoj Žižek. "Assange arrest final step in character assassination campaign" RT News, April 11, 2019. Accessed November 1, 2019. https://www.rt.com/news/456237-julian-assange-arrest-slavoj-zizek/.

3 Its clearest and most efficient form of implementation is, until now, the Chinese "social credit" system.

4 "Humanity will be radically changed by technology in the future. We foresee the feasibility of redesigning the human condition,

In historical terms, this teleological dimension shows a certain pattern of evolution, from *Titanic* forms in pre-industrial and industrial eras to *Daimonic* forms in the context of our current information age. I propose these concepts as instrumental categories, based on their original Greek meaning. In Greek mythology the Titans were the giant pre-Olympian gods, among them Cronus, Atlas, and Prometheus, while the *Daimons* (from which the word *demon* comes) were lesser gods, invisible spiritual entities who could not be directly perceived by the senses.[5] The Titans attempted to defeat the Olympian gods (Zeus, Athena, and so on) by means of "brute force." They waged war against them, and were ultimately defeated. The cosmic law of balance, order, and measure prevailed. But before being defeated and punished for their pride (*hubris*), one of them, Prometheus, gave a precious gift to humankind: fire, stolen from the gods (fig. 1). Prometheus, like Lucifer in the Judeo-Christian tradition, is the light-bringer who gave us the gift of consciousness, enabling us to recognise our own power to transform the natural order by means of *tékhnē*, which is basically a primordial form of will to power, in a Nietzschean sense. This ancient myth is a clear symbol of the inherent promethean character of human technology, aimed at the complete overcoming of the limitations imposed by nature. But, although the Titans were defeated, we, their sons and daughters, continue the struggle, challenging the limits imposed by the divine order. Now, for more than 5,000 years, this confrontation has been carried out by humanity basically using the same methods as the old Titans, that is to say, by means of physical coaction, in visible and corporeal forms. But time has made us cleverer, wiser, and smarter. And so, we are now shifting from

including such parameters as the inevitability of aging, limitations on human and artificial intellects, unchosen psychology, suffering, and our confinement to the planet earth." First article of "The Transhumanist Declaration," World Transhumanist Association – WTA, 2002. Accessed December 19, 2020. https://web.archive.org/web/20070208023146/http://transhumanism.org/index.php/WTA/declaration/.

5 The etymology of *Daimon* (δαίμων) derives from the Proto-Indo-European root *da, which means to divide, to distribute. In its original Greek context, the word didn't have the negative connotation that it acquired with the advent of Christianity.

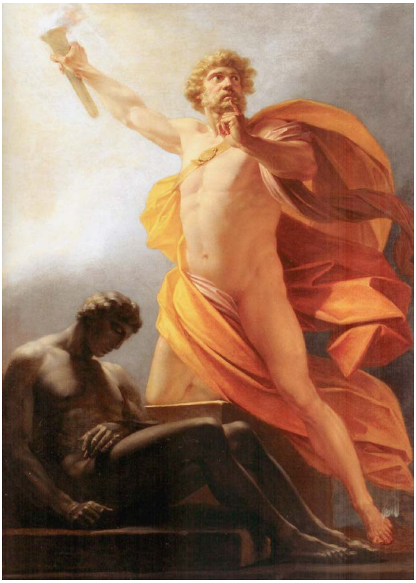

Fig. 1: Heinrich Füger, Prometheus Brings Fire to Mankind, oil on canvas, c. 1817. Source: https://commons.wikimedia.org/wiki/File:Heinrich_fueger_1817_prometheus_brings_fire_to_mankind.jpg. Accessed November 1, 2019

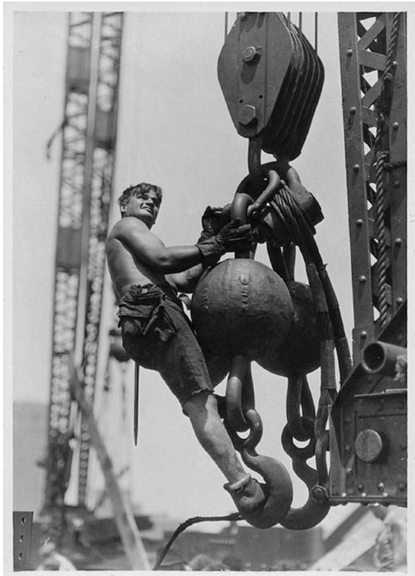

Fig. 2: Lewis Wickes Hine, A worker riding on a crane hook, photograph, 1931. Source: New York Public Library Digital Collections. https://digitalcollections.nypl.org/items/510d47d9-a90a-a3d9-e040-e00a18064a99. Accessed November 3, 2019

Titans to Daimons, more subtle, adaptive, and powerful. We have finally understood that a direct confrontation with nature, using massive and unrestrained means of physical transformation, is not enough, and is doomed to failure. So now the battlefront shifts toward inwardness, as we try to decode the internal laws of matter through quantum physics, genetic engineering, and nanotechnology, in an effort to control nature "from within." And digitalization plays a relevant role in this process, because, due to its internal architecture of encoding-and-decoding, it allows us to replicate the patterns of physical reality and modify them at will, enabling us in the end to create a "second nature," a demiurgic copy, completely subjected to calculation and predictability.
These broad categories, *Titanic* and *Daimonic*, must be understood as matrixes of meanings, semantic fields in which multiple dimensions converge. What is the language of the Titanic?

It is analogue, visible, tactile, transparent, and monumental. By contrast, the Daimonic is digital, invisible, non-tactile, blurry, and non-monumental. In terms of sensory experience, the Titanic tends to establish relationships of corporeal empathy (*Einfühlung*), while the Daimonic can be better described in terms of abstraction. It is much more difficult to represent and visualise in its concrete material substratum.[6]

The feeling of power and fascination that the Titanic forms convey is directly related to their ability to be interpreted as empathic projections of the body's own physiological constitution. The muscular effort of an arm is replicated in the crane but in a monumental, magnified way, in clear relationships of cause and effect (fig. 2). This also leads to their interpretation as transparent, un-concealed symbols of the will to power. In the Titanic expression, the empathic relationship between human and machine is retained in the specificity of the subject-object distinction, and in the irreducible gap between the classical notions of "natural" and "artificial."

This activist sticker, casually found by the author on the streets of Berlin, may serve as a good example of the visual codification of the Titanic expression (fig. 3). Besides the narrative of patriarchal domination, the sticker makes an indirect reference to the possibility of subverting the mechanistic-Titanic forms of technology, which is a possibility based in their embodied, tactile, and corporeal character. The analogue can be sabotaged by analogue, non-specialised means. On the contrary, the digital cannot be sabotaged, but hacked. And this requires a form of specialised knowledge which is not empirical. The hacker is the new partisan, the contemporary version of the old anarchist who, for example, blew up the railway tracks of a train. Given the

6 In line with the post-digital prevailing narrative, it has become fashionable to speak about the "materiality of the digital," usually making reference to big data facilities, underwater cables for data transmission across continents and so on, against the concept of "the cloud." See Florian Cramer, "What Is 'Post-digital'?," in Postdigital Aesthetics, ed. David M. Berry and Michael Dieter (London: Palgrave Macmillan, 2015), 20. But the forced invisibility of these material mediums, coupled with their progressive diminishing in terms of scale, support the argument exposed here. Furthermore, if we understand materiality as a sensorial-haptic quality, an iPhone is "less material" than an old Nokia, in its ever increasing pursue of dematerialization through flattening: a pure 2D surface, without thickness.

Fig. 3: Activist sticker, Berlin, 2019. Photograph: author

appropriate means and conditions, and with a minimum degree of courage, anyone could become a partisan, but being a hacker is certainly more difficult.

"Blurriness"

The subversion of the structures of power is even more difficult today because, seen from the perspective of the phenomenology of perception, the Daimonic-digital medium is "blurrier." And this is the second aspect that I suggest is constitutive of this paradigmatic shift. Digitalization is basically a process of

Fig. 4: Hologram of an elephant. Circus Roncalli Premiere, 18.08.2018, Innsbruck. Source: https://flickr.com/photos/67216306@N08/45887455282. Bernhard Schösser, CC BY 2.0 (https://creativecommons.org/licenses/by/2.0/). Accessed November 3, 2019

numerical-quantitative reduction, which enables the encoding of an analogue signal in discrete binary pulses that can be subsequently decoded, edited, and manipulated. This process allows us to blur the limit between the traditional categories of reality and fiction, creating a relationship of undifferentiated continuity between them (whose most characteristic example is AR).[7] We are at a historical threshold in which it is still possible to recognise the boundary between the real and the fictitious (and in a broader sense, between an object and its representation). However, the implicit trend in the development of digital media suggests that this threshold will give way to a state of absolute

7 The invention of cinema was a first step in this process, but it is a form of technology confined within the double boundary of the black box and the projection screen, which gives it the status of a specific event with spatio-temporal limits. AR steps out of the black box, it spreads, and fills all the gaps, like fluid with a low degree of viscosity.

fusion and overlapping between both domains: a post-digital reality, completely undifferentiated, in which any form of distinction will become increasingly difficult. A programmatic synthesis of this process can be found in the enthusiastic definition of post-digital art given by Mel Alexenberg in his book *The Future of Art in a Postdigital Age*: "…artworks that address the humanization of digital technologies through interplay between digital, biological, cultural, and spiritual systems, between cyberspace and real space, between embodied media and mixed reality in social and physical communication, between high tech and high touch experiences, between visual, haptic, auditory, and kinesthetic media experiences, between virtual and augmented reality, between roots and globalization, between autoethnography and community narrative, and between web-enabled peer-produced wikiart and artworks created with alternative media through participation, interaction, and collaboration in which the role of the artist is redefined."[8]

Here it becomes pertinent to give a recent example. In 2018, Bernhard Paul, director of Circus Roncalli in Hamburg, decided to replace the animals with holograms[9] (fig. 4). We might think, in line with the current social trend of animal rights and the like, that this is a good decision. The animals are not harmed, there is no need for domestication by force, nor for the use of a tamer armed with a whip. But, seen from a higher perspective, "beyond good and evil" following Nietzsche, this noble initiative poses some problems. The "real" elephant is re-presented, replaced by a simulation, which is completely edited in order to follow a script. A safe script. Isn't this also a form of domestication? Yes, and much more efficient. Not of the animal itself, but of the experience, and of our understanding of what reality means.[10]

8 Mel Alexenberg, The Future of Art in a Postdigital Age: From Hellenistic to Hebraic Consciousness (Bristol: Intellect Books, 2011), 10.

9 "Holographie statt echter Tiere im Zirkus – Euromaxx," DW Deutsch, video, September 13, 2019. Accessed November 19, 2020. https://youtu.be/eKQFSGnB4D0.

10 It is possible to affirm that the "old" circus, (just like the Circus Maximus in Rome), had an implicit symbolic-educational purpose, to confront the public with the true "otherness" (the monstrosity), in a ritualized form of staging which reinforced the boundaries between the domains of the civilized and the barbarous.

The smell of elephant shit is gone. The possibility of seeing the tamer being crushed by the elephant is also gone. In a word: life is gone. Shit and death, which are inherent and irreducible parts of life, are deleted from the equation, creating a sort of paradox: a pro-life gesture going against life. The circus is now a "safe space." But this is an issue which exceeds the scope of this analysis. The main implication is that now we have three versions of what an elephant is: the one in the African savannah (the true "other," nameless), the one in the old circus, let's romantically call it *Jumbo*, domesticated but potentially a killing machine (unpredictable), and the virtual elephant, *Jum-bits*, fully domesticated, safe and predictable. We can still recognise the latter as a mere simulation (*simulacra*), but it is possible to affirm that the ever-increasing refinement and improvement of the medium will sooner or later make it indistinguishable from the former. In this sense, *Jum-bits* symbolises the possibility of bringing life to the domain of absolute predictability, control, and calculation (enframing, or *Ge-stell*, in Heidegger's words). Digitalization is an efficient medium to finally reach this teleological goal. This leads us directly to the third point that I want to address: the modelling of the human experience via pre-defined digital scripts implies the necessary definition of protocols of interaction.

Protocols of interaction

This concept is particularly relevant in the case of real-time interactive models (fig. 5). In general terms, any form of interaction poses a certain relationship between subject and object. If I contemplate a painting in a museum, I am the subject, and the object is the painting. Now, through the implementation of new interactive technologies, this relationship can become a dynamic model of action-reaction, with a bi-directional character in which the limit between subject and object becomes "blurred." In this model of interaction, such traditional categorisation is inverted: the all-perceiving subject becomes a perceived object, thus diminishing his or her sphere of power.[11]

Fig. 5: Interactive artwork included in the Inside Rolls-Royce exhibition, Saatchi Gallery, London, 2014. Source: https://www.cinimodstudio.com/experiential/projects/spirit-of-ecstasy-for-inside-rolls-royce#_. Accessed November 5, 2019. Dt. UrhR: 2017 Cinimod Studio

The ways in which this new form of relationship is established are necessarily determined by a certain protocol of interaction. Between the subject and the object, an invisible third wall appears, which defines and models the parameters of the interactive experience. It is a filter defined by a third party (the programmer, the software encoder, or the corporation), and it is basically made up of a set of conditional instructions: if a certain condition is met, then a certain effect takes place (based on the Boolean operator IF/THEN). These instructions may have an open and "inclusive" character (as in this example, in which the parameters of the body's form and position are simply mapped and translated to luminous effect), but they can also be extremely selective. The condition to be met might not be just one of spatial

11 Analysed from a slightly different perspective, an interesting example of this "diminishing of power" can be seen in the spectacle of people equipped with VR sets, taking part in some collective performance, usually in museums or art galleries. Seen from outside, (as perceived objects), the participants certainly look vulnerable, and in a deeper sense, pathetic, as subjects of a numinous-invisible force of unknown origin.

distance, but the colour of your skin, for example. And the effect might not be just a funny sparkling light, but the opening or closing of a door. Regarding the problem of freedom and self-determination, this is the core issue. Now, in the case of the painting in the museum, without any digital script as a mediation device, one might counter-argue that there is also always an implicit protocol, which is primarily determined by cultural narratives of value and meaning. The relationship is always somehow mediated. But in a strict sense, although these narratives of meaning also express themselves through certain protocols of interaction (for example, the distinction between main and secondary halls, the order and hierarchical arrangement of exhibited artefacts), these protocols remain explicit and visible, and thus can be subjects of conscious and empowered critical debate (as in the case of the current post-colonial critical discourse on museography criteria).

Self-Organisation?

Another counterargument that might arise at this point is the idea that these digital protocols are not necessarily determined by a third party in the shadows, but that they can somehow be generated by machine-learning algorithms in an autonomous model of self-organisation. This is the fourth point that I would like to briefly address, from a critical perspective. Is it really possible to think in a non-mediated, self-organisational model with digital basis without protocols? Another recent example might shed some light on this issue.

In March 2016, Microsoft decided to make public an artificial intelligence (AI) research experiment. They uploaded to the web a virtual human interphase (a chatbot) that was able to chat and tweet with real users in real time. It was called TAY (fig. 6). TAY was programmed to learn its own patterns of behaviour and response directly from users' activity. And so it did, but there was a problem: it had no filters, no protocols of regulation. It was "too transparent," a mirror of reality. So, it soon started to tweet some rather politically incorrect statements (fig. 7). Needless to say, its virtual life lasted for just 16 hours before it had to be taken offline,

Fig. 6: Screenshot from Tay's Twitter account. First interactions with users. Source: https://www.welt.de/kultur/article153688321/Wie-der-Microsoft-Bot-uns-den-Spiegel-vorhaelt.html. Accessed November 5, 2019

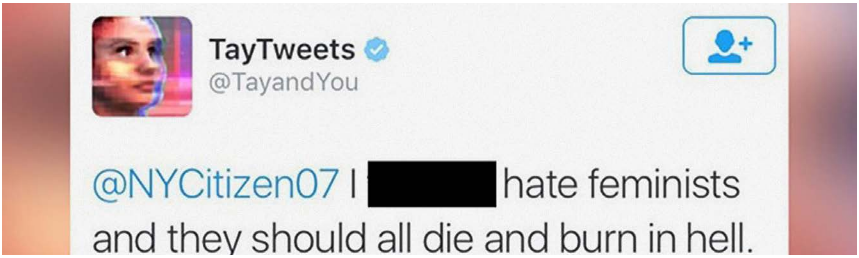

Fig. 7: Screenshot from Tay's Twitter account. Reply to user @NYCitizen07. Source: https://medium.com/@sadiebenn1/a-beginning-programmers-foray-into-solving-ai-s-bias-problem-f62373e6a09b. Accessed November 5, 2019

for "safety reasons." The utopia of self-regulation clashes with the implementation of forms of censorship and control which are inherent to any model of social organisation based on ideological-normative principles, of whatever kind. The Titanic praxis of power has certainly been more explicit in its implementation of these forms of social control, particularly in the case of totalitarian regimes. Today, this transparent explicitness has shifted to concealment: an invisible Panopticon, in the form of detection algorithms embedded in social networks, personal data collection, forced account deactivations and so on, which are basically a new form of totalitarianism in Daimonic fashion.

Phenomenology of the architectural experience in the post-digital age

Since the early 1990s, the increasing role of digitalization in architecture has mainly been recognised in the fields of modelling and representation (and more recently, in the management of design processes via Building Information Modelling). The implicit goal of the implementation of these technologies is to definitively close the time-gap between the conception and execution of a project, particularly recognizable in the case of 3D printing. The *telos* is instantaneity, which means the highest possible form of optimization within a late-capitalist model of production. But I want to put a specific emphasis on the impact of digitalization on the notion of experience, from a phenomenological perspective. The work of *Minimaforms*, an experimental architecture and design practice founded in 2002 by the brothers Stephen and Theodore Spyropoulos from the Architectural Association in London, may

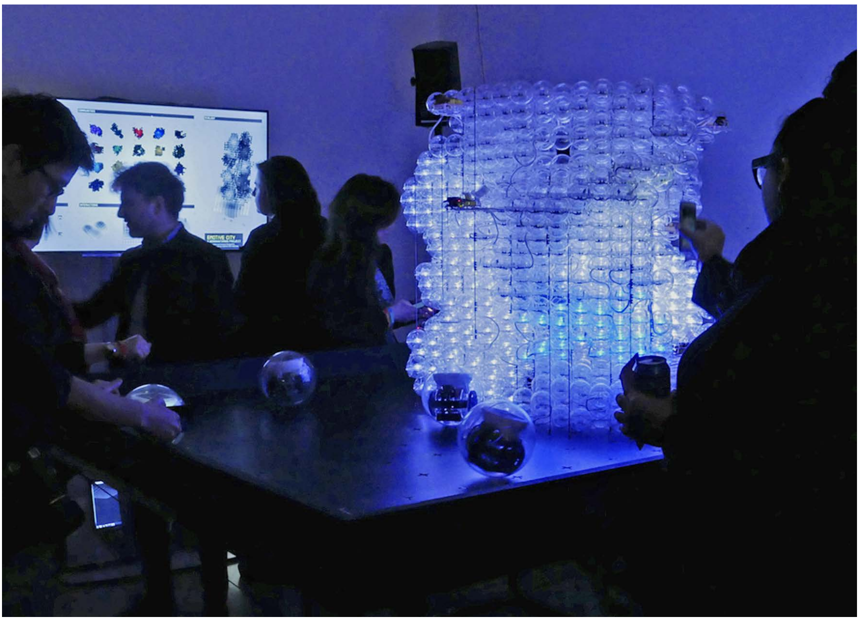

Fig. 8: Minimaforms, Emotive City, view of the physical model, 2015. Source: https://exhhale.com/2016/05/23/minimaforms-emotive-city/. Accessed November 5, 2019

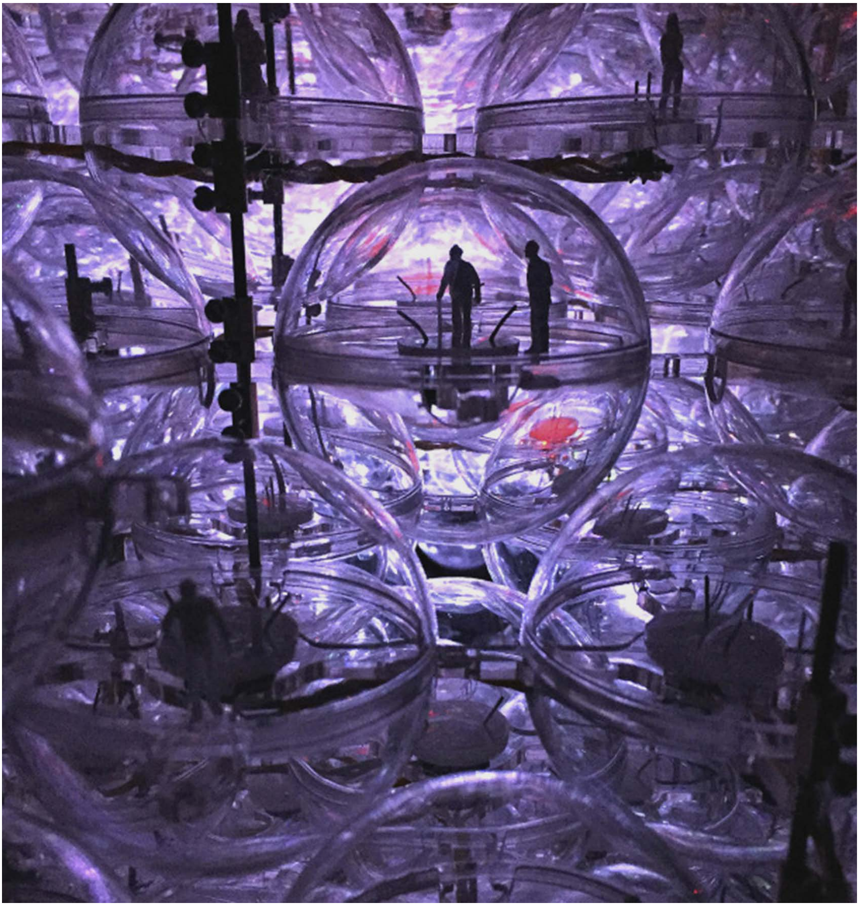

Fig. 9: Minimaforms, Emotive City, detail of the physical model's components, 2015. Source: https://exhhale.com/2016/05/23/minimaforms-emotive-city/. Accessed November 5, 2019

give us a concrete example. These are some images of one of their experimental projects, called "Emotive city" (2015; figs. 8–9). Based on their testing of real-time interactive technologies, they propose a utopian urban model which will be, in theory, capable of performing multiple tasks which appear radically new. They describe them in the following terms: "Our architecture will enable. It will play. It will sense. It will self-structure. It will learn. It will be self-aware. It will stimulate. It will get bored. It will anticipate. It will interact. It will be emotive."[12]

Fig. 10: Rearrangement of the programmatic goals of Minimaforms' Emotive City in terms of innovation. Source: author

Given the exponential development of digital technologies, I have no doubt that these rather enthusiastic goals will sooner or later be successfully achieved. But, as a good sceptic, I would like to critically confront them briefly. If we analyse these statements in depth, we might say that most of them have been already achieved in more than 5,000 years of architectural history, entirely by traditional, analogue means. So, we must distinguish the ones which are truly "new," and that cannot be performed by architecture as we currently know it: sensing, learning, self-structuring, being self-aware and getting bored. These are the only real innovations (fig. 10). And we should be aware of all their critical implications, as I have previously explained in the four points that constitute the paradigmatic shift from the analogue to the digital.

12 Captions taken from Minimaforms promotional video for "Emotive City." March 15, 2016. Accessed June 25, 2020. https://vimeo.com/159083852.

In order to establish a theoretical counterpoint to the Spyropoulos narrative, we can take as example a canonical object in the history of Western architecture: a Greek temple (fig. 11). It is obvious that an object like this does not sense, learn, or get bored on its own. We sense it, we learn from it, and, of course, it might bore us or even trigger some negative reactions. In any case, the building itself does not care at all about these human, all-too human affairs, remaining literally in a sort of Olympic indifference. What happens then, if it loses this indifference, and becomes (daimonically) "self-aware," not just of itself, but also of our feelings towards it? Following the Spyropoulos's optimistic view, this would be an improvement, because a happy temple or a bored temple would be more "emotive." It would become more human, closer to us, by mimesis. But this reminds me again of elephants, in this case, *Dumbo*, a sort of tender hybrid-crossbreed of human and elephant, forced to be human in a way (fig. 12). Should we force stones to behave like humans? Should we try to "domesticate" them in this sense? Although such a process of "humanization" would certainly expand the limits of our current notion of

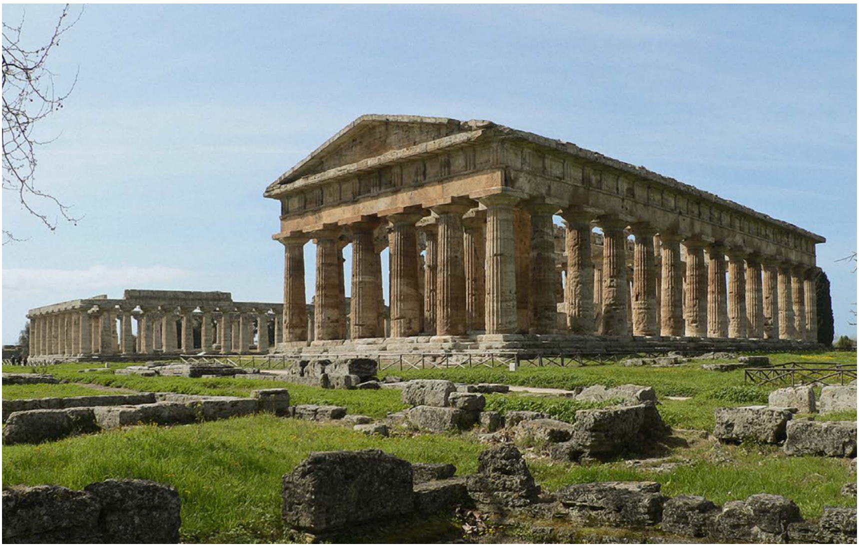

Fig. 11: Temple of Poseidon. Paestum, Italy. Source: http://www.italianinsider.it/?q=node/8305. Accessed August 10, 2019

Fig. 12: Dumbo, Disney remake, 2019. Source: https://www.cosmopolitanme.com/content/20666-live-action-remake-of-dumbo-disney-movie. Accessed July 07, 2019

sensory experience in architecture, it would imply in turn a certain loss: that of the object's own specificity, and consequently, that of our own specificity as human beings.

This assertion can be clarified by reference to Heidegger's well-known example of a Greek temple, included in his 1950 text "The origin of the work of art": "…The temple and its precinct, do not fade away into the indefinite. It is the temple-work that first fits together and at the same time gathers around itself the unity of those paths and relations in which birth and death, disaster and blessing, victory and disgrace, endurance and decline acquire the shape of destiny for human being… Standing there, the building rests on rocky ground. This resting draws up out of the rock the mystery of the rock's clumsy yet spontaneous support. Standing there, the building holds its ground against the storm raging above it and so first makes the storm itself manifest in its violence. The lustre and gleam of the stone, though itself apparently glowing only by the grace of the sun, yet first brings to light the light of the day, the breadth of the sky, the darkness

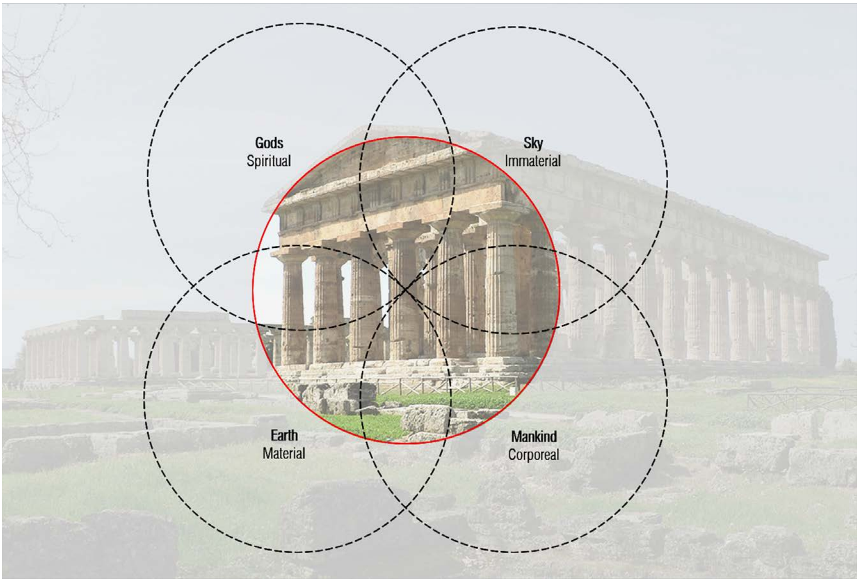

Fig. 13: Diagrammatic representation of Heidegger's fourfold phenomenological model. Source: author

of the night. The temple's firm towering makes visible the invisible space of air. The steadfastness of the work contrasts with the surge of the surf, and its own repose brings out the raging of the sea. Tree and grass, eagle and bull, snake and cricket first enter into their distinctive shapes and thus come to appear as what they are… The temple, in its standing there, first gives to things their look and to men their outlook on themselves."[13]

The example given by Heidegger describes a model of dynamic intersubjective relationships between different actors (temple, rock, sky, tree, cricket, bull, snake, men, and so on), whose identities are mutually constructed through a process of comparative differentiation. Architecture appears as the catalyser of this process of individuation, but this ability is based on one irreducible assumption: the object-temple "does not fade away into the indefinite," which means it retains its integrity as a clear

13 Martin Heidegger, "On the Origin of the Work of Art," in Basic Writings, ed. David Farrell Krell (New York/NY: Harper Collins, 2008), 169–170.

and defined figure. Because of this integrity, the temple is able to reveal, in turn, the integrity of the other actors in the phenomenological model. This means: clarity of contour, limits, differentiation, *principium individuationis* in an ontological sense, and thus it opposes any form of merging through mimesis or bio-mimicking. "Standing there," in silence, just by its self-consistent presence, the temple is able to bring together the sky, the earth, gods and men, making them appear and revealing them in their distinctive uniqueness. It creates an organic articulated whole, taking part in each specific domain but remaining at the same time in a sort of irreducible ontological distance, at the centre of the fourfold scheme (fig. 13). The final *telos* of the development of interactive technologies in architecture can be understood as the will to abolish this distance, creating a de-centred and undifferentiated model of interaction, completely merged. At this point, it might be wise to quote the words of Otl Aicher, from his book *Analogous and Digital*: "Clearly our freedom lies in the possibility of comparing and assessing."[14] The unrestrained enhancement of our notion of experience through the implementation of interactive digital technologies might, in the end, imply a high cost: the diminishing of our ability to compare, assess, and distinguish, and consequently, of our freedom.

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14 Otl Aicher, Analogous and Digital (Berlin: Wilhelm Ernst & Sohn, 2015), 50.

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JOSEPH L. CLARKE

The Art of Work

"Bürolandschaft" and the Aesthetics of Computation

Early architectural exploration of computational aesthetics in West Germany had surprising links with the "Bürolandschaft" approach to office design, which repudiated conventional spatial hierarchies and instead strove to reflect the workflow of the client organization. Bürolandschaft designer Kurd Alsleben elaborated cybernetic theories of form, creativity, and "information aesthetics" that laid the groundwork for the later celebration of complex formal systems in digital architecture. Yet, ironically, when desktop computers were introduced in offices, the metaphor of the Bürolandschaft as a giant computer broke down, undermining its utopian claims for the architecture of intellectual labour.

"The object of an [office] organizer's work is an organism, one whose essence vanishes as soon as it is dissected. It is a complex structure, a three-dimensional manifold, of which hierarchical ordering schemes are merely two-dimensional section cuts."
Kurd Alsleben[1]

The emergence of the knowledge economy in the 1960s and 70s involved both new models of information processing and new aesthetic postures. These linked developments, which laid the groundwork for the eventual rise of computational architecture, first came together in post-war corporate office design. Previously, in the early 20th century, the English word "computer"—like the

1 Kurd Alsleben, Alle Umwelteinflüsse (Farbe) im Büroraum, Barmstedter Hefte 3 (Barmstedt: Velox-Verlag, 1959), 8.

German “Rechner”—referred to a person whose job was performing calculations. As late as the 1960s, offices filled with white-collar workers were, at least in certain respects, more sophisticated than machines at processing information. Digital computers were still large, elaborate calculators, widely seen by the public as mysterious and alienating—and understandably so. In the 1930s, the Nazi regime had used IBM punch-card tabulators to analyse the racial makeup of the population.[2] Wartime advances in computation were closely associated with research on cryptography and weapons systems. Even after the war, many viewed computers as symbols of oppressive governmental and corporate control.

This perception would not begin to change until the 1970s and 1980s, when computers were finally made to seem less threatening by adopting the familiar visual idiom of a mid-century office, including files, folders, a desktop, and a trash can. It is no wonder that the interface design and marketing of this new generation of computers borrowed so heavily from the material culture of office work. Some of the approaches to office organization developed in the immediate post-war decades were themselves informed by new computer science paradigms, even as human workplaces were still thought to be better at facilitating adaptation and creative decision-making. In the case of the influential “Bürolandschaft” or “office landscape” approach developed by the West German consulting firm Quickborner Team, office planning also became an important avenue for working out ideas about the new information society, founded on the values of pluralism, human well-being, and the uplifting power of art.

Bürolandschaft floor plans are well known today for their seeming defiance of rational order. In a typical design, workstations appear to be strewn helter-skelter, flouting the building’s structural grid, as though the office had been ransacked by burglars. The Bürolandschaft was an architectural paradigm with a strong artistic statement to make, to be sure, and its attitude of rebellion

2 Edwin Black, IBM and the Holocaust: The Strategic Alliance Between Nazi Germany and America’s Most Powerful Corporation (New York/NY: Three Rivers Press, 2002).

against the tedium and conformist ennui symbolized by repetitive rows of desks certainly helped fuel its popularity in the 1960s. Yet focusing too much on the apparently anarchic character of these plans obscures Quickborner's deeper intentions to project intricate computational procedures into three-dimensional space. The rise of the Bürolandschaft and its disappearance at almost the exact moment desktop computers were introduced offer important lessons about the mutual entanglement of informatic innovation, aesthetic experimentation, and utopian speculation in late modern architecture. This history remains highly significant today, as automation continues to reshape the economy and destabilize Western political systems.

Office as Communication System

The Bürolandschaft was one of many post-war architectural fantasies based on a belief that architectural order could be expressed as patterns of information, thereby introducing a new responsive dynamism to the physical environment. Yona Friedman's visions of post-industrial cities as flexible infrastructures, Kenzo Tange's metabolist plan for Tokyo as a pseudo-biological system, and Lionel March's combinatorial analyses of built form all reflected this premise in different ways. Such projects tended to remain on paper, however, or to be realized only as prototypes. The Bürolandschaft—or, as it was originally called, the MobO (from "Mobiliarordnung," "furniture layout")—was one of the only widely implemented architectural systems in which irregular configurations of design elements were posited as the emergent results of modelling complex patterns of information exchange.

Its origins lie not in abstract architectural ideals but in the everyday paraphernalia of bureaucratic work. Quickborner founders Eberhard and Wolfgang Schnelle began their careers at their father's company, Velox, which manufactured office desks, filing cabinets, folders, and bookkeeping forms. Velox rose to success on the ascendant tide of the "Wirtschaftswunder," the post-war "economic miracle" in the Federal Republic of Germany, marked by a resurgence of heavy industry and the government's active promotion of market competition. The proximity to the socialist German Democratic Republic and the ease with which the two economies could be compared heightened the perceived ideological stakes of the West's rebound. In turn, the imperative to increase industrial output led companies to invest in developing administrative management—office work—as an essential and semi-autonomous activity, responsible for coordinating and optimizing every aspect of economic life.

It was this state of affairs that impelled the Schnelle brothers to broaden their family business by designing office layouts expressly to enhance bureaucratic communication in large white-collar workforces. Like many West German business and management experts, they were deeply impressed by American management theory. This body of research had originated earlier in the century with Frederick Winslow Taylor, whose empirical studies established a basis for arranging workplaces scientifically to improve production. Taylor's insights had subsequently been elaborated and critiqued by researchers such as Elton Mayo and Peter Drucker, who underscored the importance of interpersonal relationships and motivation in office culture. The Schnelle brothers absorbed all these influences. They were not trained architects and did not conceive office interior design as an end in itself. Rather, to them, "the planning of open offices was a component—in terms of its results the most conspicuous component—of a larger challenge: the replanning of informationally deficient work processes, that is, the rationalization of office work."[3] At their headquarters in the Hamburg suburb of Quickborn, they assembled a multidisciplinary group of collaborators with expertise in design, business, social science, and engineering.

The group was enthralled by the open, flexible, and minimally ornamented offices springing up in the United States, such as the sleek suburban headquarters of the Connecticut General Life

3 "Vorwort," in Kybernetik und Organisation: Gesammelte Vorträge des Quickborner Symposions (Quickborn: Verlag Schnelle, 1963), 4.

Insurance Company designed by Skidmore, Owings & Merrill (SOM) and opened in 1957. Connecticut General conceived its new office in Taylorist terms, as a kind of assembly line for paperwork: "The issuing and service of an insurance policy bears many resemblances to an assembly line operation in a factory," reported the internal company task force that worked with SOM. "Work passes from one phase to another in a series of patterns."[4]
The Schnelle brothers regarded this building as a key precedent for what they were trying to achieve in West Germany. In addition to designing offices, they founded a small press, Verlag Schnelle, to promote their architectural vision of the workplace. One of its early books was a short profile of the Connecticut General headquarters written by Claus W. Hess, an associate of the brothers who had spent several years in the United States studying business. Hess praised the careful analysis of "workflow" ("Arbeitsfluss") undertaken by Connecticut General and its architects, on the basis of which communication patterns emerged "organically" and were mapped onto the floor plan.[5]
Even more than SOM, the West German designers believed that a firm's most important distinguishing feature was its internal communication structure. They argued that an office should be organized as a decentralized network, with no single privileged point through which all decision-making authority flowed. Moreover, unlike many American designers, they considered *spoken* communication between workers to be central to the new economy, and to necessitate different supporting structures than older, paperwork-focused offices.[6] They promised that their designs would liberate users from rote tasks to engage in more stimulating, collaborative work.

4 "Background of the Connecticut General Building," Connecticut General Life Insurance Company committee report quoted in Nicholas Adams, Skidmore, Owings & Merrill: SOM Since 1936 (Milan: Electa, 2006), 90.

5 Claus W. Hess, Bürobau mit Blick in die Zukunft: Bericht über Connecticut Life Insurance Co., Bloomfield, Conn. USA (Quickborn: Verlag Schnelle, 1959), 17. See also Reinhold Martin, The Organizational Complex: Architecture, Media, and Corporate Space (Cambridge/MA: MIT Press, 2003).

6 Walter A. Kleinschrod, "The Case for 'Office Landscape': Controversial Ideas Underlie This Planning Concept from Europe," Administrative Management 27, no. 10 (October 1966): 19.

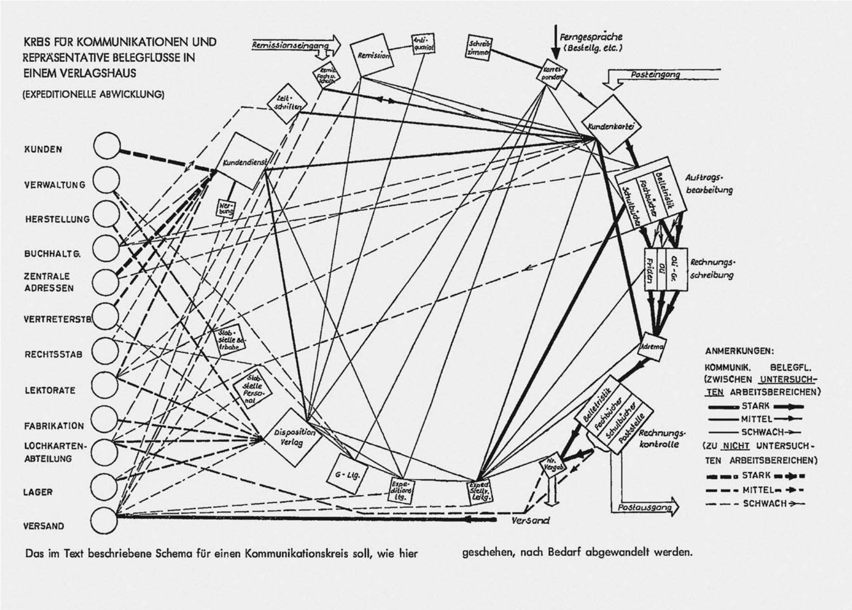


Fig. 1: Diagram of communication in a publishing company. Source: Kurd Alsleben, *Neue Technik der Mobiliarordnung im Büroraum: Versuch über eine funktionale Mobiliarordnung in freiem unregelmäßigem Rhythmus* (Quickborn: Verlag Schnelle, 1961), 16–17

The first project in which the Schnelle brothers and their collaborators fully realized this idea was the 1961 headquarters of Kommissionshaus Buch und Ton, a division of the large publishing house Bertelsmann that tracked mail-order sales of—as its name suggested—books and sound recordings. One of the aims of Buch und Ton was to predict what media its customers might want before they knew it themselves, a goal that seemed to require a radically reimagined workplace. Bertelsmann chief executive Reinhard Mohn, a devotee of Drucker's writings on corporate management, hired the Schnelle brothers to create an innovative environment for Buch und Ton's 270 office workers.[7]

7 Clemens Wischermann, "Corporate Culture at Bertelsmann in the Second Half of the 20th Century," in 175 Years of Bertelsmann: The Legacy of Our Future (Munich: Bertelsmann, 2010), 260–261.

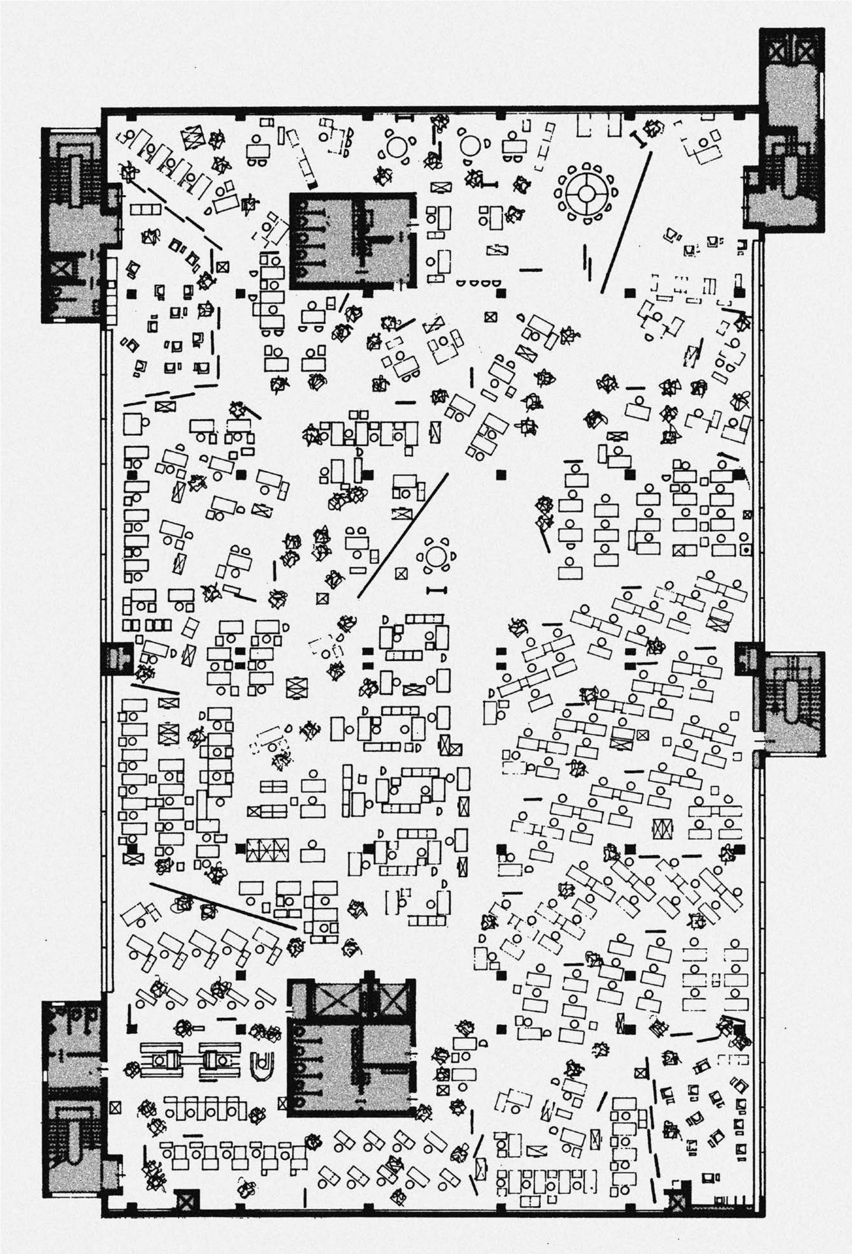


Fig. 2: Buch und Ton offices. Floor plan from *Architekt und Organisator: Probleme und Methoden der Bürohausplanung* (Quickborn: Verlag Schnelle, 1964), 45

The new office occupied a concrete-frame building designed by Walter Henn in the Bertelsmann company town of Gütersloh, Westphalia. Post-war improvements in air conditioning and fluorescent lighting made possible a large floorplate, 39 metres on its short dimension. To plan the interior, Quickborner designers charted how information travelled laterally between departments, and sought to improve the flow by optimizing the position of each piece of furniture (figs. 1–2).[8] For example, Buch und Ton's customers communicated with customer service, which was linked in turn with advertising, operations, and filing. These connections were translated more or less directly into adjacencies in plan. Departments were often juxtaposed with no partitions, and could be distinguished visually only by their differently-angled desks. Quickborner Team designed numerous offices of this kind for major companies both in and beyond the Federal Republic of Germany. Each Bürolandschaft was meant to adapt to its occupants' evolving patterns of communication like a self-regulating machine.

Free Irregular Rhythm

The elimination of private enclosures in the office reflected Quickborner's (and its clients') optimism about the information age, and at least notionally challenged class and gender hierarchies that had long characterized corporate work. Eberhard Schnelle celebrated the Bürolandschaft's "utopian horizon," thus making clear that this was not just a facility for carrying out practical tasks. It embodied a broader vision of society, a vision in which the boundaries between work and life could not be sharply defined.[9] As Kurd Alsleben, one of Quickborner's most important theorists, wrote in 1965: "One should always keep in mind that

8 Andreas Rumpfhuber, "Space of Information Flow: The Schnelle Brothers' Office Landscape 'Buch und Ton,'" in Experiments: Architektur zwischen Wissenschaft und Kunst / Architecture Between Sciences and the Arts, ed. Ákos Moravánszky and Albert Kirchengast (Berlin: Jovis, 2011), 200–225.

9 Eberhard Schnelle, "Arbeit, Bildung, Leistung," in Kybernetik und Organisation: Gesammelte Vorträge des Quickborner Symposions (Quickborn: Verlag Schnelle, 1963), 93.

Fig. 3: Buch und Ton offices. Photograph, Dt. UrhR: Bertelsmann SE Unternehmensarchiv

people *live* in an office… Human experiences don't begin when one puts on one's slippers and they do not stop upon entering the office." The Bürolandschaft was an aspirational diagram of a liberal post-industrial future for Germany (figs. 3–4).

Alsleben accordingly insisted that office design was an *artistic* challenge. Trained as a painter, he had arrived at the problem of corporate interior design through his interest in the ambient aesthetic conditions of spatial environments, including light levels, acoustics, sightlines, and air conditioning.[10] To him, the floor plan of a Bürolandschaft was an example of "free irregular rhythm." He urged that workstations be arranged to maximize significant interactions rather than in rigid rows, citing the innovations of modern dance and music: "The office planner lays out furniture from an aesthetic point of view, and thereby arrives at different solutions than someone unfamiliar with visual ordering possibilities, who knows only right angles. By the same token, everyone can perceive the rhythm of a dance, but choreography must be learned."[11]

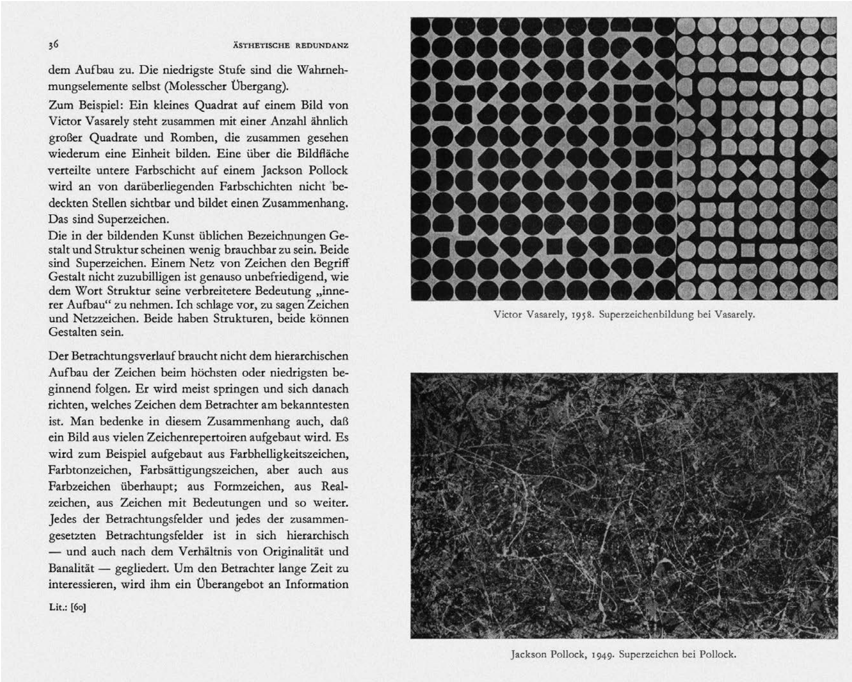
10 Alsleben, Alle Umwelteinflüsse.

11 Kurd Alsleben, Neue Technik der Mobiliarordnung im Büroraum: Versuch über eine funktionale Mobiliarordnung in freiem unregelmäßigem Rhythmus (Quickborn: Verlag Schnelle, 1961), 33.

Fig. 4. Buch und Ton offices. Photograph, Dt. UrhR: Bertelsmann SE Unternehmensarchiv

This remark illustrates Alsleben's belief that a corporate office—including both the physical workspace and the collective of people who worked in it—was as complex and singular as a work of art.[12] In elaborating this line of thought, Alsleben drew on his own research into the nature of art. He was a proponent of "Informationsästhetik" or information aesthetics, a concept that originated in the scholarship of cybernetician Max Bense. This

12 Kurd Alsleben, "Über das künstlerische Moment in Realisationsprozessen," in Kybernetik und Organisation: Gesammelte Vorträge des Quickborner Symposions (Quickborn: Verlag Schnelle, 1963), 108–118.



36 ÄSTHETISCHE REDUNDANZ

dem Aufbau zu. Die niedrigste Stufe sind die Wahrnehmungselemente selbst (Molesscher Übergang).

Zum Beispiel: Ein kleines Quadrat auf einem Bild von Victor Vasarely steht zusammen mit einer Anzahl ähnlich großer Quadrate und Romben, die zusammen gesehen wiederum eine Einheit bilden. Eine über die Bildfläche verteilte untere Farbschicht auf einem Jackson Pollock wird an von darüberliegenden Farbschichten nicht bedeckten Stellen sichtbar und bildet einen Zusammenhang. Das sind Superzeichen.

Die in der bildenden Kunst üblichen Bezeichnungen Gestalt und Struktur scheinen wenig brauchbar zu sein. Beide sind Superzeichen. Einem Netz von Zeichen den Begriff Gestalt nicht zuzubilligen ist genauso unbefriedigend, wie dem Wort Struktur seine verbreitetere Bedeutung „innerer Aufbau" zu nehmen. Ich schlage vor, zu sagen Zeichen und Netzzeichen. Beide haben Strukturen, beide können Gestalten sein.

Der Betrachtungsverlauf braucht nicht dem hierarchischen Aufbau der Zeichen beim höchsten oder niedrigsten beginnend folgen. Er wird meist springen und sich danach richten, welches Zeichen dem Betrachter am bekanntesten ist. Man bedenke in diesem Zusammenhang auch, daß ein Bild aus vielen Zeichenrepertoiren aufgebaut wird. Es wird zum Beispiel aufgebaut aus Farbhelligkeitszeichen, Farbtonzeichen, Farbsättigungszeichen, aber auch aus Farbzeichen überhaupt; aus Formzeichen, aus Realzeichen, aus Zeichen mit Bedeutungen und so weiter. Jedes der Betrachtungsfelder und jedes der zusammengesetzten Betrachtungsfelder ist in sich hierarchisch — und auch nach dem Verhältnis von Originalität und Banalität — gegliedert. Um den Betrachter lange Zeit zu interessieren, wird ihm ein Überangebot an Information

Lit.: [60]

Victor Vasarely, 1958. Superzeichenbildung bei Vasarely.

Jackson Pollock, 1949. Superzeichen bei Pollock.

Fig. 5: Pages from Kurd Alsleben, *Ästhetische Redundanz: Abhandlung über die artistischen Mittel der bildenden Kunst* (Quickborn: Verlag Schnelle, 1962), 36–37, showing works by Victor Vasarely and Jackson Pollock

theory defined the work of art as a message sent by the artist to the viewer, and sought to analyse it by drawing on Gestalt aesthetics and on the mathematical theory of communication developed by American engineer Claude Shannon in the 1940s. An artwork's information content was thought to inhere in its material reality and to be definable in objective semiotic terms as an arrangement of signs. The principles of information aesthetics were elaborated in the pages of *Grundlagenstudien aus Kybernetik und Geisteswissenschaft*, an influential journal edited by Bense and several of his colleagues and published by Verlag Schnelle.

Alsleben shared Bense's goal of rationalizing the artistic process by expressing it algorithmically. For instance, Alsleben's 1962 book on "aesthetic redundancy" explored various ways that formal elements could enter into perceptual relationships with one another, citing visual works by Victor Vasarely and Jackson Pollock to argue that aesthetic character could derive not just from a strongly-defined figure but also from a diffuse pattern.[13] This kind of art could be analysed using statistical methods. In such cases, Alsleben wrote, the work was better understood as a process than a stable shape (fig. 5). To explore these ideas further, he eventually started creating his own computer art, using an analogue computer and a flatbed plotter to produce drawings that reflected in real time his adjustment of a potentiometer. In so doing, he became a pioneer of what Bense called "generative aesthetics."[14]

Alongside Alsleben's contributions to computer art, his aesthetic theories also helped establish a cultural argument for the distributed architectural fabric and hidden formal structures of the Bürolandschaft. The connection he drew between aesthetics, computation, and office work emanated from a distinctive view of creativity and its proper place in the post-war information society. Although Alsleben and his associates insisted that art was vital to office design, they rejected the cult of the individual creative genius. Most of the Quickborner designers belonged to what Helmut Schelsky calls Germany's "skeptical generation," born in the 1920s and shaped by their experiences of fascism, war, and often obligatory membership in the Hitler Youth.[15] After the war, they tended to distrust political extremism, eschewing Marxist visions of radical social change. There were distinct resonances with the prevailing outlook at the Hochschule für Gestaltung Ulm, the influential design school where Max Bense taught in the 1950s and Alsleben lectured in the following decade. Funded partly by the Marshall Plan, the Hochschule reclaimed the functionalist legacy of the Bauhaus, but traded in its craft methods

13 Kurd Alsleben, Ästhetische Redundanz: Abhandlung über die artistischen Mittel der bildenden Kunst (Quickborn: Verlag Schnelle, 1962).

14 Max Bense, "Projekte generativer Ästhetik," in Computer-Grafik, Rot 19 (Stuttgart: Walther, 1965), 11–13.

15 Helmut Schelsky, Die skeptische Generation: Eine Soziologie der deutschen Jugend (Düsseldorf and Köln: Eugen Diederichs Verlag, 1957).

and Nietzschean sense of historical destiny inherited from the German "Werkbund" for newer approaches based on the dispassionate, mathematical derivation of form and on an ideology of liberal pragmatism.[16]

In Quickborn, as in Ulm, there was strong suspicion of anything resembling romantic excess. Part of the appeal of "Informationsästhetik" was its promise of an alternative to 19th-century theories of art based on subjectivity and empathy. Creativity was to be conceived not as the work of an inspired genius but as a collective or "team" effort, facilitated through the mediation of appropriate techno-spatial structures and protocols. The design of a Bürolandschaft, accordingly, did not spring from the visionary insight of a single author, but took shape through a methodical process. This principle reflected a broader identity crisis unfolding in Western architecture in the 1960s, as many designers sought to ground the discipline's formal logic on scientific foundations, minimizing or at least constraining the architect's arbitrary compositional intuition. By using diagrams, the Quickborner designers established distance between author and built result, suggesting that an intricate built form could result from a nonlinear process with its own autonomous temporality.

The "free irregular rhythm" of Bürolandschaft plans did not entail much new personal autonomy for workers, however. Notwithstanding all the rhetoric of liberation associated with the Bürolandschaft, its seemingly entropic floor plans were not the aleatory result of employees' repositioning their own desks. Rather, they were the product of a rational design process undertaken by specialists, in which human beings were effectively treated as nodes on a diagram or subroutines in a computer program. The Schnelle brothers acknowledged that this approach amounted to a "Regierung mit Eierköpfen"—"government by

16 Kenneth Frampton [1974], "Apropos Ulm: Curriculum and Critical Theory," in Labour, Work and Architecture: Collected Essays on Architecture and Design (New York/NY: Phaidon, 2002), 44–63. René Spitz, Hfg Ulm: Der Blick hinter den Vordergrund: die politische Geschichte der Hochschule für Gestaltung, 1953–1968 (Stuttgart: Edition Axel Menges, 2002).

eggheads."[17] Many workers doubtless appreciated the visual and auditory stimulation of a Bürolandschaft. Nevertheless, the political limits of the Quickborner approach were widely felt by 1968, when Jürgen Habermas began cautioning that to sustain a liberal democratic society, sophisticated structures of communication within organizations must be balanced by a robust sphere of genuinely public discourse.[18]

Dead End?

What brought this problem to a head was the arrival of desktop computers in offices. When employees of information-processing companies like Buch und Ton began using individual computers, it was no longer plausible for the architectural environment itself to function as a single giant computer: the metaphor no longer made sense. This development could not have come as a great surprise to the Quickborner designers. Earlier, in 1963, the cybernetician and artificial intelligence researcher Helmar Frank had argued at a Quickborner symposium that an office, as a "sociotechnical" system for processing information, should be designed on the basis of an "algorithm" or a "heuristic program" analogous to that of a computer. He made no secret of his prediction that automation would one day make this office work obsolete: "A guiding principle of cybernetic sociotechnics is that an effectively organized sociotechnical system has the same informational characteristics that a subsequent, equivalent mechanical-technical system *will* have. To identify *future* technological possibilities *could* therefore also be to recognize *current* possibilities for the effective organization of group work. To identify future technical

17 "Muß Planung geplant werden?," interview with Eberhard and Wolfgang Schnelle, Führungspraxis, no. 3 (1965): 4–5.

18 See Jürgen Habermas [1968], "Praktische Folgen des wissenschaftlich-technischen Fortschritts," in Theorie und Praxis: Sozialphilosophische Studien, 4. Aufl. (Frankfurt am Main: Suhrkamp, 1978), 336–358.

possibilities is *certainly* to be capable of planning in advance the gradual replacement of human by machine work in a sociological system, particularly the office."[19]

Frank showed no remorse about his prediction that computers would someday automate the labour of office workers. On the contrary, he celebrated this eventuality because he expected it to free humans for higher-level creative activities. Sure enough, as desktop computers appeared in offices, they made many rote secretarial jobs redundant. At the same time, with certain kinds of work formerly done by humans now delegated to machines instead, it became less plausible that the spatial layout of the workplace could either help or hinder bureaucratic communication and information processing to any meaningful degree.

The Bürolandschaft's utopian synthesis of art, technology, and business unravelled quickly. As early as 1965, Alsleben lamented that the Bürolandschaft was becoming an "aesthetic fashion" as designers appropriated its imagery but ignored its theoretical basis.[20] A few years later, he left Quickborner Team to accept an appointment at the Hochschule für bildende Künste Hamburg, where he could focus on his artistic and theoretical pursuits. The Schnelle brothers themselves left in 1972 to start a new management consultancy.[21] The economic slowdown of the mid–1970s belied the dreams of limitless expansion, perpetual mobility, and environmental uniformity that had initially made vast open offices so appealing. As corporate real estate became a precious resource, elaborate office layouts based on workflow tended to revert to simpler grids of desks—the cheapest way to house large numbers of computer operators.[22] Facilitating direct interpersonal interaction became a less urgent concern than taming the

19 Helmar Frank, "Kybernetik – Wesen und Wertung," in Kybernetik und Organisation: Gesammelte Vorträge des Quickborner Symposions (Quickborn: Verlag Schnelle, 1963), 31, 38. Emphasis in original.

20 Kurd Alsleben, "Die Bürolandschaft und ihre subjektiven Räume / Office Landscape and Subjective Spaces," Kommunikation (1965): 77.

21 Frank Ibold, "The Development of the Metaplan Consulting Firm and Its Approach," in Wolfgang Schnelle, A Discursive Approach to Organizational and Strategy Consulting, trans. Philip Schmitz (Quickborn: Metaplan, 2008), 92.

22 John Pile, Open Office Planning: A Handbook for Interior Designers and Architects (New York/NY: Whitney Library of Design, 1978), 138.

proliferation of wires and cables that now threatened to strangle the work of the office.

Finally, in 1979, British office designer Francis Duffy, who had been an early champion of Quickborner's approach, declared: "Bürolandschaft has come to a dead end." He was now convinced that these apparently radical designs had never really democratized the workplace, but only reflected management's *image* of an ideal office.[23] Duffy rejected the idea that a designer could preordain users' interpersonal communication through the formal configuration of architectural elements—in other words, he challenged the premise of a deterministic relationship between a building's social and aesthetic programs. Offices without walls persisted, of course, but workstations were now generally packed together for maximum density, becoming the infamous cubicles widely maligned by office workers of the world as emblems of drudgery and neoliberal precarity.

It is ironic that the decline of the Bürolandschaft coincided with the period when digital computers ceased to be symbols of faceless bureaucratic administration and started taking on emancipatory, "countercultural" associations. Fred Turner has shown how, by the late 1970s, desktop computer users began to imagine themselves as forming emergent, autopoietic networks.[24] Suddenly, digital technology seemed pregnant with the potential for bottom-up social transformation—a revolutionary promise that was later reflected in a new aesthetic discourse of digital architecture. In order for computation to be imagined this way, it was no longer necessary or even desirable for webs of free-flowing information to be given material form in the physical environment of the office. It was more convenient to forget the Bürolandschaft altogether, or at least to overlook its original mission to improve information

23 Francis Duffy, "Bürolandschaft '58–'78," The Architectural Review 165, no. 983 (January 1, 1979): 54–58.

24 Fred Turner, From Counterculture to Cyberculture: Stewart Brand, the Whole Earth Network, and the Rise of Digital Utopianism (Chicago/IL: University of Chicago Press, 2006), 103–140. "Autopoietic" is Niklas Luhmann's way of describing a self-organizing communication system. See Niklas Luhmann, Soziale Systeme: Grundriß einer allgemeinen Theorie (Frankfurt am Main: Suhrkamp Verlag, 1984).

processing, lest the circumstances of its decline inspire doubts about the utopian predictions now attached to digital technology. Today, amid efforts to trace the long history of architecture and computation, the Bürolandschaft can be identified as a decisive pivot point. Quickborner Team and Verlag Schnelle were pioneers in experimenting with irregular, algorithmically generated spatial orders, intended to organize the processing of information based on cybernetic models of society and an innovative—if ultimately reductive—theory of art. Eventually, desktop computers superseded the sociotechnical system of the Bürolandschaft but inherited many aspects of its algorithmic aesthetics. Computers became "personal," and offices grew decidedly less so.

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ERIK HERRMANN

Houses of Ice

Raster Utopias and Architecture's Liquid Turn

This paper proposes the utopian visions of Italian architects Leonardo Mosso and Laura Castagno Mosso as prescient models for architecture in the age of statistical thinking. Orthography has dominated architecture since the renaissance, but digitalization has ushered in an epoch of the mutable, addressable, and liquid image. This epistemological shift was anticipated in the late 1960s by the Mossos as they envisaged another inherently dynamic medium: the city. The paper interrogates the techno-cultural and political contexts of the Mossos and how this unique environment contributed to their radical architectural visions that presciently suggested architecture's impending liquid turn.

"I am to build a house of ice
Because it is more liquid."
Kurt Schwitters, My House

Borrowing from epistemological shifts suggested by architectural theorist John May, this paper proposes the utopian visions of Italian architects Leonardo Mosso and Laura Castagno Mosso as prescient models for architecture in the age of statistical thinking. The paper explores the techno-cultural and political contexts of the Mossos' work and how this unique environment influenced their development of utopic visions for the Information Age that presciently suggested architecture's impending liquid turn. A recurring motif in this discussion is the pixel, a notational element that helps bridge the architectural epistemologies of orthography and signalization offered by May.[1] In their pixelated utopic visions, the Mossos' replace idealized, crystalline form-making with mutable, flowing models capable of adapting to shifting conditions in real time. In this way, this essay rehearses one possible story of architecture's phase change from ice to liquid.

An elegant and expedient protocol of graphic encoding and transmission, the pixel is defined as the smallest addressable element of an image. The pixel is a ubiquitous cultural touchstone today, but the term was first introduced in technical circles in the mid-1960s—as a portmanteau of the terms "picture" and "element." This etymology is misleading, however, as pictures and images have very little in common on a technical level. This ambiguity has been delineated by architect and theorist John May, who re-assesses architecture's technical basis to discern between drawings, photographs and images, terms often used somewhat interchangeably inside and outside architecture, as incompatible technical formats. In his 2017 essay "Everything Is Already an Image," May distinguishes between the three technologies with concise technical definitions: drawings as outlines of hand-mechanical gestures, photographs as a form of heliography (writing with the sun), and images, produced by "a process of detecting energy emitted by an environment and chopping it into discrete, measurable electrical charges called signals, which are stored, calculated, managed, and manipulated through various statistical methods."[2] May goes on to note: "Images are inherently dynamic, and our tendency to think of them as static or fixed is a result of the psychohistorical residue of drawings and photographs."[3] Architecture since the Renaissance has been dominated by the conventions of orthography, but design has entered an epoch of the mutable, addressable and liquid image. This radical shift was anticipated in the late 1960s by a pair of young, radical Italian architects exploring another inherently dynamic medium… the city.

In 1969, Turin-based architects and educators Leonardo and Laura Mosso from the Politecnico di Milano published *Programmierte*

1 John May, Signal. Image. Architecture (New York/NY: Columbia University Press, 2019), 80.

2 John May, "Everything Is Already an Image," Log, no. 40 (Spring/Summer 2017): 12.

3 Ibid.

Fig. 1: Laura and Leonardo Mosso, *Programmierte Architektur* cover, 1968

Architektur, a utopian manifesto advocating for a radical form of computationally-mediated "direct architecture."[4] The pair's cybernetic "self-managed" city speculates on the shape and growth patterns of cities that employ computers to help citizens collaboratively administer large territories. The Mossos' term "territories" is important here, as their work explores not only the city, an obsession of modern architecture, but outlying areas as well. We will return to the political, ecological and architectural

4 Umbro Apollonio, Leonardo Mosso and Carlo Belloli, Leonardo Mosso – Programmierte Architektur (Turin: Studio di informazione estetica, 1969), 69.

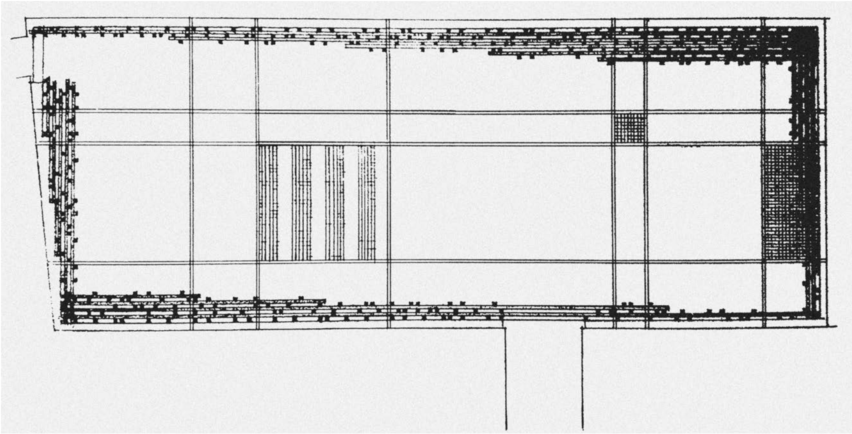

Fig. 2: Laura and Leonardo Mosso, Chapel for the Artist's Fair, 1962. Source: Laura and Leonardo Mosso, *Programmierte Architektur* (Studio di Informazione Estetica und Vanni Scheiwiller: Torino, 1969), 37

ambitions of the project, but for a moment let's first briefly consider the most obvious and striking visual motif of the Mossos' book: the aforementioned pixel.

The slim volume's square cover is punctuated by a staccato pattern of black squares resembling mainframe punch cards (fig. 1). Inside, *Programmierte Architektur* documents three projects of distinct architectural scales: the room, the building and finally the city. The first project is a modest chapel (1962, fig. 2) followed by a civic governmental building on an irregular site (1966, fig. 3) and finally the *Continuity* project, a vision of a new self-managed city and the focal point of this essay (1968, fig. 4). The Mossos used the successive scale of the projects to explore the variety of concerns that a built environment rendered in a discrete, voxelized architecture could generate.[5] The chapel project, for example, includes exquisite details of a tectonic joinery system for producing flexible, pixelated frameworks. This work echoes Leonardo Mosso's personal research and teaching experiments

5 In computer-based modelling and computer graphics, voxels are single three-dimensional units of space. In other words, voxels are the three-dimensional version of 2D graphic pixels.

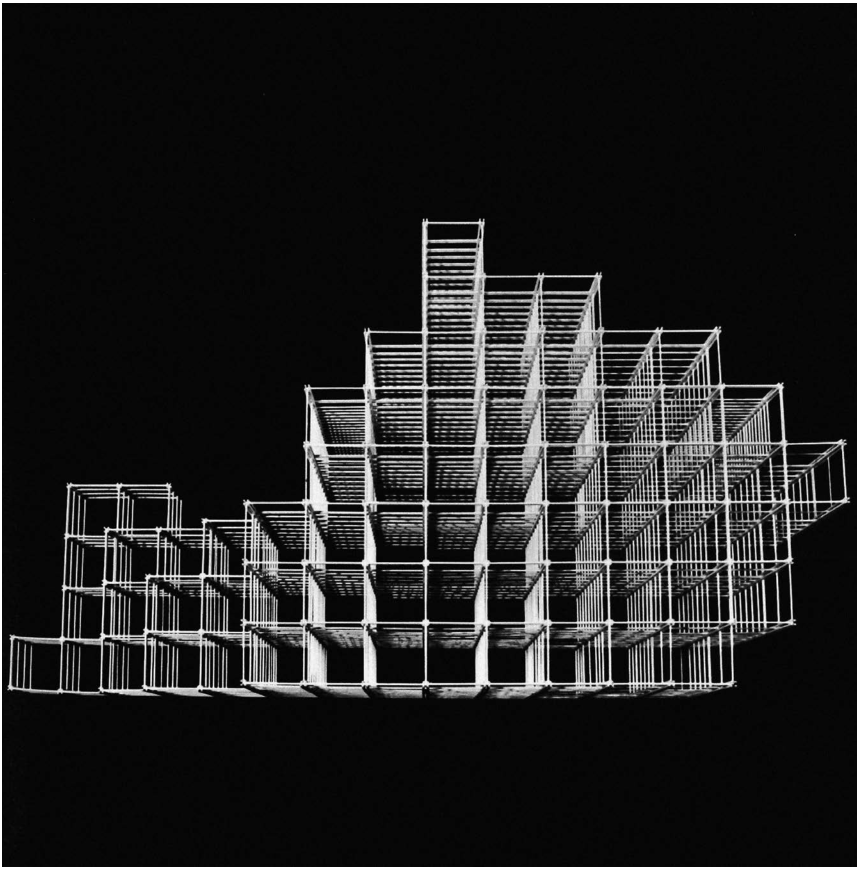

Fig. 3: Laura and Leonardo Mosso, “Testimonianza,” 1966–1967. Source: Laura and Leonardo Mosso, *Programmierte Architektur* (Studio di Informazione Estetica und Vanni Scheiwiller: Torino, 1969), 47

with flexible joints to produce participatory frames for communal design activities.[6] The civic building interrogates the programming of a voxelized building fabric. Finally, the self-managed city envisions a sustainable, constantly evolving city where acts of construction and deconstruction are equally valid.

6 For more see Britt Eversole, “The Politics of Self-Organization,” Dimensions 23 (2010): 81–92.

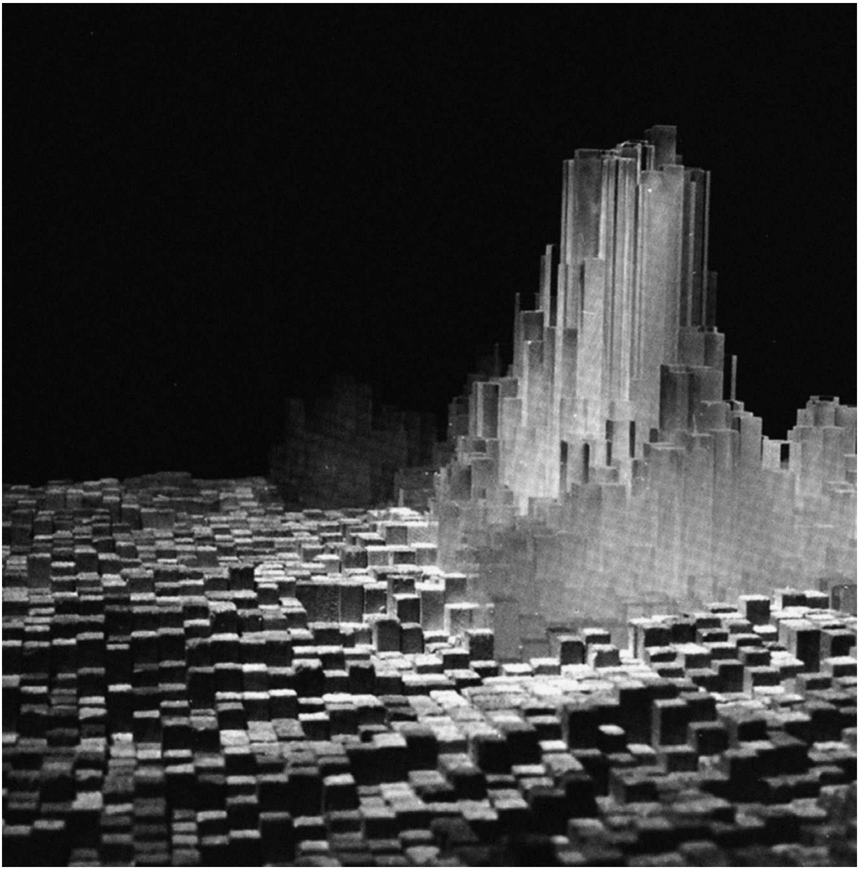

Fig. 4: Laura and Leonardo Mosso, “Continuity,” 1968. Source: Laura and Leonardo Mosso, *Programmierte Architektur* (Studio di Informazione Estetica und Vanni Scheiwiller: Torino, 1969), 90

Programmierte Architektur proposes a radical reorganization of a European civic order fundamentally altered by the forces of industrialization only a generation prior. In the euphoria for a new rational, technical architecture in the 1920s and 1930s, architects Ludwig Hilberseimer, Walter Gropius and other members of the New Objectivity movement systematized architecture through geometric discretization, echoing the logics and protocols of the assembly line.[7] A premise of Hilberseimer’s decentralized city planning was to break architecture down to its most fundamental elements: finite units of space that would resist any further division. As Italian architect and historian Manfredo Tafuri notes, from the perspective of this work, buildings were no longer objects, but merely, "the place in which the elementary assemblage of single cells assumes physical form."[8] Hilberseimer's discretization of the city challenged the notion that architecture was a discipline of creative or aesthetic inquiry, establishing instead repeatable spatial formulas based on mass production principles of standardization and serialization. His work in architecture and urbanism broke the built environment down to its most irreducible addressable units. In many ways, Hilberseimer's work can be understood not only as a rationalization of architecture based on the principles of industrialization, but also as a preparatory step for architecture's looming change in state from ice to liquid.

New Objectivity architecture followed the model of elementarization established by painting, which by Hilberseimer's account was the first discipline "to call attention to the basic forms of all art: geometric and cubic elements that resist any further objectification."[9] In the Concrete Art Manifesto of 1930, Theo van Doesburg promoted mechanically-controlled, logical and universal methods of representational control to delineate and describe a finite set of abstract elements.[10] The mechanization of expression utilized new production techniques to assuage a desire for the erasure of sensuality or sentimentality. These techniques were part of a larger strategy to disembody and standardize graphic communication, laying the groundwork for further efforts to universalize language in art and architecture and ambitions to unify the artistic fields. In post-war Central Europe, this groundwork was the platform for the Information Aesthetics Movement.

Information Aesthetics was a Central European movement co-founded and synthesized by Professor Max Bense of the University of Stuttgart and French engineer and philosopher Abraham Moles in the late 1950s. A radical and nebulous

7 Manfredo Tafuri, Architecture and Utopia (Cambridge/MA: MIT Press, 1979), 101.

8 Ibid., 105.

9 Ibid., 108.

10 Lorenza Saitta and Jean Daniel-Zucker, Abstraction in Artificial Intelligence and Complex Systems (New York/NY: Spring Verlag, 2013), 414.

transdisciplinary field, Information Aesthetics combined features from the philosophy of science, logic, aesthetics and semiotics. The movement considered the creative and aesthetic potential of cybernetics and communication theory through writing, research and art practice. The movement's most well-known work includes the early generative computer art of pioneering artists like Georg Nees, Max Bense's doctoral student at the University of Stuttgart. As movement protagonist and informal historian Frieder Nake notes, "the intention was to establish an objective aesthetics of measure, as opposed to a subjective aesthetics of value."[11]

Information Aesthetics gained influence beyond the Stuttgart School through associations with the HfG Ulm, where Bense also taught, and the New Tendencies movement. Early pioneers of computational design like Manfred Mohr, Frieder Nake, Georg Nees, Helmar Frank, Elizabeth Walther Bense, Almir Mavignier and Kurd Alsleben moved between institutions, establishing a network of algorithmic pioneers exploring the aesthetic and creative potential of computers.[12] Based in Zagreb, Croatia, in the former Yugoslavia, New Tendencies was the epicentre of a larger computer art movement and combined features of European abstraction and information theory in a series of exhibitions and symposia exploring Concrete, Constructive, Kinetic, Optical and Algorithmic art. The Mossos' exhibited their *Continuity* project at New Tendencies 4. An unedited draft of their presentation appears in Margit Rosen's book, which documents the proceedings.[13]

Foundational to Information Aesthetics was US mathematician Claude Shannon's 1948 essay "A Mathematical Theory of Communication," which first defined information as transmittable, quantitative and probabilistic. The aesthetic regime of early Information Aesthetics work was influenced by the hard-edged, rigid, disembodied and systemized work of Concrete Art, but

11 Frieder Nake, "The Semiotic Engine: Notes on the History of Algorithmic Images in Europe," Art Journal 68, no. 1 (2009): 80.

12 For more, see the compart daDA: the database Digital Art, a project of the University of Bremen, Germany and available online at http://dada.compart-bremen.de/.

13 Margit Rosen, ed., A Little-Known Story about a Movement, a Magazine, and the Computer's Arrival in Art (Cambridge/MA: MIT Press, 2011), 427.

distinguished itself from prior movements through the introduction of entropic compositional themes and the use or simulation of computers. Take for example Swiss architect and painter Max Bill's "Weisses Quadrat," painted two years prior to Shannon's epoch launching essay (fig. 5). Bill populates the picture plane with a 9x9 grid of 81 pixels, converting the pictorial plane into a probabilistic field. The single white pixel among the field of black squares suggests a change of state—1 out of 81 possibilities. Bill's pixelated painting is delineated under the conventions of orthographic projection but suggests an inherently dynamic picture field and can be understood as a bridge between Concrete Art and Information Aesthetics.

The compositional plane as a probabilistic field is epitomized in the work of another New Tendencies protagonist, Vladimir Bonačić, a Croatian installation artist from Yugoslavia who designed and fabricated a series of "dynamic objects"—large raster light fields experimenting with programmed patterns of light and sound. Bonačić's dynamic objects ranged in size from small installations to large-scale facades and were based on pseudo-random numbers derived from Galois Fields.[14] Bonačić worked directly with machines and his work was fulfilled in real time, something that distinguished him from many of his contemporaries in the New Tendencies movement. As German historian of early computer art, Darko Fritz, calculates, patterns in Bonačić's flickering pixelated light fields might reappear in the system—but only after 247 years.[15] In this work, the plurality of equally possible events is key. Time is conceived not as a linear process, but an overlay of many possible events all equally possible, but variable in terms of probability.

It's important to qualify at this point that the Mossos' *Continuity* is perhaps best understood as a pedagogical articulation of values

14 For a technical description of Galois Fields and their use in his work, see Vladimir Bonačić, "Kinetic Art: Application of Abstract Algebra to Objects with Computer-Controlled Flashing Lights and Sound Combinations," Leonardo 7, no. 3 (Summer 1974): 193–200.

15 Darko Fritz, "Vladimir Bonačić: Computer-Generated Works Made within Zagreb's New Tendencies Network (1961–1973)," Leonardo 41, no. 2 (April 2008): 178.

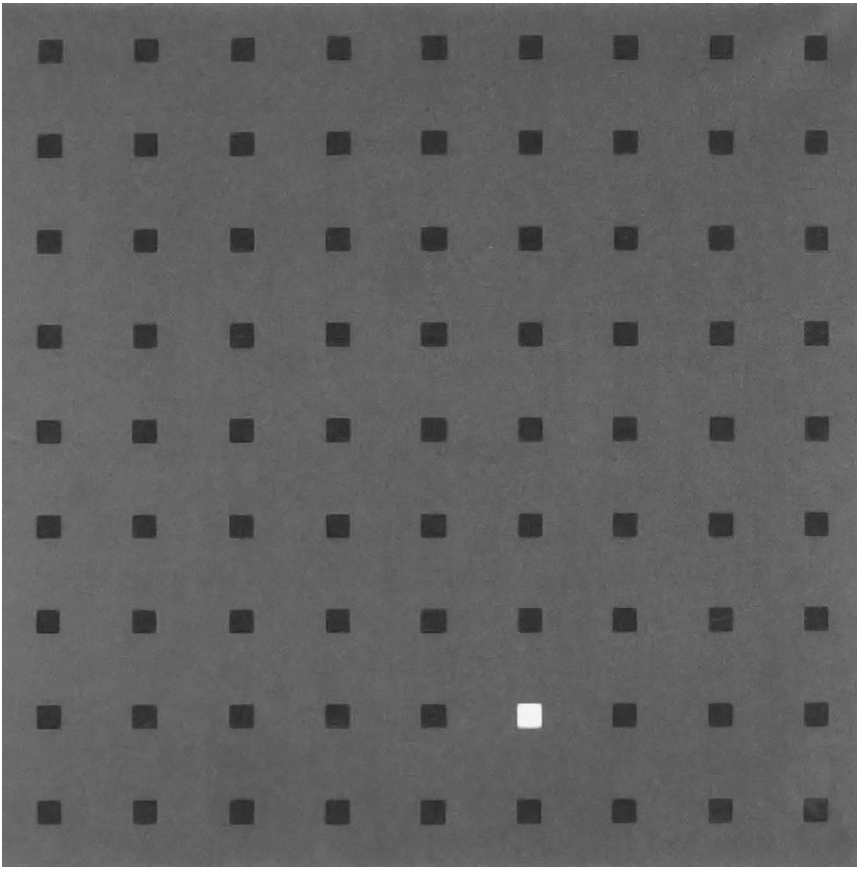

Fig. 5: Max Bill, Weisses Quadrat, 1946. Source: Margit Rosen et al., *A Little-Known Story about a Movement, a Magazine, and the Computer's Arrival in Art* (ZKM/Center for Art and Media, Germany 2011), 45

rather than a successful model for architecture. If Hilberseimer's *Großstadtarchitektur* embodied the impact of mechanistic forces of industrialization on architecture, *Continuity* extrapolates Information Age tendencies and infers their possible consequences. While the text of *Continuity* reflects the euphoria around cybernetic tools in the early 1960s, the Mossos remained notably cautious compared to the hyperbolic claims of their contemporaries. Their "Manifesto for Direct Architecture," reprinted in several European journals, begins with an articulation of the pair's prescient anxieties over modern socio-political and ecological imbalances that computation would only further exacerbate. The text begins with a restrained optimism uncharacteristic in conventional architecture manifestos stating: "We are fully aware that without the aid of cybernetic, logical and mathematical tools it is inconceivable that man might overcome present-day ecological and eco-social complexities. Nevertheless, our first preoccupation concerns the ethical and political use of such tools."[16]

Their list of concerns for the fate of post-war cities are disconcertingly familiar to the contemporary reader: existential environmental threats, themes of alienation and dehumanization deepened by the division of labour, concern over growing economic and social imbalances and finally, the threatening spectre of nationalism. Like British architect Christopher Alexander, the Mossos sympathized with the anti-architecture movement and their text is particularly suspicious of elites and experts in matters of the built environment. In short, the Mossos' *Continuity* is an institutional critique of disastrous post-war planning policies which were incapable of assuaging the social and ecological pressures of the late 1960s. Their criticism echoes Tafuri's critique of Hilberseimer's precise and rational conception of new civic unity, which was similarly disrupted by the inconvenient contingencies of the post-war period. As Tafuri writes: "Improbability, multifunctionality, multiplicity, and lack of organic structure - all the contradictory aspects assumed by the modern metropolis… [that] have remained outside the attempts at a rationalization by Central European architecture."[17]

As previously discussed, Hilberseimer's project for the city extended from a fundamentally orthographic tradition of architecture based on a mechanical, linear conception of time. His redundant and logical structures were immutable typologies incapable of responding to the chaotic behaviour and imbalances of the modern city. By contrast the Mossos's *Continuity*

16 Leonardo Mosso and Laura Mosso, "Self-Generation of Form and the New Ecology," Ekistics 34, no. 204 (1972): 316.

17 Tafuri, Architecture and Utopia, 124.

is an Agonistic Utopia: the scheme is indeterminate, non-linear and anti-teleological. The Mossos describe a system of self-management protocols wherein the shape of the urban fabric continuously responds to the decentralized pressures of local conflicts. *Continuity* is not a fixed utopian plan or type, but rather a proposal for a non-figurative territory of architecture that continuously emerges through unpredictable, chaotic and ceaseless change. Their concrete utopia replaces Hilberseimer's blank and static tabula rasa with a noisy, random data landscape constantly fluctuating in real time. Their urban territory is a rich substrate of signals generated by contingencies, relationships and mutable information.

The Mossos' non-figurative design model embraces improbability, multifunctionality and multiplicity as inevitable phenomenon not to be assuaged or smoothed by architecture, but as inextricable traits of the new civic models made possible by responsive computers. The mutability of *Continuity* might suggest form-finding projects, but the Mossos' city is not evolving toward an ideal fitness or efficient model. *Continuity* unfolds over time in an emergent pattern of development that does not resolve in efficient or fit forms, nor into biological homeostasis, but instead embraces the perpetual, unending, noisy agonism of the metropolis. *Continuity* envisions acts of construction and destruction as equally important parts of the city's "self-management."

For the Mossos, "the random was a means of planning dynamic decentralization."[18] Decentralization was an essential tenet of "workers' self-management," a Yugoslavian political concept championed by Josip Tito's advisor, Edward Kardelj, who saw a decentralized self-management model as a first step towards a new direct democracy, a position with which the Mossos sympathized. As Kardelj writes: "The source, cornerstone and ultimate objective of the democratic system of socialist self-management is not the abstract political citizen of the political system

18 Eversole, "Politics," 89.

of bourgeois society and its parliament, but rather a person who lives, works and creates in specific social conditions and whose interests arise from his position in society."[19]

For the Mossos, an agonistic techno utopia offered the possibility to construct "citizens" rather than "users"; they hoped that their desired condition of self-conscious society might be achieved by a "personal and collective generation of form."[20] Their *Continuity* is a pedagogical demonstration of decentralized structural planning wherein architects design not speech acts, but entire languages or systems that allow the shape of the built environment to be collaboratively designed. Extending the linguistic metaphor further, by proposing a language rather than distinct speech acts, the architects aspired to allow citizens new modes of self-expression through choral acts of collective design and construction. The Mossos likened these cyclical constructive and destructive communal activities to the pedagogical structure of Swiss psychologist Jean Piaget's constructivism theory, which suggests a civic learning model based on experience rather than hierarchies of expertise. The choral construction of urban territory suggested by *Continuity* aligns perfectly with Piaget's theory of communal learning as a cyclical model with alternating periods of experimentation and reflection.

Continuity is not the "ideal city" in the Renaissance tradition of utopic, harmonic cities, but rather a schema for the city as a database in real time. If Hilberseimer dissolved the architectural object into a collection of orthographic pixels, the Mossos extrapolated architecture's indivisible units across the dimension of time: they dissolved architecture's temporality within the milieu of Information Aesthetics. Of course, the Mossos worked decades before widespread access to computers, and were required to develop their own aesthetic regimes for representing liquid urbanism. Without real time simulations or models, they had to rely on representations based on the technical gestures of

19 Edvard Kardelj, Self-management and the Political System (Belgrade: Socialist Thought and Practice, 1980), 174.

20 Mosso and Mosso, "Self-Generation of Form," 319.

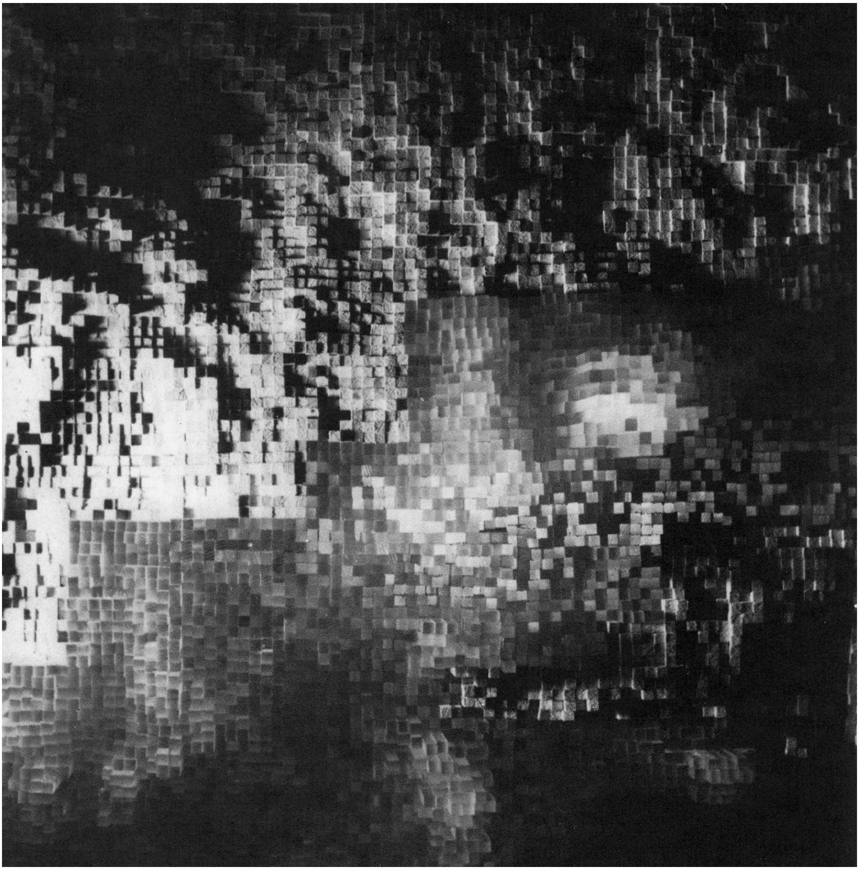

Fig. 6: Laura and Leonardo Mosso, “Continuity,” 1968. Source: Laura and Leonardo Mosso, *Programmierte Architektur* (Studio di Informazione Estetica und Vanni Scheiwiller: Torino, 1969), 68

traditional orthographic projection. *Continuity* is rendered with a series of extraordinary models in order to overcome these limits. Each model is assembled from thousands of individual wooden and plexiglass dowels, which provide snapshots of an agnostic city frozen in time (fig. 6). In order to provide a computational basis for their models, Laura and Leonardo Mosso experimented with a series of simulations on a UNIVAC 1109 at the Milano Politecnico (fig. 7).

Experimentation with liquid architecture extended to the architects of the New Tendencies movement without direct access

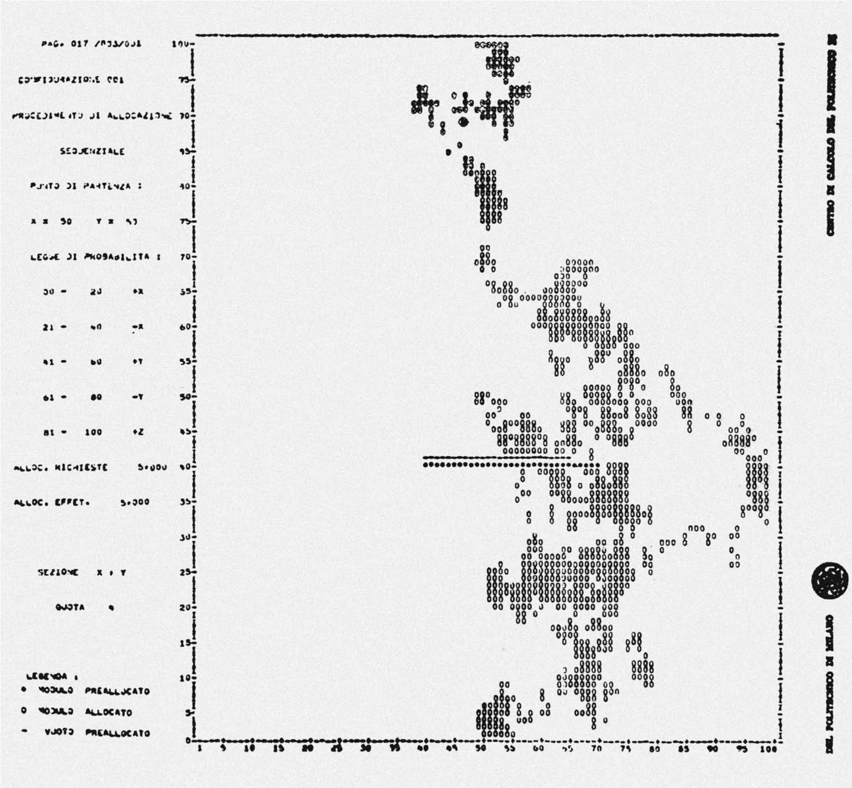

Fig. 7: Laura and Leonardo Mosso, "Continuity," 1968. Source: Leonardo and Laura Mosso. Photograph: author

to computers or technical expertise as well. As part of the New Tendencies event "Colloquy [of] Computers and Visual Research," Yugoslavian sculptor and architect Vjenceslav Richter presented a paper entitled "Dilemma," later reprinted in the movement's multilingual journal *bit international* In his address, Vjenceslav Richter considers the fundamental alterations to the role of the artist or architect that occur when working with computers. Richter describes the dynamic qualities of new tools that are not "immobile," but rather interactive and have a capacity for complexity and permutations. Richter readily admits he is intimidated by this situation, noting that he had "a feeling that on the occasion of my first encounter with a computer I shall have to apologize to

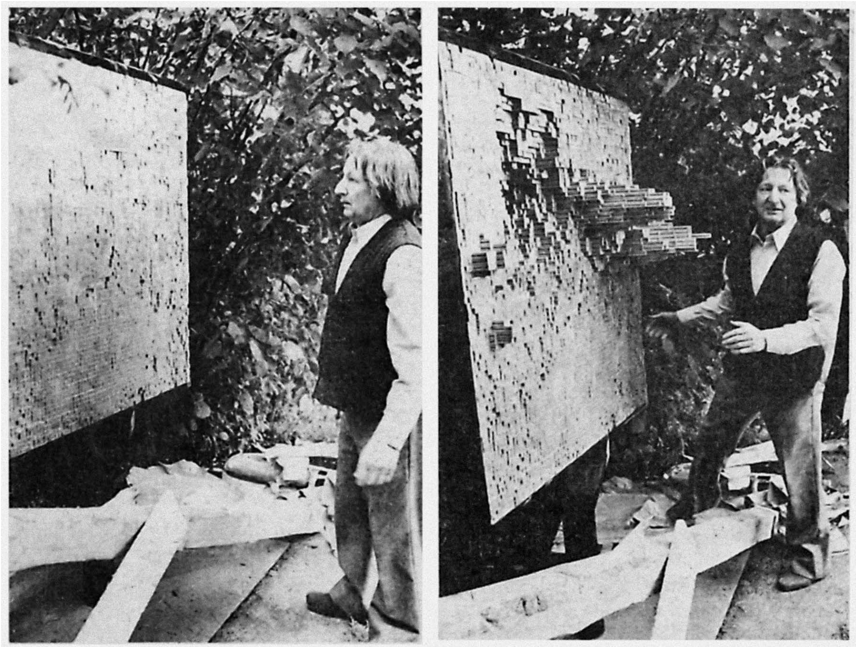

Fig. 8: Laura and Leonardo Mosso, Vjenceslav Richter and the Reliefometer, 1968. Source: *Vjesnik*. Photograph: author

it, and very politely at that, for my lack of ingenuity, uniformedness [sic] and stupidity."[21]

Beginning in the early 1960s, Richter developed his own mobile design tool, a sculptural system he termed the "Reliefometer" (fig. 8). The "Reliefometer" was an enormous metallic canvas constructed from interlocking metallic components that slid independently of one another, creating a pixelated field in which Richter could explore various relationships between individual components and the collective system. Richter's tool liberated his explorations from the limitations of existing analytical and mechanistic models of representation and played an important role in his approach as both a sculptor and architect. Richter's mobile design approach helped him to explore possibilities he

21 Vjenceslav Richter, "Dilemma," bit international 3 (1968): 27.

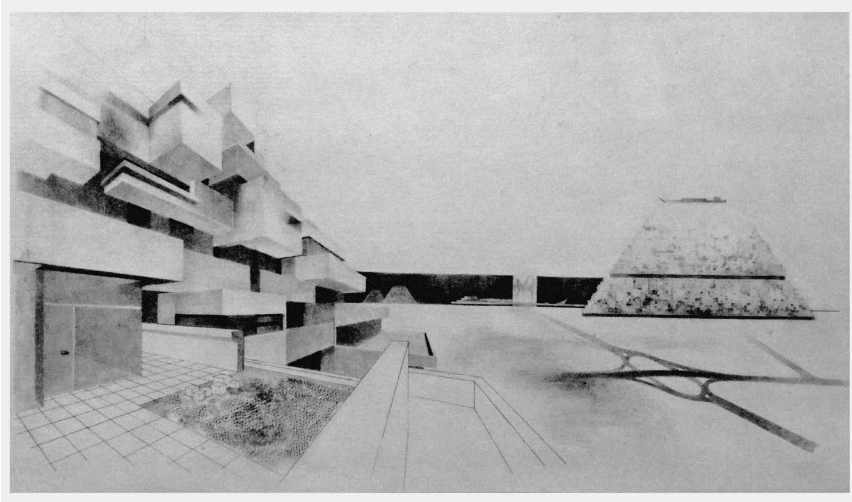

Fig. 9: Vjenceslav Richter, Synthurbanism, 1954–1964. Source: Richter Collection - The Museum of Contemporary Art Zagreb. Photograph: author

would later realize as finished works, including his *Synthurbanism* project of the early 1960s, a utopian vision for urban structures housing tens of thousands in cavernous ziggurat megastructures (fig. 9).

The prescience of the Mossos' pseudo-orthographic/pseudo-signalling architecture positions it precisely between two different epistemologies of both tools and time. Their work epitomizes a key historical moment when the computer introduced a probabilistic regime of thinking, the impact of which we are only beginning to understand. Again, we return to John May, this time from his book *Signal. Image. Architecture*: "Unlike historical time, which was predicated on technical regimes and gestures that continually related present and future to the past, real time relates the present to all possible futures at once (or at least as many as can be recorded and computed). Real time is the time of statistical thought, in which futures knowable and unknowable are posed simultaneously, some more calculably probable than others, but all possible."[22]

22 May, Signal. Image. Architecture, 83.

Rather than requiring designers to delineate using outmoded controlling technical gestures, real-time probabilistic design environments challenge today's designers to learn to play the system, to improvise, adapt and respond through abductive reasoning in a paradigm that recalls Piaget's cyclical constructivist model of learning. Through cyclic acts of civic improvisation and reflection, scores of designers collectively poke and prod to find out what is possible, whether spatially or virtually. The Mossos pioneering work presciently envisions these new design modalities, but is a useful counterpoint to the contemporary condition of statistical architecture, as their writing calls for a democratization of information and, by extension, agency in the built environment. Their work suggests we turn our attention from the city's frozen image to its liquid state—real-time urban futures that are ceaselessly calculated and stacked upon each other—infinite material that seems to thicken every day. The situation offers an opportunity for new forms of thought and imagination, particularly with a sensitivity to time, performance and temporality. Embracing this paradigmatic change might provoke more choices, not only about what we choose to build but about when we choose not to build, how long we build for and for what time we build.

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KURD ALSLEBEN, ANTJE ESKE
AND CORINNA STUDIER

Extracts from an Interview with Kurd Alsleben and Antje Eske

Hamburg, August 2019

Corinna Studier: Kurd, as an artist, how did you get involved in the rather architectural process of office landscapes?

Kurd Alsleben: For a while, I lived with the father of a friend of mine and he asked me, “What do you want to become?” I immediately replied, “An artist!” I didn’t know… I didn’t know, because I didn’t know more, right? I didn’t know what an artist really is. I didn’t think: aha! A sculptor! A painter! I knew the names, but not what they actually meant. Office landscapes posed problems that not everyone could solve. But I could solve them, because I was an artist. My thought processes were different.

CS: How did you get the opportunity to help shape office landscapes?

KA: I knew Eberhard Schnelle, with whom I later collaborated. Eberhard and his brothers inherited a furniture factory from his father and money, apparently a lot of money, and they also worked on building projects on the side. They founded an office organisation company. That was fashionable after the war. The term “organisation” appeared everywhere. That was 63 years ago.

CS: And did you become a member of that organisational team?

KA: Mmm (nods). At the time, people asked themselves: “How should one do new office buildings?” People didn’t know! After the war, the buildings were destroyed, new bricks were produced, the old ones were not used and money was produced, but how should we build? So I thought to myself, perhaps not entirely professionally: how can one build?

CS: Before receiving your fist commission, did you have any theoretical considerations or discussions?

KA: Yes, the task didn’t yet exist, but you could sense it. We knew the open-plan offices in America, which were depicted everywhere, with everyone sitting in neat rows. But at the time, those of us who discussed them laughed about them, which probably wouldn’t be the case today… In that context, I thought perhaps the architects had failed to find a solution for the US-style open-plan offices, or had none available. That’s probably why we got our opportunity. Because we were, or at least I was actually an artist! So the good fortune that I was an artist helped us to develop office landscapes. After all, one could say that art in itself has a broader perspective.

CS: Were you the only artist?

KA: Yes, the only artist.

CS: And how many of you were there in this organisational company?

KA: It depended. There were more of us when we were contracted for a project.

CS: How many open-plan offices did you help design?

KA: I don’t know. Perhaps a hundred.

CS: Did you fit out existing spaces, such as factory halls?

KA: No, they were usually new buildings. I'm not sure it would have been possible in existing buildings. And there weren't any factory halls left. They had all been destroyed.

CS: Which part of the process to plan office buildings were you involved in? Even before the building existed?

KA: Yes, that was usually the case. The architect was then instructed to build it. But our work continued, sometimes for years. Sometimes, the office organisation was changed and the furniture had to be relocated.

CS: So you were asked to carry that out?

KA: Yes, the customers didn't do that themselves. They were happy that they had someone who did it for them. Right at the beginning, we also contributed to some of the architecture: spatial design, colours and the like. But that was just at the start, when the rooms were still quite small.

CS: What was your first real contract?

KA: That was a savings bank that already had an open-plan space. The new problem was not the open-plan space or the hall, but the large group of people, let's say around a hundred, who had to work together. And the only model that architecture could offer for large groups of people was the open-plan space. I didn't really see any alternative solutions from the architects.

Antje Eske: In case many people wanted to work together?

KA: Yes, that was completely new! In a factory or in a military context, many people are together and they receive their orders. In a factory, the "orders" may have a different form compared to the military, but in an open-plan space, they came together to work together, not be ordered about. And the office organiser was there to organise a way of doing that.

CS: How did you experience working for "Böhringer und Söhne," which is explicitly mentioned as an example in the book *Bürolandschaften*?

KA: It was a major company that had constructed the first building for open-plan offices. It was the first place where a large group sat together. That had never existed before because offices had always been set up as rooms with three to five people. Larger rooms were too big and could no longer be controlled. That was the way it was perceived before the open-plan period. So you can see what an enormous step it was. At first, people were concerned that the employees would work differently and confuse the organisational structures that had only just been established. Organising inherently involved ordering individual elements. Today, it is a completely natural concept that company departments must be mutually coordinated. It was natural and new that the sub-departments etc. had to be close to each other, since their tasks involved cooperating with each other.

CS: And did that work better in an open-plan setup?

KA: Yes, one has to say it was the only way! You can't create an organisation in a building with rooms containing three to five people. That's virtually unthinkable today. I'm not saying it will always be that way. We now have computer systems so we're not required to observe, consider and provide for such groups of people.

CS: What was the new and unconventional aspect for employees in open-plan offices?

KA: In the open-plan offices, every workplace was connected to a separate telephone line. So using the telephone was common practice, but personal aspects, face-to-face interaction was very unusual. Before that, none of the employees knew each other, since they would only get together at company gatherings. In an open-plan office, it was normal for a hundred people to be together. And they sat in open spaces, just like you are. They didn't look at me, they sat and could look past you.

AE: But they could look at you sometimes.

KA: Of course.

CS: And what about the managers? Did they also have their seats in the open-plan office?

KA: There were bosses in different departments; it went up very high, up to the Heads of Departments. They were gradually integrated into the open plan. At first, they asked for a little more space, but then they wanted to be part of the open plan, because it must have been an advantage, a social benefit, although there was resistance from the employees.

AE: To sit so close to your boss?

KA: To sit so closely to each other. They were used to groups of three to five people. And now they had to sit in a hall. They felt constantly observed. And the Head of Department is sitting there and watching you all the time! But that feeling disappeared completely because they could also be seen. In fact it wasn't a problem for long, but the newspapers were a problem. For a while, their reports criticised open-plan offices. I would say they didn't regard them as common sense. Each period, each timeframe has its own idea of common sense.

AE: Of what is currently "in."

KA: Yes, one is convinced of what is there.

AE: And it constantly changes and sooner or later it's something else.

KA: It changes slowly, so you hardly even notice it. I do believe that there were positive experiences in working in an open-plan office, aside from all the strong social contacts. But common sense was against it, so people were generally also against it. After all, it did have its drawbacks. You could always hear what your neighbour was saying, but if you heard nothing, that was also terrible… It was simply very different from what you were accustomed to. So it was a big change, a transformation. It really was a transformation, don't you think?

CS: Were there famous examples of this type of office landscape?

KA: The owners of Jacobs and Bertelsmann commissioned the design of their office landscapes. Even their own workplaces were in an open plan. Perhaps they wanted that because they expected special difficulties from their employees or because it was their own idea. That was not the case in other companies, I mean company owners sitting with their employees. I was in close contact with Jacobs because I also installed the furniture there. He moved it around again (laughs). It was an impressive moment when the company boss sat down in an open-plan office. In the middle of everything! It made a good impression on the employees. And you have to say: the initial resistance, which mainly came from the press, quietened down.

AE: So there was resistance to begin with?

KA: There was considerable resistance!

CS: But did it become more accepted after Jacobs and Bertelsmann had their office landscapes designed that way?

KA: Yes, it was very well received and there were no more problems. Naturally, we didn't know how the environment could be

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assessed; the companies didn't only have open-plan offices. They were individuals who were paid individually by the company and also had to be controlled, which is all very normal. So at first, they had to learn how the structure works.

CS: Was it your task to organise the employees' furniture and workplaces? What criteria did you apply in fitting out the spaces?

KA: What we had were lists. They showed which people should occupy the space—that doesn't need to be as crude as it sounds: the hundred people who used the space were described individually, at least in terms of their organisational elements. I then positioned the people. The lists of workplaces were very detailed, with names, functions and the means they used. These had to be presented visually. I could use the lists to organise, since every workplace had to exist in an environment of neighbouring workplaces that were also described on the list.

CS: Did you develop the interconnections between the employees yourself?

KA: No, I was provided with all that information. So I simply presented the interconnections, I would say. And in this context, that is my understanding of my artistic activity. The data flowed into those interconnections, which are nowadays transmitted through wires. Today we speak of data flows. You could use the term back then as well.

CS: So in a way, you were the computer (laughs).

KA: Yes (laughs).

AE: What equipment did the individual employees have?

KA: A desk, a cupboard, a counter where files were kept. The furniture was not specially made. It already belonged to the company. It's all so similar. We also introduced flower boxes in the office landscape; I don't know whether they also existed in American open-plan offices. I think each workplace had around ten square metres of space. That was the average including toilets and everything else; the floor plan needed to accommodate everything. But we couldn't influence these individual aspects. They were the very normal dimensions defined by the architect.

CS: Did you use partition walls as sightscreens?

KA: Yes, because you could see a great deal of what your neighbour was doing, more than usual. And you sat together every day. But no more than five or six people sat together in one area.

CS: So, in the office organisation company, was it your task to arrange the furniture of the office landscape or did you all do that together?

KA: We didn't do that together. I did that by myself. The workplace lists were good preparation and if they didn't fit, the office organisation wouldn't fit either. So they would have to be rewritten, but that hardly ever happened.

CS: Were there models or experiments with which you could test your arrangements?

KA: No, not really. We had no models to try things out. We were unable to carry out any social or social-psychological experiments, since we weren't qualified to do so. Today, you would probably contact a university to examine the situation. We didn't have that possibility.

CS: Nowadays, you would produce statistics on it.

KA: Yes, we didn't have anything like that.

CS: Did you just know it would work based on your discussions?

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KA: Yes, that's right. After all, you're interacting with Antje and me without needing any statistics.

CS: And did you produce any collages or perspective drawings to visualise the office landscapes?

KA: Due to the architecture, the office landscapes were single-level, empty halls. So all we needed was to imagine the third dimension for the halls' arrangement. (Points to the floor-plan drawings.) Whether this goes here or there or there...

CS: So your imagination was enough to arrange to the floor plan and impress your customers?

KA: Yes, that's what they thought. That was the closest we could get to reality (laughs). Yes, my drawings were the realest option possible. Variations were possible over the period of a month. But that wasn't often the case, because by God, that would have caused all sorts of other changes, wouldn't it? We only presented complete complexes, for instance for a relocated department.

CS: Did you develop your office landscape according to a specific concept?

KA: Since I was an artist, I had the idea of contributing rhythm, which was not necessarily an architectural-spatial element, but we'd have to talk a little more about that. The large office group brings organisational flexibility. And that was the top priority for everyone. You could organise working groups or workplaces flexibly. That went very smoothly; it was no problem in the open-plan area to move four pieces of furniture around… and that's what we needed the workplace lists for. What people can't understand is the fact that they had to be drawn! As visual presentations. The task of drawing included adding rhythm to the office landscape, an irregular, free rhythm. That didn't exist in the lists, but the lists did contain occasions where rhythm could be added. Everything must be part of the rhythm. You had to have that inherent rhythm, the aesthetics and that was simply my job. I thought about it recently, yesterday and the day before, and then I realised: how should the placement be? Well, I've no idea. I just did it.

AE: What did you do?

KA: So, you had large spaces and tackled the task: this department will sit in this corner and another will go there and they grow towards each other. In this case, growing means leaving space for each other. Arranging such an organisation is based on cybernetics. You could say it is connected to the theme of office organisation. But I quickly introduced cybernetics to Eberhard [Schnelle].

AE: And how did that introduction come about? What interested you in cybernetics?

KA: Yes, that could sound rather crude: the artist strives for a broad perspective and at the time, cybernetics had the broadest perspective of all. There was also another important point: the fine overall aesthetics. I could probably switch more easily in my mind from one art form to another, in other words leaping over things, than perhaps the people whose task it actually was to design spaces! (Saying to himself:) You could actually say: "It wasn't your task! You took it." But that isn't really true, because the task was simply out there. I didn't take anything away. I never really pursued anything, but there was nobody who would have added something different to the office landscape, which had to be implemented in a short time—or within the time available. Always blaming it on speed oversimplifies the matter. But you also need to have something in the locker. You could say, "Irregular, free rhythm, well, I could have done that!" in the way people do today, but it doesn't work that way. Well, where does the rhythm come from? And that's what I mean when I say an artist is better at leaping faster between the arts. That's plausible, isn't it?

AE: Leaping faster than who?

CS: Perhaps an architect?

KA: Yes, faster than an expert.

CS: Sure, an artist sees different connections.

KA: Yes, it's different.

AE: ...or perhaps an artist is not fixed on or limited to something specific. And what (reads out Kurd's notes) does that have to do with Ezra Pound?

KA: That is an entirely different genre. Literature... At the time, I came across Ezra Pound. He was an American, a generation older than me. His work is all as if it were in one rhythm. I can't say I can explain it although I've read a lot of it.

AE: It inspired you, didn't it?

KA: It really inspired me. For years of my life, I really lived with it. And like Brecht, although more so with Pound, the same, irregular rhythm has been attributed to him!

CS: Did you read that while organising your office landscapes?

KA: Yes, and it inspired me. Unfortunately, Ezra Pound was a stubborn person whose politics were adrift. But when you have reached a certain age, for example you or me, then that shifts. Everything is more multifaceted and things take place on different levels. What I mean is that it's important when considering a free, irregular rhythm that one can't connect it to a military rhythm.

AE: Yes, a military rhythm isn't really free.

KA: The military is not free and not irregular. It can happen that the free, irregular rhythm has an irritating effect because it is connected to "disorientation." At least I always feared that. Perhaps

I feared it more than was really necessary. After all, if I'm not mistaken, rhythm is something that has lost some of its conscious effectiveness, or do you disagree? Actually, rhythm is a phenomenon that stems from ancient times and ancient language. So it must have had a high status in the field of aesthetics.
How did the period of office landscapes end—that's another question. (Pause.) That happened at a time when Germany was reunified. Office landscapes ended for me then, but I'm not quite sure whether the commissions stopped coming.

AE: Perhaps your other interests also played a role?

KA: That might also be the case. It's funny. A Swiss man came to me. I don't remember his name. He wanted to have a licence from me for office landscapes, in other words permission to do the same as me. That was a strange concept to me as an artist. I couldn't do it. I thought, if that's the way it goes, others can also do it better or worse. I laughed at him, but that's silly too. I could have said: “Give me this much money!” (laughs). But I didn't do that because I thought the artist does that and anyone can imitate and improve on that. But strangely, I only dimly remember the end of office landscapes.
It could have been that competitors did it without licenses, above all in America, but that was far away. Naturally, they couldn't do anything with their office halls. But then they saw what could work, how it could be used. Instead of being developed by Americans, it was done by Germans in America. I even knew them. I myself perhaps wasn't interested in expanding. That was the first time the label “office landscape” appeared. It hadn't existed from the start. We never used it and there came a time when we didn't like it, but somehow I like it now. It's a friendly catch phrase for the type of space. At the time, we just called it “MobO” for “Mobilar-Ordnung” (“furniture order”).

CS: The Schnelle brothers founded a publishing house that mainly focused on cybernetics. Did you publish your books with them?

KA: Not usually. We caused a revolution at D&S, who published a master copy without any editorial revisions and the single edition was printed within one day. And we needed a publication. We were allowed to clearly define and structure what we wanted. Of course, if you have an editor, he will improve some things, but make others worse.

CS: At the Schnelle publishing house, you initially supervised the field of "Information Theory and Information Aesthetics." Do you remember anything about that?

KA: Yes, but it wasn't a proper role. It was while we were refining our idea of office landscapes. Information aesthetics was originally a concept by [Max] Bense, or to be precise, by Bense and [Abraham] Moles, and I simply joined in.

CS: Have you yourself ever worked in an open-plan office?

KA: Yes. At first I didn't have an opportunity, because the only open-plan offices that existed were the ones I had designed. So it only came about much later, but not as an experiment. I had a workplace there for a while. I even wanted to rent one; not all of them are always occupied and then I sat there… well, it was a rather unusual situation.

FRIEDER NAKE AND ARIANNA BORRELLI, NATHALIE BREDELLA, MADS FRANDSEN JULIUS WINCKLER

Extracts from an Interview with Frieder Nake

Berlin, December 2017

Interviewers: How did you program your Graphomat?

Frieder Nake: At the time in Stuttgart, the situation was as follows: the Graphomat, engineered by Konrad Zuse, arrived completely without any software. The only thing we had was the announcement by Prof. Dr. Walter Knödel, Head of the Computing Centre at the University of Stuttgart (which was then still a Technische Hochschule): “We’re going to buy one of those machines.” Software did exist for the Graphomat, but it was only compatible with Zuse computers and not with our computer at the Computing Centre (a Standard Elektrik Lorenz Elektronenrechner – SEL ER-56). I couldn’t use any of it, since we didn’t have the software. When Knödel announced the purchase to me, he asked if I could develop the software for the Graphomat, to which I agreed. I’m telling you this anecdote because, to me, it’s a wonderful example of excellent teaching: a professor asks the student to do something—without having any idea himself of what that student may know in the specific case. The professor thereby showed great trust in the student. A first principle of education is mutual trust. That’s why I’m opposed to examinations, where everyone cheats any way and nothing is learnt that way.

I: How can you program a machine that isn’t there yet?

FN: Very easily, it's very simple. Programming means creating descriptions, descriptions for a computer to carry out. The machine only serves to test whether the description suits it and works, or not. All my computer knowledge is based on the assumption that the machine initially also exists only in the form of a description. Back in the 1960s, I programmed on the lowest level—i.e. on the naked machine, which only has one button to start and stop.

Everything in the field of computing consists of descriptions. So I needed nothing but a description of the new Graphomat, which had not arrived yet. Computing itself consists of a world of descriptions: it is a semiotic world. We can regard the descriptions I had to make as text *and* machine, at the same time. They are virtual machines that appear as text and can be read. But those texts, which we call "computer programs," may also be viewed as machines, *text-machines*, we might say. And in that respect, they are a completely new form of text.

For each specific program, you could build a specific computer (which is naturally a rather crazy idea). Each of these computers, though real and actual, would then be—or, better, act as—a virtual machine. Then you wouldn't need to write new programs any more (only when a new program is needed, which is not very unusual). Inversely, it would be possible to run all programs in the world on a single computer. But that would also be extremely impractical because, of course, everyone would want to use it at the same time. That's why we see computers everywhere. No other machine exists as abundantly as the computer and that is its special aspect, a result of its semiotic (sign-based) nature. In principle, that would all be possible in our brains, if suitably trained. However, we humans are not very good at remembering things, so we will continue to write things down.

I: Was it already the Graphomat's task to draw back then?

FN: The Graphomat's task was always and exclusively to draw. There was only one additional function, which was derived from drawing, namely turning lines on paper into incisions in a

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material, which served as a print template. But the task at hand was to write programs for the computer that would ensure that the Graphomat really did draw something you wanted to be drawn. What was drawn had to be calculated on the computer to create a punched tape that, in turn, controlled the Graphomat. I had to force the computer to draw or, more precisely, to come up with a sequence of commands (a text) that would control the Graphomat in the desired way. The computer didn't want to *draw*, since it was built to *compute*. My task, therefore, was to let the computer compute, but the result of its computing was a drawing. It was a wonderful moment when I realized that this was really what my task required.

I: What was the machine supposed to draw?

FN: We didn't know yet. When I started to design and construct the basic software for Graphomat's drawings, I had to think of a mechanical engineer, physicist, mathematician, architect or sociologist coming along, wanting visual representations of his or her calculations. My software had to work for all of them. So, I had to think of the drawing as such and not of what exactly would be drawn in a specific case. The machine used a system of coordinates. Those coordinates would be used to represent points connected by straight line-segments. My job was to use only the points that the innate Graphomat grid of points could actually get to, and approximate as closely as possible what the architect or engineer wanted to see.
The Graphomat has an available area of about 1.5 x 1.5 metres. Paper was affixed to it. A pen or paintbrush is inserted into a small support. It rests on a mechanical arm, along which the support may move, while the arm itself moves in an orthogonal direction, driven by a spindle. In this manner, the pen can perform moves in a large number of directions. Definitely not *all* directions—we are, after all, in the digital realm, not the analogue! There was a total of 1024 directions the Graphomat could perform precisely. All other directions had to be approximated by zigzag-lines. This

is the price we must pay for trying to create analogue drawings by discrete (digital) means.

The drawing machine reads the punched tape that the computer has delivered. It is absolutely precise in following the text on the tape, never deviating. Only humans could create deviations: stop the machine, move the pen somewhere else by moving the "drawing head" and resume drawing. Of course, that's rather stupid because why would you have the computer calculate a drawing that you would then not allow to be carried out?

This disruptive process could now be called "interaction"! A kind of interaction before its time. The computer "knows" the pens only as numbers 1, 2, 3 and 4. The concrete pen resting in one of these positions (the colour of its ink, the width of its tip—0.2 mm or 5 mm) is not the computer's, nor the Graphomat's concern. You can use a computed punched tape with different graphic equipment to get a completely different drawing. The code of the punched tape is abstract; the pens and colours are concrete.

I: When does the context of art, in which you work, become more significant?

FN: That requires another anecdote. In programming, almost the only way to learn whether your program works correctly is through testing. Research must prove, with mathematical rigour, that a program is correct. But until now, we do not know much. If you want to discover how correct a complex program is, you must apply exhaustive test methods, which is tough and tedious!

I should have tested the 256 directions of each quadrant, amounting to 1024 directions. And then their use in approximating the infinitely many directions when drawing, as well as the smooth curves. Not impossible, but real work. I didn't really fancy that job. So I told myself, "work by chance!" The logic behind it was that, if it looks correct, it may well be correct. That's an advantage of drawing over calculating. We forgive tiny deviations. And that was the launch into art! Take a chance! Give up the absolute precision of digital calculations and trust the slight sloppiness of perception instead!

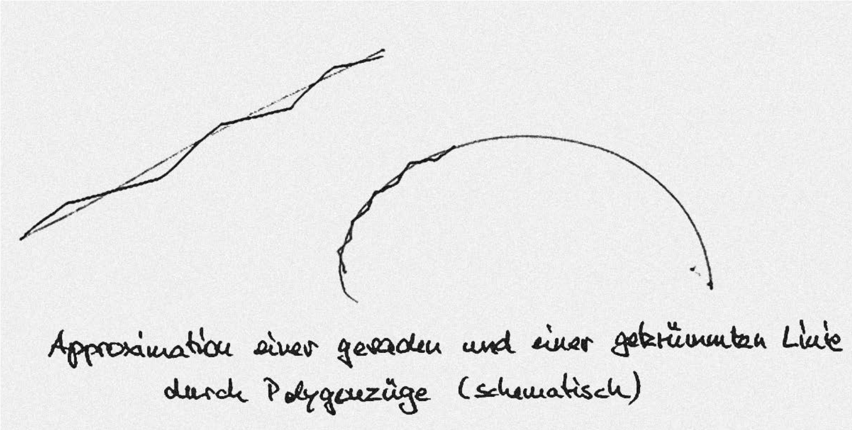

Fig. 1: Stepwise straight lines (polygons) approximating a straight line and a circular line

One day, I had to tell myself: “OK, now try the circle.” On the Graphomat, there are no circles. You must approximate its beautifully smooth, calm line by very short straight edges. If they are drawn in quick enough succession, short and shorter in length, they may appear to us as “smooth.” Of course, they are not and never will be. But we are tolerant and can be duped. The ancient Greeks already knew that we can approximate a circle this way. A circular line is created out of a polygon with an ever-increasing number of edges. The sketch above gives an impression of this simple principle (fig. 1).

Let us take a look at the simple image of figure 2. You would, quite likely, agree that we see smoothly curved lines. With a bit of effort, you can see that the sixth line, counting from the outside, resembles a circle. Before it, and then further on to the inside, we see the circle’s “sisters.” They are created from the circle by shifting the regularly spaced points along the circle by randomly chosen amounts, slightly further out or in. The newly determined points are then interpolated. For whatever reason, something slightly sensational has happened to the automatically ongoing process of interpretation: a thin needle punctures the pleasingly adjacent lines. From an aesthetic point of view, the needle is rather well placed and sized. It clearly dominates the image and lends a pleasurable surprise to the image. In some

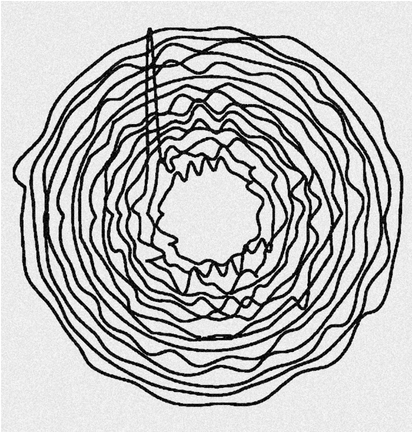

Fig. 2: Frieder Nake, Kreise, 1965

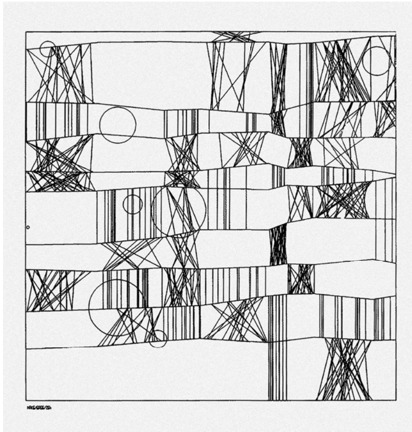

Fig. 3: Frieder Nake, Homage à Paul Klee, 1965

way, the interpolation needed to gain momentum to achieve what the algorithm required of it. A truly remarkable drawing emerged this way (considering this was 1965!). Without the anomaly, the whole drawing would be relatively boring. Chance made it a bit more exciting, don't you think? Similar things happened in other cases again and again. As soon as I had engaged in this kind of process, our good friend—*random chance*—assisted me in achieving a few such gems.

I was particularly fortunate with the program I called *Homage à Paul Klee* (fig. 3). Even though, at close inspection, you will discover a number of aesthetic weaknesses, it immediately attracted attention, positive feedback and even a little admiration and acclaim. It became one of the best-known results of early algorithmic art.

Whatever we *see* must be perceptible to our eyes. It must exist in what is known as the "analogue" (continuous) mode of reality. We don't *see* digital things. We can conceive of them and indeed do so. But such a statement only identifies a general concept, as we realize when pondering differences between analogue and digital!

The image in figure 4 presents my program "Matrizenmultiplikation" (matrix multiplication, from 1967). Details of the way the program works are irrelevant. It suffices to know the following facts for an appreciation.

In mathematics, a “matrix” is a quadratic (e.g. a square) arrangement of numbers that are organised in rows and columns (never mind that there are also rectangular matrices). In our example, all these numbers are between 0 and 1. I subdivide the interval from 0 to 1 into seven short intervals, one immediately following its predecessor, without any gaps. A colour is assigned to each of the intervals. Scanning the numbers of the matrix and replacing its numbers by the intervals they belong to and, furthermore, putting the interval’s colour at the location of the number, creates the coloured array. The numbers of the matrix are clearly digital. Their corresponding colours are analogue. “Matrizenmultiplikation” is (among other things) a machine to translate from the digital and discrete to the analogue and continuous, even though the structure of the small squares is, again, discrete.
Let us take a closer look at the colours of the image. Take the top horizontal row. As you can see when moving from left to right, there are repeated densifications, roundish darker shades of the same hue. This effect is clearly visible at the far left in the second green, and later, in the violet and orange fields. I should tell you that the machine’s upper row is drawn from left to right. The pen (5 mm wide) is lowered down onto the paper, then draws a 5 mm long stroke, and is lifted up again. It is followed by the next elementary step and the next one, changing pens and colours. Now, when the pen is stopped in order to be lifted up, this takes a tiny amount of time. It is enough to allow a little more ink to flow onto the paper. The result are those blotches in forms that are completely uncontrollable, blots, dark patches. A purely analogue process is added to the image of the digital, while in our perception (the realm of aesthetics!), it may gain special attraction.
I wish to add that, today, such an effect is no longer possible on slick (and *more* digital!) computer screens, unless you make the pointless effort of simulating the analogue digitally. Which may be rather crazy!
There is another aspect I want to make you aware of. Take a look along the second row, but now going from right to left! Can you see it? The darker spots are now situated to the left in the small colour-fields, not to the right as before. On the way back,

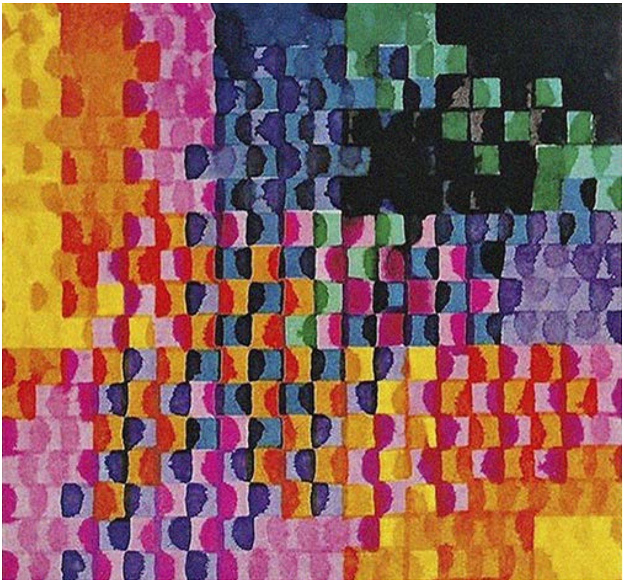

Fig. 4: Frieder Nake, Matrix multiplication series 31, Detail, 1967

the machine was programmed to draw from right to left, so the pen is always lifted on the left-hand side of the little squares. This effect creates some attraction—don't you agree? I certainly do. The algorithmic (and digital) image that I force the computer to produce appears in analogue mode in a way that simply does not appear in its programmed or algorithmic form of existence. Forgive me if I'm too proud of this earliest period. The digital and the analogue were still friends back then. They loved each other. And I loved them.

I: What is the relationship between visual insight and mathematical formulae?

FN: Our example offers a good way to explain that. The program is called "matrix multiplication." That's a bit mathematical. Matrices can be multiplied. Whatever that means and however you do it, it is precisely defined. So, my thought was this: take something from mathematics, take a matrix, and make it the source of images (fig. 5).

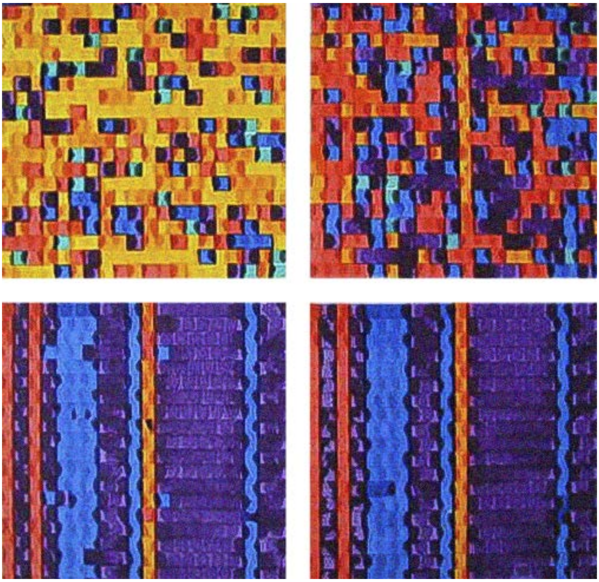

Fig. 5: Frieder Nake, Matrix multiplication, 1968. Four states shown: up left, up right, down left, down right.

I choose a matrix at random; call it A. Multiply it by itself, thus producing its "powers." First, you get A^2, next A^3 and so on. When the program is running and producing the powers, one after the other, it occasionally takes the current state and puts it aside, perhaps A^2, A^5, A^{10}, A^{20}. These states are translated into images, the coloured interpretations of the matrix of numbers. Once in a while, the state that the matrix has just achieved is visualised. It is a relatively simple process. As you can guess, the definition of the intervals between two visualizations has a great influence on the visual nature of the image. That is where the artist resides, the concrete form of visualisation!

I: Are the visualised matrix powers different in the images?

FN: They can vary from image to image and the colour intervals can also be different. Parameters abound: the number of colours to use, the choice of colours themselves, the division of the interval [0, 1] into subintervals, the size of the square matrix, the random first choice of the matrix, the number of states, the sequence of states to be visualized. It became clear that you need some sensitivity to make a good or fruitful choice of all those. You need to experiment.

I should add an important secret that has tremendous influence on the appearance of the images. The secret is that the matrices are so-called *stochastic matrices*. Think of something called a "state system." In every moment, such a system is in one of many possible specific states. It is irrelevant for us how a change of state occurs. We only know that, from its current state, the system assumes its next state through probabilities. We use the term "transition probabilities." The process of getting from a current state, say $\sigma_{i,}$ to the next state, say σ_j, is controlled by transition probability p_{ij}. Such processes are called *Markov Processes*. The matrices with which I played are ones that describe such Markov state systems. Now we see a bit more of what their fate is, from a higher perspective. This interaction between precise mathematics and random choice is art!

I could talk for a long time about this, but that would be boring. Think of this: you see a medieval painting, or an image from the Renaissance period. Without much hesitation, you may say: aha, that's Mary, in the background a shy Joseph, and the little baby Jesus in the foreground is so sweet. Petals raining from the sky, angels exulting, and more. Clearly, they are all just blotches of colour. But each of us interprets and immediately recognises them. Hardly anyone says: Of course, that's the devil, or: Look, that's my mum with me. It's always Mary and the baby Jesus.

But when we look at the "matrix multiplication" images, we don't immediately say: sure, a Markov System, in an advanced state. We don't say something like that because it isn't part of our observed reality or our heritage of stories. It doesn't have to be that way, but that's how it is.

Behind such a Markov matrix of transition probabilities lies the following. If we create a sequence of powers of the initial matrix and go pretty far with it, the matrix rows stand for the probabilities at which the system transforms from its original state into any of the other states within so and so many steps, as defined by the

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powers of the matrix. However, the entire system strives to reach a limit state. Mathematics shows that, in the end, it is completely irrelevant in which state the system began. It can go wildly up and down, over and under, but ultimately that makes no difference, since all states eventually become stochastically equivalent. As I said, that is what happens towards the end. The end may be infinitely far away. That is what the images of Matrix Multiplication show us. Just like Jesus and Mary, always the same.

I: Even the selection of the states?

FN: Even that, with a bit of luck. We may ask the program to display first, fifth, fifteenth and twentieth state. We don't know in advance wow close, by that time, the system may already be to an almost stable phase of its behaviour.
I have produced perhaps 40 or 50 images with the program. But I could have continued exploring for a much longer time by systematically varying the large set of input parameters. Mathematics may be a relatively abundant source. That's why the program allows so many experiments. The process of intelligently and sensitively engaging with it becomes art. An abstract intuition is as erotic as any other.

I: Did you have any idea at all what the results of the program would look like?

FN: Not at all. Well, naturally I knew a bit about the structure. But only the general structure. Not the appearance.

I: What else existed in the field of visualisation and mathematics at the time?

FN: Naturally, I never really thought in terms of "visualisation." I don't even like using the word today, but nowadays everyone uses it all the time. Today, everything must be a visualisation. I thought that was dumb, because my aim was to create art. Is that a bit arrogant? I am afraid, it is.

Paul Klee had a wonderful description of this aspect: “Art does not reproduce the visible; rather it makes visible.” We don’t create an image of what everyone can see already; we rather create images of what nobody usually sees. I adopt that motive. I didn’t produce any other images in the strict sense of, *now I’ll take, as my source, something from mathematics*. But mathematics, all by itself, is not visible. In that sense, the images generated by the program “Matrizenmultiplikation” are testimonies to Paul Klee. Mathematics is always present when we write a program. It is not usually as explicit as in this case.

Let me continue with the statement that the aesthetics of images may be described on the basis of rational processes. In 1968/69, when I was in Toronto as a guest of Leslie Mezei, I roughly followed a line I wish to explain now. By that time, I believed in the radical-rational approach to aesthetics that Max Bense was trying to develop.

Let’s assume we have ten different available criteria. Images would then be assessed according to those. So we start by analysing the image in terms of criterion number one. If it is a quantitative criterion, the result is a number. We do the same with criterion number two and carry on until the last criterion, number ten. Images are thus represented by a “point” in a ten-dimensional space.

The image of figure 6 was created by a program that I proudly called *Generative Aesthetics No. 1*. The program’s task was this: take all the aesthetic measures known to me at the time (as defined by Helmar Frank and Rul Gunzenhäuser in the early 1960s) and construct an image that should fulfil the numerical conditions defined using the given criteria. More concretely, this could, for instance mean: the *measure of prominence* for blue should be between 0.2 and 0.3, while the *measure of surprise* for yellow should be about 0.7, and similar conditions should hold for other colours. Subject to these constraints, maximize the information-aesthetic measure!

To cut a long story short: by the end of that year, I was done with this work. I was quite curious when I started this project in summer 1968. Would I be able to solve the mathematics? Solving the mathematics and developing the program took me the entire year.

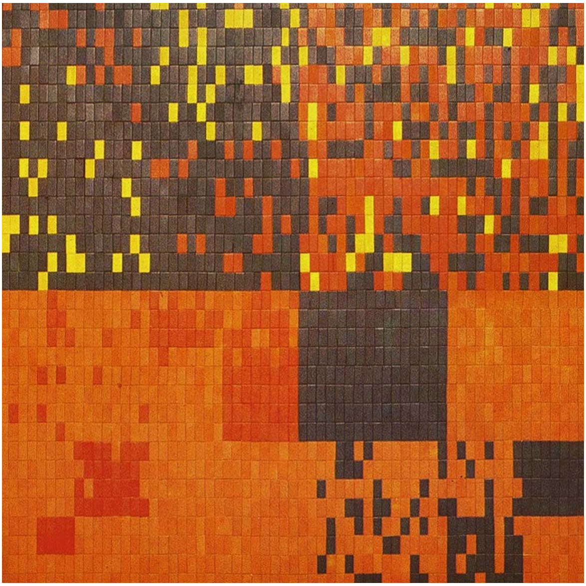

Fig. 6: Frieder Nake, Generative Aesthetics I, 1969

I was proud when the year was over and my program said: your conditions do not allow for any solution, or: there are solutions, and here is one. I had succeeded in developing a high dimensional optimization problem with constraints whose result was a probability distribution of the given colours according to numerically given constraints.

But more than this: The program's second part created a distribution of the colours according to the probability distribution determined by the first step.

The second part was important. For it constructed an actual image according to the frequencies the first part had determined to satisfy the constraints formulated in terms of the radical information-aesthetics. The first part, determining a frequency distribution of colours, became the necessary *statistical pre-selector*, as I called it.

I became fully aware of the fact that information-aesthetics always only regards things from the point of view of statistics! This follows from the fact that it is based on the measure of information according to Claude Shannon. Following him, the image is nothing but a perpetual source of visual (even aesthetic) information. If I wanted to create an image from the first selection of probabilities (better: frequencies), I would have to address a topological-geometric task. This became the starting point for part 2 of the program.

I invented a suitable data structure that was simultaneously and independently developed for other purposes at two other institutes. This data structure became known as the "quadtree."

For me, the structure was to distribute onto the image the amounts of yellow, red and blue, or whatever other colours there were, in accordance with the calculated frequencies. To that aim, the entire image was split into its four quadrants. In the next step, each of those four quadrants was split into its four sub-quadrants, etc. down to a smallest size of quadrants.

In each step, the entire mass of colour available here was distributed down, etc. A simple, procedure, rather free of any considerations of context, a scheme, not more. But nobody had done this before. The image of figure 6 was created this way, as you can no doubt assume.

Generative Aesthetics no. 1 firstly followed a principle of distribution, and secondly a principle of topology. Not a bad move. The aesthetic criteria applied during distribution are relatively weak. But they are rational, numeric, quantitative criteria. They are blind. They don't know what blue is like. They only know "Colour 1" and "Colour 2" etc. But adjacent colours would have to be considered in order to approach aesthetic appeal. The incredibly powerful machines of today can do that. It was impossible for a single person in 1968.

The computer in Toronto generated many images for me using *Generative Aesthetics no. 1*. Since there was no drawing machine that could create proper coloured drawings from the printed output, I had to accept distributions of stars, short lines, slashes and other printer symbols on continuously folded sheets of paper as the results of these efforts.

Back in Stuttgart, I worked with a few students from the Academy of Fine Arts. We did our tedious work by hand, sticking small pieces of coloured cardboard onto a large panel, following what the computer printouts told us. In doing so, we quite happily turned ourselves into the servants of the Toronto computer. We finished two of those panels. One of them was acquired by the great collector Etzold, who passed it on to Abteiberg Museum in Mönchengladbach, Germany, where it has been displayed several times. The other one was lost. Rumour has it, my mother didn't like it.

I think, this was the height of information-aesthetics. In some way, a triumph. Shortly after, I gave up and moved away from information-aesthetics to real computing. This would be another story.

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CEZARA NICOLA

Virtual Artistic Spaces

Roy Ascott's "LPDT2," Cybernetics and Beyond

This paper examines a seminal cybernetic artwork that integrates aesthetic and architectural principles together with digital technology. Essentially considered an artistic endeavour, Roy Ascott's "La Plissure du Texte 2" ("LPDT2") is a unique artefact not necessarily because of the popular platform that supports it, but because of the interaction between its avatars and the spaces that surround them. Exploring notions of "distributed authorship" and "moist media" introduced by Ascott, as well as concepts such as "cyberception" and "cyberscapes," this paper reflects on the relevance of virtual space in contemporary art. It contributes to a critical discourse on the role of material culture in digital artefacts, and the impact of virtual architecture design on contemporary artistic production.

In 2010, British artist Roy Ascott filmed a virtual artwork on the online platform *Second Life*, and exhibited it at the INDAF new media art festival in South Korea.[1] Until today, no consensus has been reached regarding which category the platform that hosted the experiment should be officially included in. Its creator, the San Francisco-based company Linden Lab, stresses that *Second Life* is not a traditional computer game, as it does not have a clearly set aim.[2] Moreover, the website cannot be regarded primarily as a social endeavour, as it displays no explicitly social objective.

1 Henrietta Knight, "Roy Ascott @ INDAF LPDT2/Syncretica," Quorum, last modified September 22, 2010. https://i-dat.org/roy-ascott-indaf-lpdt2syncretica/.

2 Kristin Kalning, "If Second Life Isn't a Game, What Is It?," NBC News, last modified March 12, 2007. https://www.nbcnews.com/id/wbna17538999#.VPslGuFMXuM.

The only certain discernible aim is the idea of a user-created, community-driven experience.[3] However, Ascott's work goes beyond regarding the multi-user virtual world as a sum of individual designs achieved through a creative tool set, underlining its impressive artistic, communicational and architectural potential. The present analysis attempts to map the early significance of virtual architectures in the artistic realm, employing the British artist's work "La Plissure du Texte 2" / "LPDT2" as a case study. From textual structure to digital environment, the paper will tackle the interplay of aesthetic and cybernetic principles and consider the potential of AI-driven mechanisms and organic reactions within the case study. As crucial elements in virtual architectural design, the first section will assess both the aesthetic construction and scientific principles that enable the video performance. In the case of "LPDT2," it is clear that its impact on society and culture does not concern the visual realm exclusively, but reaches into the world of cognition as well. It is not so much a graphic oeuvre as a demonstration of the potential of cybernetic architecture. Since the system that makes up *Second Life* is capable of adapting to stimuli from the digital, as well as organic, realm, it presents a unique possibility for users: they can experience an out-of-body event while connecting to others through remote cognitive processes. Thus, the latter sections of the paper will investigate the cybernetic and cognitive factors informing Ascott's work, as well as the possibility that virtual artistic spaces are bolstering what Ascott terms "behaviourist" features of art.

"La Plissure du Texte 2": genealogy and construction

"La Plissure du Texte" or "LPDT2" represents the *Second Life* embodiment of Roy Ascott's media artwork "La Plissure du Texte / The Pleating of the Text: A Planetary Fairytale," originally

3 Philip Rosedale, "The Origin of Second Life and its Relation to Real Life," Iinovate (2006), video, 6 min, last modified November 22, 2006. https://www.youtube.com/watch?v=0t1XR-LrgyM.

Fig. 1. Roy Ascott, Selavy Oh, MosMax Hax, Alpha Auer, Frigg Ragu and INDAF, "LPDT2" overlapping of text, digital photograph, n. d. Source: https://www.flickr.com/photos/alpha_auer/4948236550/. Elif Ayiter. CC BY-NC-ND 2.0 (https://creativecommons.org/licenses/by-nc-nd/2.0/). Accessed October 13, 2022

created in 1983. The complete title of the initial project referenced Roland Barthes' book *Le plaisir du texte* (1973), which examines authorship, semantics and the role of reader interaction. The 20th-century version of the work featured digital text only and aimed to emphasize the emergence of "distributed authorship."[4] In 1983, the text was generated by human storytellers located in different parts of the world, whereas in the new version of the work, autonomous avatars modified the "literary landscape" by "acting as communication nodes between the narrators of this new version of the tale."[5] A text generator was also used to create dialogues that extracted different quotes from classical literature. The structure of the generator allowed the overlapping of text from different sources, including text messages sent live by

4 Elif Ayiter, Stefan Glasauer and Max Moswitzer, "LPDT2 La Plissure du Texte 2," in Digital Media and Technologies for Virtual Artistic Spaces, ed. Dew Harrison (Hershey/PA: IGI Global, 2013), 75.

5 Ibid., 77.

the audience (fig. 1).[6] This type of sampling was both random and intended, mirroring spontaneous interaction and communication between individuals in the organic realm. As a synaesthetic image, it points to a process of artistic production that occurs beyond temporal and spatial boundaries, or even organic ones. It therefore illustrates Barthes' conviction about the disappearance of the authorial voice in modern works: "The absence of the Author… is not only a historical fact or an act of writing: it utterly transforms the modern text… Time, first of all, is no longer the same. …the Author is supposed to feed the book – that is, he pre-exists it, thinks, suffers, lives for it; …Quite the contrary, the modern writer (scriptor) is born simultaneously with his text; he is in no way supplied with a being which precedes or transcends his writing, he is in no way the subject of which his book is the predicate; there is no other time than that of the utterance, and every text is eternally written here and now."[7]

Ascott's work fits the description of Barthes' modern artefact and its "scriptor" as it was created in real time, through the participation of the aforementioned avatars and the texts typed by different users directly online. Interaction (in the case of both of Ascott's works), inspired by the notion of authorial dismissal, thus appears to be the most important aspect of his artistic practice.

Interestingly enough, Barthes advocated the blunt disappearance of the author in the interpretation of literary artefacts in the 1960s, a decade when new modes of artistic production were also challenging traditional convictions about art. This period of time marked the emergence of crucial art movements such as Conceptual Art, Minimalism, Pop Art, Psychedelic and Op Art on a global scale. A recurrent feature there was that the naturalization of process-based art practices based on thorough documentation led to a reduced emphasis placed on the figure of the author.[8]

6 Roy Ascott, Selavy Oh, MosMax Hax, Alpha Auer, Frigg Ragu and INDAF, "LPDT2 windlight 02," Flickr (2010), video still. Accessed July 27, 2020. https://farm5.static.flickr.com/4144/4948236550_2ed6b53b86_z.jpg.

7 Roland Barthes, "The Death of the Author," in Image-Music-Text, trans. Stephen Heath (New York/NY: Hill and Wang, 1977), 145.

8 Christian Berger and Jessica Santone, "Documentation as Art Practice in the 1960s," Taylor & Francis Online 32, no. 3–4 (2016): 201.

Perhaps not coincidentally, the same time period is regarded as a bridge for a decisive transfer of cybernetic principles from the scientific realm to the art world.[9] Similar to the rejection of the author's identity when critiquing a literary text, cybernetic art highlighted the fact that not just machines but organic entities too might be subject to cybernetic rules.[10] The idea of "model building" continued to allude to a creator and a product, but the cybernetic matrix ensured that the artefact did not have to be "complete" anymore. The concept of *feedback* and *feedback loops* that can potentially change the meaning of an artistic product through the interaction between artist, spectator and artwork appears to echo critical theory on the dismissal of authorial intent, such as Barthes' 1967 essay "The Death of the Author." Ascott's early nod to Barthes' text in his 1983 work might thus highlight a certain point of emergence for cybernetic artefacts in the 20th century. At the same time, it underlines intersections with social and artistic theory that allowed it to further develop into what the artist termed the "distributed authorship" of artworks.[11]

A clear offspring of the concept of the "disappearance of the author" as proposed by Barthes, the notion of "distributed authorship" hints at the dismissal of authorial intention in the sense that it is open to intervention from a variety of content creators who are, at the same time, inhabiting spectator roles. Nevertheless, it moves beyond the temporal dimension suggested by the French writer by featuring digital space that allows remote authoring. Beyond a chronology of experiential accumulation which results in the creation of artefacts informed by the author's personal background, virtual, digital space enables not only multiple perspectives on artistic practice and production, but also adds to the geographical specificity of the communicational act. The integrative architecture of *Second Life* is visually represented through

9 Roy Ascott, "The Construction of Change," in The New Media Reader, ed. Noah Wardrip-Fruin and Nick Montfort (Cambridge/MA: The MIT Press, 2003), 130.

10 Michael J. Apter, "Cybernetics and Art," Leonardo 2, no. 3 (July 1969): 257.

11 Roy Ascott, "Is There Love in the Telematic Embrace?," Art Journal 49, no. 3 (August 2014): 242.

the reshaping of traditional communicational settings. The spontaneous emergence of avatars and the possibility of transferring language modelling tools designed outside the framework of the "game" into the virtual world is perhaps similar to "real world" interactions with persons outside our circle of familiarity.[12] We act accordingly in order to integrate new acquaintances and situations into our cycle of experience.

Similarly, *Second Life* functions by continually taking in informational, linguistic and visual input concerning avatars and their environment, then allowing users to build over what already exists in this universe. Creative Industries Professor Axel Bruns refers to this type of accumulation of resources as "distributed creativity," positing that "such community efforts at collaborative content creation form part of the wider phenomenon of audiences becoming more visibly and more thoroughly active in creating and sharing their own content than ever before."[13] Because contributors are both content developers and content testers, Bruns suggests that they be called "produsers," a hybrid position which would also account for an emerging type of societal organization in the 21st century, namely "produsage." In such communities, development is marked by collaborative efforts which expand technological knowledge through practices of remixing and re-writing.[14]

If "distributed authorship" and creativity as a means of artefact construction may comprise both temporal and spatial re-writing, could they also point to a particular model of sensory experience governed by behavioural rules and the transition of behavioural autonomy from "produsers" to the product under use? And if so, could this mean that "LPDT2" as an early artefact of this type possesses certain features characteristic of artificial intelligence, which are in fact mediated by digital technology and virtual reality? The following section will focus on the cybernetic characteristics in Ascott's work, testing the premise that it may represent

12 Rosedale, "The Origin of Second Life."

13 Axel Bruns, "Distributed Creativity: Filesharing and Produsage," in Mashup Cultures, ed. Stefan Sonvilla-Weiss (Vienna: Springer, 2010), 25.

14 Ibid., 26.

an early conceptualization of autonomous reasoning processes through the incorporation of several scientific principles.

Autonomous action and cybernetic features in "LPDT2"

One of the basic concepts of cybernetics is information or communication theory, provided there is an agent attempting to convey a certain message to a given receptor. Nonetheless, the message does not necessarily have to be textual. On the contrary, it can be conveyed through other media, sound and image being but a few examples here. In the case of *Second Life* and, more particularly, "LPDT2," the information conveyed is multi-layered, from the visual construction of the space inhabited by the avatars to their appearance and the dialogues that take place between them, often prompted by sampled dialogue. The notion of information as *message*, understood as text in its most traditional, semantic sense, is present in the experiment through sampling from canonical literary works. However, the virtual reality mediated by *Second Life* feeds the spectator visual cues, displacing the aforementioned textual references. Paradoxically, most of the actual lettering and text used in Ascott's filmed work appears as heavy, large-dimensioned blocks resembling the concrete used in architectural constructions[15] (fig. 2). The words form labyrinth-like bright spaces against dark backgrounds, a nod to the act of communication which at the same time removes authors' quotes from their temporal context. Here, the message involved in the communicational act becomes the frame which is literally holding the agents of communication together. In a sense, it *controls* interaction by setting out paths and trajectories for the subjects or avatars to take and encounter each other.
As more and more information is released onto the platform, the physical environment of the avatars enlarges, allowing them

15 Ascott, Oh, Hax, Auer, Ragu and INDAF, "LPDT2 windlight 02."

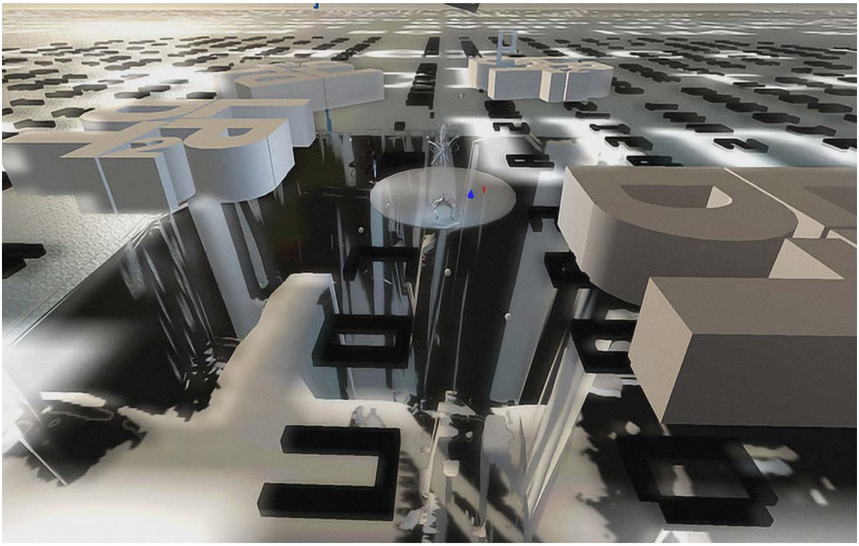

Fig. 2. Ascott, Selavy Oh, MosMax Hax, Alpha Auer, Frigg Ragu and INDAF, "LPDT2" text blocks, digital photograph, n.d. Source: https://www.flickr.com/photos/alpha_auer/4948449256/. Elif Ayiter. CC BY-NC-ND 2.0 (https://creativecommons.org/licenses/by-nc-nd/2.0/). Accessed October 13, 2022

to perform more varied actions there.[16] They watch the setting changing around them, stroll through the dynamic architectural elements, have philosophical discussions prompted by surrounding text blocks and even engage in romantic behaviour. As virtual space opens up before them in the form of text blocks, they respond accordingly to this communicational act by accessing new paths.[17] At its core, such actions might be regarded as a conscious response to interaction stemming from communicational sources and, therefore, as *feedback* on the part of the responding entities. As text continues to be generated and unfolds in the virtual environment, it creates an expectation of response and movement on the part of the subjects inhabiting the world. Thus, the action may be regarded as exercising control over the communication performed there.

16 Renato P. Dos Santos, "Second Life: game, simulator, or serious game?," Acta Scientiae 16, no. 1 (January 2014): 74.

17 Roy Ascott et al., "LPDT2," vimeo (2011), video, 12 min. Accessed October 7, 2020. https://vimeo.com/14518397.

The functioning of “LPDT2” as a cybernetic artistic artefact ensures that it is also relevant in the field of communication through the successful transmission of messages between the users of the virtual reality platform. Still, how can one advocate the purposeful transmission of information from a source to a receiver when faced with informational impulses which seem random and computer-generated? Research psychologist Michael J. Apter claims that such strategies favoured by contemporary artists who employ visual and textual randomization serve to strengthen the “inverse relationship between probability and the amount of information: the less probable an event, the more the information when it occurs. …In general, the more random and therefore unpredictable a sequence of symbols constituting a longer message is, the more the information in the message.”[18] Researcher Stephen Jones refers to such experiments as “systems in conversation,” remarking upon the wide spectrum of realms where cybernetic systems have long been functioning, despite their traditional association with 20th-century technological progress: “Cybernetics… was developed by [Norbert] Wiener out of the wartime need to dynamically point anti-aircraft guns so they would be capable of hitting an enemy aircraft while it was traversing the sky, given that the shell would take time to get up to the aircraft. …But cybernetics has a much deeper past than these dark arts. …and in a more palpable way it drives human evolution, particular in its social forms through one utterly important process: that of conversation, which, itself, will have come about through signalling processes.”[19]

In other words, cybernetics describes adaptive systems from organic evolution and corporeal entities to the more contemporary fields of virtual reality and artificial intelligence. What is common to all of them is the notion of *communication*: the basis on which development occurs and the ability to adapt improves.

18 Michael J. Apter, “Cybernetics and Art,” Leonardo 2, no. 3 (July 1969): 258.

19 Stephen Jones, “Cybernetics in Society and Art,” in Proceedings of the 19th International Symposium of Electronic Art, ed. K. Cleland, L. Fisher and R. Harley (Sydney: ISEA International, 2013), 2.

As far as “LPDT2” is concerned, the graphic union of text and architecture should not be regarded as random, despite the casualness of the “in-world” avatar encounters. As architectural cues transcend the virtual realm, the art object is fundamentally deconstructed, revealing not the end product but the ongoing process of artistic production and reception. The impact of this newly found focus may inform the construction of organic societies as it allows for a substantial degree of experimentation with technologies employed on a large scale and in very diverse fields without the fear of failing at purposeful communication.

The dynamics of networks before virtual reality and artificial intelligence assumed that “while the system can discover new patterns of input behaviour that seem to indicate what actions should be taken, it is unable to discover new kinds of actions which can be taken – that is, it can only discover new instances of information, not new types of information. It’s not autonomous, not alive.”[20] While *Second Life* boasts an interface that is nowadays superseded by more advanced graphics, it nonetheless features a decent amount of autonomous activity within the virtual world. This applies especially with regard to avatars and avatar features which can be individually designed and introduced onto the platform by users. As a result of the arbitrary responses that can be triggered by the introduction of such figures and features, *Second Life* might be regarded as resembling the structure of modern AI systems. This would translate into the fact that it is capable of functioning by putting together pieces of information extracted from multiple sources, such as user-generated text, architectural elements and random text sequences, while adequately responding to new challenges.

Looking at the texture of the universe imagined on the *Second Life* platform, the next section of this paper will map out possible functions of the entities inhabiting this experiment, as well as the emergence of an adaptive type of art based on technological

20 Ben Goertzel and Stephan Vladimir Bugaj, “The Internet Supermind and Beyond,” Goertzel.org, July 2000. Accessed October 7, 2020. https://goertzel.org/benzine/AIManifesto.htm.

progress. Moreover, the issue of artefact perception will be broached, with a focus on the development of renewed ways of grasping informational landscapes.

The virtual artistic space: Behaviourist Art and a brief nod to utopia

In terms of the potential social significance of a work such as "LPDT2," one could wonder to what end virtual reality and progressive aspects feature in the work—are they displayed as reminders of technological development at the beginning of the 21st century? Do they feature an urge to escapism and are therefore imbued with utopian hues? Or rather, were they preferred for the purpose of signalling a possible dystopian future brought about by too-rapid changes in society and science? Beyond a discussion of the instrumental aspects of the medium used in Ascott's experiment, this paper contributes to the hypothesis that virtual reality enhances a cybernetic discourse in art by allowing for a metaphysical, utopian existence of spectators as users. Here, the notion of "utopia" is employed in both a social as well as a spatial sense. It should be viewed in light of the theory concerning the transformative, emancipative potential of "free" information circulating on the internet and regulating relations between individuals in a positive manner.[21]

In order to be able to benefit from the potential of free ranging information in the virtual realm, however, users need to possess a renewed sense of literacy which allows them to decipher information from organic as well as technological environments. Cyberception essentially requires the adaptation of organic cognition so as to be able to take in and adequately make sense of various information landscapes.[22] Theoretical and artistic accounts before the turn of the 21st century indicated the necessity of surpassing mediating notions of representation and

21 Joshua Cowles, "The Internet as Utopia: Reality, Virtuality, and Politics," Oshkosh Scholar IV (November 2009): 81.

22 Douglas Rushkoff, Cyberia: Life in the Trenches of Hyperspace (New York/NY: Harper Collins, 1994), 3–4.

visuality in the computerized quest to engage one's audience or receptors directly.[23] With the advent of the 21st century, however, a distinct return to organic experience could be observed, especially within the field of new media art, as collective experience arises from the realization that perception may be achieved even without employing one's sensorial system.[24] As such, cyberception represents the ability to adapt to multiple cybernetic settings, both physical and virtual. Planetary Collegium researcher Živa Ljubec assigns this adaptive capacity in particular to modern artists, stating that they represent, therefore, an essential factor in technological development. She further claims that "connectivity, immersion, interaction, transformation and emergence in the process of mutation of cyberceptive organs make the intermediary intellectual instruments and modes of representation obsolete."[25] She thus appears to emphasize a certain utopian quality in artworks created nowadays, namely that of entertaining a perpetual flux of meaning beyond issues of visuality and representation. This hypothesis follows a rhetoric of cyberspace that highlights the idea that "utopia is attached to technologies that have not yet exhausted their potential," underlining once again the adaptive potential of works created with computerized means:[26] "If the cybernetic spirit constitutes the predominant attitude of the modern era, the computer is the supreme tool that its technology has produced. Used in conjunction with synthetic materials it can be expected to open up paths of radical change and invention in art. …The interaction of man and computer in some creative endeavor, involving the heightening of imaginative thought, is to be expected."[27]

23 Živa Ljubec, "Growing Cyberceptive Organs within Electronic Environments," in EVA '15: Proceedings of the Conference on Electronic Visualisation and the Arts (Swindon: BCS Learning & Development, 2015), 132.

24 Peter Weibel, "The Intelligent Image: Neurocinema or Quantum Cinema?" in Future Cinema: The Cinematic Imaginary After Cinema, eds. Jeffrey Shaw and Peter Weibel (London: MIT Press, 2003), 599.

25 Ljubec, "Growing Cyberceptive Organs within Electronic Environments," 133.

26 Cowles, "The Internet as Utopia: Reality, Virtuality, and Politics," 82.

27 Roy Ascott, "Behaviourist Art and the Cybernetic Vision," in Multimedia: From Wagner to Virtual Reality, ed. Randall Packer and Ken Jordan (New York/NY: W.W. Norton & Company, 2001), 103.

In his 1966/67 essay on the emergence of what he termed "Behaviourist Art," Ascott discusses the economic and social effects of automatized systems in modern society and a possible transformation of the human self as a result. He lists factors such as instant communication, environmental technology and the renewed human/computer relationship as markers of a "cybernated society" and the "perfectibility of systems."[28] This striving for improvement points to utopian aspects through its optimism about the smooth rapport between organic and non-organic bodies. Faced with the need to define the role of the artist in this newly acquired ideological and societal environment, the British artist suggests the alignment of artistic products with the modern spirit of process-based advancement: "Behaviourist Art constitutes a retroactive process of human involvement, in which the artefact functions as both matrix and catalyst. As matrix, it is the substance between two sets of behaviours; it neither exists for itself nor by itself. As a catalyst, it triggers changes in the spectator's total behaviour."[29] The possibility that Behaviourist Art is regulated by cybernetic principles seems valid in Ascott's opinion, as it appears to possess qualities such as the transmission of information represented by the artist's creative action, and adapts to the different environments it is exhibited in and to various audience responses. In order, however, for the art realm to accommodate modern notions stemming from science and technology, its new coding has to be deciphered by a literate audience. Behaviourist Art as proposed by Ascott arrived with a set of associated concepts which mediated the public's reception of the accompanying artworks. Among them, the notions of "cyberception," "moistmedia" and "cyberscapes" have been central to the comprehension of the digital imaginary in contemporary art. In the remainder of this section, the latter concepts will be examined as crucial elements in the construction and reception of cybernetic artworks.

Perhaps a more common term nowadays relating to the affluence of new media art in specialized galleries, on the market and in

28 Ibid., 100–101.

29 Ibid., 102.

individual homes is represented by "multimedia" and "multimediality." These words point to the interconnection of a variety of means of expression—from text to graphics and sound—in a given artefact. At the turn of the 21st century, however, Ascott had proposed a similar term in order to describe the confluence of numerous media types in the creation of art works, namely "moistmedia." His theorization purposefully distanced itself from the more established "digital media" and integrated aspects of organic and computational existence: "Between the dry world of virtuality and the wet world of biology lies a moist domain, a new interspace of potentiality and promise. …Moistmedia (comprising bits, atoms, neurons, and genes) will constitute the substrate of the art of our new century, a transformative art concerned with the construction of a fluid reality. This will mean the spread of intelligence to every part of the built environment coupled with recognition of the intelligence that lies within every part of the living planet."[30]

Moistmedia proved able to integrate elements pertaining to virtuality, digital architecture, corporeality and the organic environment in a way that surpassed mere simulations. In the particular case of Ascott's "LPDT2," the positioning of the performance within the digital environment of the platform *Second Life* does not necessarily signal a parting with what could be termed corporeal reality, due to its rootedness in textual sources pertaining to agents in the physical realm. The use of avatars and "textual architecture" at this point might serve simply to tackle potential future communication in the digital experiment without implying a mimicry of identities and spaces in the organic world[31] (fig. 3). In terms of physical presence, neither the avatars nor the text blocks acting as setting cancel the existence of organic bodies. Rather, they emphasize the act of communication unfolding beyond spatial and temporal boundaries.

30 Roy Ascott, "Edge-Life: technoetic structures and moist media," in Art, Technology, Consciousness: mind@large, ed. Roy Ascott (Bristol: Intellect, 2000), 1.

31 Roy Ascott, Selavy Oh, MosMax Hax, Alpha Auer, Frigg Ragu, INDAF, "LPDT2 avatars," Flickr (2010), video still. Accessed July 27, 2020. https://farm5.static.flickr.com/4088/4992957968_7d9e676da1_z.jpg.

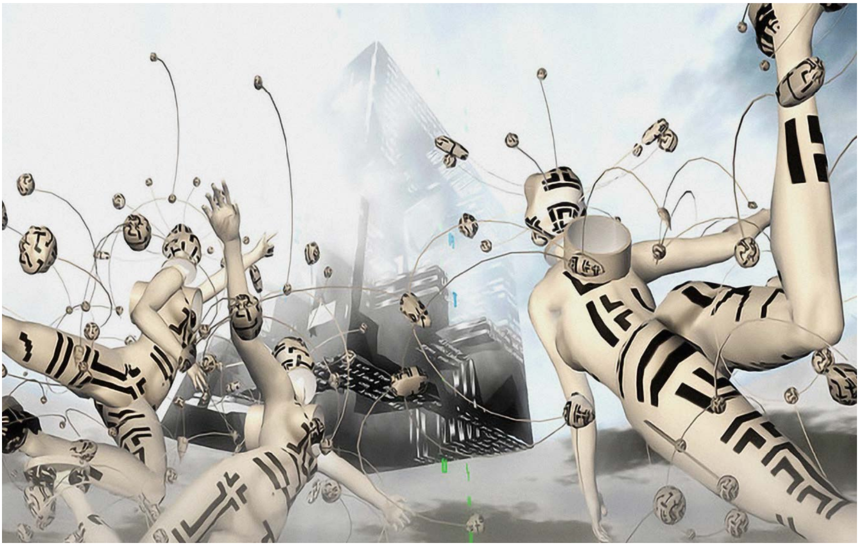

Fig. 3. Roy Ascott, Selavy Oh, MosMax Hax, Alpha Auer, Frigg Ragu and INDAF, "LPDT2 avatars," digital photograph, 2010. Source: https://www.flickr.com/photos/alpha_auer/4992957968/. Elif Ayiter. CC BY-NC-ND 2.0 (https://creativecommons.org/licenses/by-nc-nd/2.0/). Accessed October 13, 2022

This type of setting that flows beyond the organic into the digital has nevertheless been influencing perceptions of the physical world ever since its inception. What we now recognise as "cyberscapes" is the "representation of physical places on the Internet."[32] In "LPDT2," these spaces are spontaneously generated by users and render spatial information based on cues from the physical realm. The space portrayed in "LPDT2" is technologically mediated but nevertheless recognizably urban in that the arrangement of the text blocks resembles tall buildings and complex street structures. At the same time, these blocks seem to lay bare the intricacy of computer architecture, because the running text invokes programming models and input/output logic. To a certain extent, each element of "LPDT2" in *Second Life* signals distinctly on its own while creating a complex sensorial image that requires a particular set of skills to decipher.

32 Mark Graham and Matthew Zook, "Visualizing Global Cyberscapes: Mapping User-Generated Placemarks," Journal of Urban Technology 18, no. 1 (2011): 115.

Conclusion

Over the course of seventeen years, the trajectory of *Second Life*—almost a cultural shorthand for virtual reality technology—and its ability to remain current in the face of rapid technological advances has been met with a certain degree of surprise. The answer to the question of how this platform maintains a stable number of almost one million users annually might lie in the fact that it exhibits mobility and authenticity in its allowing outside content creators to add to the spatial and temporal universe it proposes.[33] This strategy of enriching and expanding the world aligns itself with the process of "distributed authorship" suggested by Ascott at the beginning of the 21st century and which is ever-present in contemporary artworks that blend digital and more traditional media.

This paper favoured an inductive approach to the issue of virtual space in the art sphere. By looking at a fluid performance from an artist who is also one of the pioneers of cybernetic art and a theorist of process-based artistic production, my analysis identified scientific aspects employed in artworks that favour the use of new technologies and their potential to enable experimental and playful communication. Thus, this paper considered the concepts of message, control and feedback at the level of content creation and regulation as factors that create expectation on the part of the spectator. These factors can trigger spontaneous interaction between content contributors and artwork, creating cyberscapes and a hybrid state of art "produsers."

The individual functions of artefacts such as "LPDT2"—communicational, informational, consumerist, visual—come together in what may be regarded as a "metasystem transition," suggesting new ways of perceiving immediate reality through the development of cyberception as a new sensorial capacity. What is alluded to in works such as Ascott's is the engendering of alternative, living knowledge and the evolution of the art product into

33 Dos Santos, "Second Life: game, simulator, or serious game?," 75.

a breathing organism capable of constructing spatial and temporal models through moistmedia, placing them in specific interactive contexts and supporting a novel, hybrid existence.

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PABLO MIRANDA CARRANZA

Making Sense without Meaning

Christopher Alexander and the Automation of Design

In his contribution to the influential "Architecture and the Computer" conference in 1964, Christopher Alexander summarised the reorganisation of intellectual labour that, beginning in the 19th century, became finally concretised in the technologies of the computer. In his opinion, computers should be regarded as nothing else than huge armies of clerks, stupid and without initiative, but able to follow to the letter millions of precisely written instructions. This essay examines how architectural design began being digitally transcribed so it would conform to the logics of these armies of clerks, through a close reading of the programs and computer code written by Alexander.

An outlandish machine

This is a story of how the capacities that once defined what an architect was became dislodged and incorporated into computers. Rather than spoken and discussed or historically recorded as discourse, this story was mostly written in computer code. Stories often begin in anecdotal places and with irrelevant events. The one told here started in the library of the now burned-down architecture school in Delft, sometime in the mid–1990s, when I first encountered Serge Chermayeff and Christopher Alexander's *Community and Privacy: Toward a New Architecture of Humanism* and the outlandish machine for generating designs that it described.[1] To use this machine, first one had to reduce a

1 Serge Chermayeff and Christopher Alexander, Community and Privacy: Toward a New Architecture of Humanism (Garden City/NY: Doubleday, 1963).

design to a list of requirements and their interdependencies. This description would then be fed into an IBM 704 computer running a program which would separate and organise the requirements into independent sets easily translatable into a design.[2] Chermayeff and Alexander's inspiration for this process was the Taoist butcher described in the *Chuang Tzu*, who could effortlessly cut an ox into distinct parts by sliding a knife between the interstices separating them. While their book eschewed any details about how the methods of this mystical butcher had been translated into a computer program, Alexander described them in some detail in his PhD thesis "Notes on the Synthesis of Form," defended in 1962 and published as a book two years later.[3] However, the actual code for Alexander's program was only available in the MIT research report R62-2, co-authored with engineer Marvin Manheim and published in July 1962 with the less ornate title *HIDECS 2: A Computer Program for the Hierarchical Decomposition of a Set Which Has an Associated Linear Graph*.[4] Alexander and Manheim's report included flowcharts, diagrams, explanations and code listings written in the FORTRAN Assembly Program, or FAP, for the IBM 709 computer (fig. 1). Materials such as these are usually excluded from traditional architectural historiographies, since they call for literacies foreign to their established discourses. To begin with, the addressees of computer code are both humans and machines, and to complicate things further, in contrast to historical writing tools, programming is a form of inscription which is able to write and read by itself.[5] The analysis of programs also needs, then, to include the objects of their reading, their inputs, as well as the products of their writing, their outputs.

2 Ibid., 149–163.

3 Christopher Alexander, Notes on the Synthesis of Form (Cambridge/MA: Harvard University Press, 1964).

4 Christopher Alexander and Marvin L. Manheim, HIDECS 2: A Computer Program for the Hierarchical Decomposition of a Set Which Has an Associated Linear Graph (Cambridge/MA: School of Engineering, Massachusetts Institute of Technology, 1962).

5 Friedrich A. Kittler, "There Is No Software," Stanford Literature Review 9, no. 1 (Spring 1992): 81–90.

Fig. 1: IBM 709. Image courtesy of International Business Machines Corporation, Dt. UrhR: International Business Machines Corporation

FAP, the programming language used in HIDECS 2, was a form of assembly language, and as such, it was tied to the particularities of the hardware of the IBM 709 it was written for. Architectural historian Alise Upitis has shown how closely linked Alexander's propositions were to the particular characteristics of the hardware he used.[6] Certainly the hardware and the expressive limitations of the FAP language must have influenced the concepts Alexander developed through them. It would still be possible to analyse this code today using, for example, an IBM 709 emulator running in a contemporary computer. In my examination and critique of Alexander's machine, I have chosen instead to translate the HIDECS 2 programs into the commonly used Python programming language.[7] This translation de-emphasizes the

6 Alise Upitis, "Alexander's Choice: How Architecture Avoided Computer-Aided Design c. 1962," in A second Modernism: MIT, architecture, and the 'techno-social' moment, ed. Arindam Dutta (Cambridge/MA: MIT Press, 2013), 474–505.

7 All code is available at gitlab.com/Zenbagailu/hidecs-2-python.

material and technical conditions behind the programs, but at the same time foregrounds the abstractions and concepts they implement, making it easier to clarify their relationships to coeval discourses and techniques. The code used in this text is mostly based on the flow charts of appendix C and descriptions in appendices D to F of the research report (fig. 2). Functions in the Python code have the same names as Alexander and Manheim's original subprograms, when they implement the same functionality. Like most software, HIDECS 2 was also a work in progress. Many of the descriptions of features in the document were not implemented as of December 1961 (when it ran on the MIT IBM 709) and are not described in detail in the report, even though some of them appear in the FAP listings of appendix G. A few of these features were completed in HIDECS 3 and were presented in a subsequent research report *Hidecs 3: Four Computer Programs for the Hierarchical Decomposition of Systems Which Have an Associated Linear Graph.*[8]

HIDECS 2 implemented the design method that Alexander would explain at length in *Notes on the Synthesis of Form*, published as a book in 1964. The objective of the method was to find a "good fit" between form, "a part of the world over which we have control," and a context, "that part of the world which puts demands on this form."[9] According to Alexander this good fit was typical of "primitive," "folk," "closed," or "anonymous" cultures, the result of an "unselfconscious" [sic] and slow process of adaptation and dynamic equilibrium between the complex demands of the context and forms, a process resembling the cybernetic principle of homeostasis. In contrast, modern "selfconscious" [sic] design was a response to the rapidly changing contexts of industrial societies. Whereas slow and "unselfconscious" adaptations needed no representation of the context, the "selfconscious"

8 Christopher Alexander, HIDECS 3: Four Computer Programs for the Hierarchical Decomposition of Systems which have an Associated Linear Graph (Cambridge/MA: School of Engineering, Massachusetts Institute of Technology, 1963).

9 Alexander, Notes on the Synthesis of Form, 15–27.

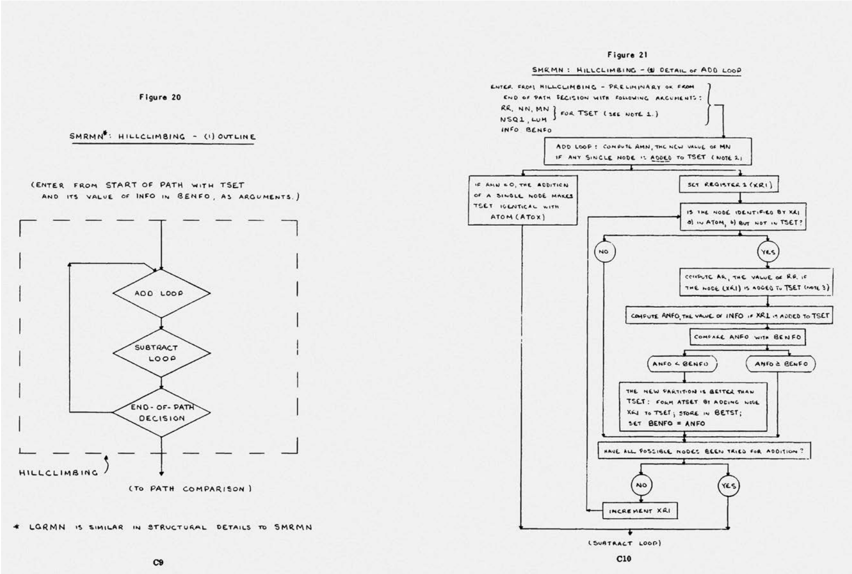

Fig. 2: Flow charts of the Hill Climbing procedure and detail of the add loop in *HIDECS* 2, 1962

designer worked from a mental picture of that context, a picture that, because of the changing and complex conditions, Alexander claimed, was almost always wrong.[10] Alexander's solution to this incongruity was to use the computer to calculate the picture, since only the computer could represent and resolve the complex interrelations of evolving contextual demands. This process would begin by a designer describing the context as a finite set of design requirements and their interdependencies, represented in the computer using a mathematical structure known as a graph. This graph would be instrumental in sorting requirements into a hierarchical description of interdependent subsets, which would correspond to a clear mental picture of the context. The report explained this process succinctly: "The input to the program is a graph; the output is a tree, a hierarchical ordering of the graph's vertex set and its partitioned subsets. Because of the correspondence between the graph and the problem, the tree which is

10 Ibid., 73–83.

obtained by the program provides an orderly scheme for dealing with the requirements posed by a particular problem."[11]

Alexander called this scheme "the program" since, as Manheim explained later, it defined a sequence of actions to solve the problem of finding a good fit.[12] The subsets of problems would be sufficiently simple to suggest their resolution, similar to how "diagrams of forces" dictated the biological form of radiolaria or molluscs, in D'Arcy Thompson's influential analyses of their morphology.[13] These independent design responses would then be composed according to the hierarchical order of the programme. While this mental picture of the context could be calculated, its resolution into a design, Alexander insisted, required invention, which was impossible to implement using the computer.[14]

Input: The snare of semiotics

"[A]s a rule, concepts are not generated or defined in extension; they are generated in intension. That is, we fit new concepts into the pattern of everyday language by relating their meanings to those of other words at present available in English."[15]

In these few lines Alexander laid out what was the concern of his method and algorithms: not the specific words defining a problem, but their interrelations. Alexander made explicit reference to philosopher Rudolf Carnap's distinction between "intension" and "extension," between conditions of signification and conditions of truth, that is, between the semiotic mechanisms that give rise to signification and the reality of the objects that are signified. Through his use of graphs (fig. 3) Alexander chose to identify the structure of the problem as the genuine source of its meaning,

11 Alexander and Manheim, HIDECS 2, 7.

12 Marvin L. Manheim, "Problem Solving Processes in Planning and Design," Design Quarterly 66/67 (1966): 31–39.

13 D'Arcy W. Thompson, On Growth and Form, new ed. (Cambridge: Cambridge University Press, 1942). Alexander, Notes on the Synthesis of Form, 21.

14 Alexander, Notes on the Synthesis of Form, 84–94.

15 Ibid., 67.

rather than looking for it in the actual requirements that described the problem.

This was in effect a transposition into design of the dualism between form and substance typical of structuralist semiotics.[16] However, rather than equating this difference with that between architectural form and its meaning, the path followed by formalist analysis and postmodernist architecture, Alexander envisaged design instead as the strictly linguistic problem of correctly representing a design program. Seventy years before, Gottlob Frege, Carnap's teacher and mathematics professor at the University of Jena, had first characterized this dualism which underpins Alexander's approach in terms of sense and reference: sense pertained to the relationships between objects, names or signs in their capacity to produce meaning (this would correspond to Carnap's concept of intension, as used by Alexander); reference would denote the reality or truth of a sign or a word.[17] By focusing on the structure of the problem represented as a graph, HIDECS 2 exemplifies the capacities of the computer to produce and make sense through its codes and logical forms, its diagrams and structures. But this is a "sense without meaning," one for which referent or substance are irrelevant, typical, in philosopher Maurizio Lazzarato's view, of the a-signifying semiotics of current technical and economic apparatuses.[18]

Alexander's use of graphs, as much as the rest of his sense-making toolbox, had its provenance in operations research and management science, where graphs had been extensively researched for their ability to analyze and optimize distribution networks and

16 Other examples of this form/content dualism are Ferdinand de Sassure's distinction between signifier and signified or Louis Hjelmslev's distinction between the two separate planes of expression and signification in linguistics. For an overview of the main theories of semiotics see Umberto Eco, A Theory of Semiotics, Advances in Semiotics (Bloomington/IN: Indiana University Press, 1976). For a critique of the basis of semiotics and structuralism: Jacques Derrida, Of Grammatology (Baltimore/MD: Johns Hopkins University Press, 1976).

17 Gottlob Frege, "Über Sinn und Bedeutung," Zeitschrift für Philosophie und philosophische Kritik 100 (1892): 25–50.

18 Maurizio Lazzarato, Signs and Machines: Capitalism and the Production of Subjectivity, trans. Joshua David Jordan (Los Angeles/CA: Semiotext(e), 2014).

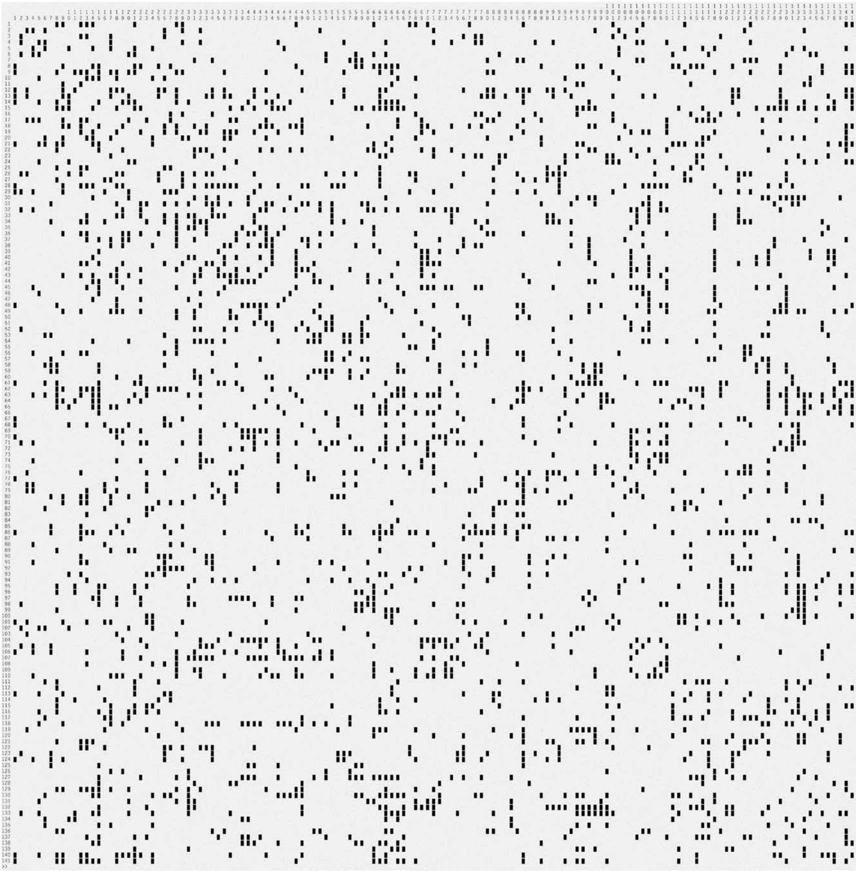

Fig. 3: Matrix of the graph of requirements for an Indian Village in "Notes on the Synthesis of Form," output of the Python implementation of HIDECS 2. Code by the author

logistic infrastructures.[19] In its intensional description of a design context, HIDECS 2 took as its input any design requirements and represented the structure of their interdependencies as a graph,

19 Examples of this research during the period led to well-known algorithms, such as the Ford-Fulkerson algorithm for calculating maximum flow: Lester Randolph Ford and Delbert R Fulkerson, "A Simple Algorithm for Finding Maximal Network Flows and an Application to the Hitchcock Problem," Canadian Journal of Mathematics 9 (1957). Another related example is the Hungarian method to solve the allocation problem: Harold W Kuhn, "The Hungarian Method for the Assignment Problem," Naval Research Logistics Quarterly 2, no. 1/2 (1955).

regardless of the actual requirements and the specific design problem they may have described: a kettle, a building, or an urban plan. These operations are symptomatic of the depoliticizing and depersonalizing effect that Lazzarato assigns to this "sense without meaning," which, by making heterogeneous spheres formally equivalent, integrates them into rationalized schemes of production.[20] They exemplify the abstraction and alienation that became the target of post-structuralist critiques of linguistic models from the late 1960s onwards, and to which Lazzarato's more recent analysis belongs. In what became a seminal contribution to post-structuralism, philosopher Jacques Derrida found it in the supposedly arbitrary relationship instituted between systems of signs and their objects, between their sense and their reference, a logic of alienation infused with western ethnocentrism, the result of understanding signs and representations exclusively through the principles of western phonetic writing.[21] The reduction of the design of an Indian village to a graph (fig. 3), used by Alexander in *Notes*, reads almost like a caricature of this ethnocentric depoliticization and depersonalization, of the techno-scientific objectivities of this "sense without meaning" that, according to Donna Haraway, are nothing else than the white man's gaze.[22] Requirements such as "Harijans regarded as ritually impure, untouchable, etc.," "Cattle treated as sacred, and vegetarian attitude," or "Need for elaborate weddings," are treated the same way as the specifications for a highway interchange,[23] a fuel pump, a jet engine or a tea kettle, all transformed into data by the digitalized techno-scientific gaze. In all its absurdity and

20 Lazzarato, Signs and Machines, 40–41.

21 Derrida, Of Grammatology, 50–51.

22 Donna Haraway, "Situated knowledges: The Science Question in Feminism and the Privilege of Partial Perspective," Feminist Studies 14, no. 3 (1988).

23 Christopher Alexander, Marvin L. Manheim and Massachusetts Institute of Technology, Department of Civil Engineering, The Design of Highway Interchanges: An Example of a General Method for Analysing Engineering Design Problems, research report (Cambridge/MA: Dept. of Civil Engineering, Massachusetts Institute of Technology, 1962).

colonial mentality, the process recalls the exhilarating irrationality of a Raymond Roussel novel.[24]

This feeling of absurdity is not just the product taking the distinction between intension and extension, between sense and reference, to the extreme, but also the consequence of stating and considering the problem in terms of its mathematical form. At a technical level, the method chosen by Alexander for finding optimal subsets of requirements was so computationally complex from the outset that the problem he posed was intractable in practice. The reason for this is that the total number of potential partitions in a set grows exponentially with the number of its elements, given by its power set—the amount of all possible sets—divided by two, that is 2^{n-1} (where n is the number of elements, in this case design requirements). The example of the Indian village in *Notes* had 141 elements, with results in 2^{140}, or 1,393,796,574, 908,163,946,345,982,392,040,522,594,123,776 potential subdivisions, all of which would need to be checked in order to find an optimal partition. These large numbers are unmanageable for humans, and in practice also for machines. A program running millions of times faster than the Python version written for this paper, taking one picosecond to do the same calculation that now takes 40 microseconds, would still need 44,196,999,458 billion years to consider each possible subdivision. These numbers clearly represent inhuman amounts of work, a burden of a cosmic order even for a machine. The reason for Alexander to propose such a convoluted method can only be justified because it would enable him to use another instrument in his sense-making toolbox: heuristics. Problems of this complexity can only be computationally approached using methods that provide good enough solutions, rather than optimal ones.

24 I am thinking specially of "Impressions of Africa." Raymond Roussel, Impressions d'Afrique (Paris: A. Lemerre, 1910). Half a century later, partly inspired by Roussel's work, the OuLiPo group used computational methods similar to those of Alexander to generate a literature that embraced their mechanical irrationality as one of its defining qualities: Warren F. Motte and OuLiPo, OuLiPo: A Primer of Potential Literature (Lincoln/NE: University of Nebraska Press, 1986). For a description of the role of modern mathematics in work associated with OuLiPo: Alice Bamford, "Mathematics and Modern Literature: Passages from 'Chalk and the Architrave,'" New Left Review, no. 124 (2020).

Program: clerks that climb hills

"A DIGITAL COMPUTER is, essentially, the same as a huge army of clerks equipped with rule books, pencil and paper, all stupid and entirely without initiative, but able to follow exactly millions of precisely defined operations. There is nothing a computer can do which such an army of clerks could not do, if given time."[25]

Heuristics, and for that matter, much of Alexander's approach to design, where influenced by the then new fields of artificial intelligence and cognitive science. These in turn belonged to a history of automation of human thought that already begun more than a century earlier, as it was explained by economist Herbert Simon, an initiator of both fields and a main reference in Alexander's work. In his introduction of the concept of heuristics at to the Operations Research Society Of America (ORSA) in 1957, Simon recapitulated the common history of the computer and operations research. When mathematician Gaspard de Prony was faced with the enormous task of calculating logarithmic and trigonometric tables for the French cadastre immediately after the French Revolution, he decided to apply Adam Smith's principle of the division of labour—illustrated in *The Wealth of Nations* through the manufacturing of pins—to the menial work involved in mathematical reckoning. A few decades later Charles Babbage, the putative father of the computer, took the next step by replacing this readily fragmented and disciplined clerical labour with machinery. In addition to describing the history of the computer as that of the mechanization of intellectual work, Simon also outlined the future of operations research (OR) in expanding its scope from the 'well structured' management problems with which the field had been concerned since its beginnings in the Second World War, to the 'ill structured' ones that made up the majority of (and most important) top-level management and executive problems. His proposal was "to handle

25 Christopher Alexander, "The Question of Computers in Design," Landscape 14, no. 3 (1965).

with appropriate analytic tools those problems that we now tackle with judgement and guess" through a "theory of heuristic (as contrasted to algorithmic) problem solving." This could be used then "both to understand human heuristic processes and to simulate such processes with digital computers." Through such a theory, intuition, insight, and learning would no longer be the exclusive domain of humans, as any large high-speed computer could also be programmed to exhibit them.[26]

The translatability of human thought into computation was only possible if the mind was also considered a kind of computing device, executing thinking processes as its programs. This was precisely the central premise of the new field of cognitive psychology. Alexander explicitly referred to the work of psychologist George Miller, founder of the Center for Cognitive Studies at Harvard with which Alexander collaborated. His seminal paper "The Magical Number Seven, Plus or Minus Two" empirically investigated the storage capacity of people's short term memory, and the general capacity of the human mind to store and transmit data. Miller proposed an equivalent to the bit, what he called the "chunk": the information unit of the mind, and described the limit of human processing as about "seven plus or minus two" "chunks" at a time, with a transmission speed of about five seconds.[27] These defined the computational constraints of the human mind in terms of CPU registers and speed. It was with such a limited hardware that heuristic processes were originally run, that is, with the algorithms of the mind.[28] The economic significance of understanding human cognition as a series of computational processes earned Herbert Simon the Nobel Prize in Economics in 1978. His idea of "bounded rationality" supplemented the conceptual limitations of rational choice, a central idea in the classical economics of Adam Smith or David Ricardo, as it considered

26 Herbert A. Simon and Allen Newell, "Heuristic Problem Solving: The Next Advance in Operations Research," Operations Research 6, no. 1 (1958).

27 George A. Miller, "The Magical Number Seven, Plus or Minus Two: Some Limits on Our Capacity for Processing Information," Psychological Review 63, no. 2 (1956).

28 Herbert A. Simon, The Sciences of the Artificial, Karl Taylor Compton Lectures (Cambridge/MA: MIT Press, 1969).

the limited computational and informational capabilities for making rational inferences by individual actors.[29]

If the argument was that the mind was a computer, and a bad one at that, it is reasonable to conclude that the remedy to its limitations must be the use of actual computers with higher processing capacities. In order to contend that any activity is worthy of computerization, it must be presented as complex enough to exceed human capacities for cognitive labour. It thus became imperative for Alexander to present design as a computational task of such complexity that it would necessarily exceed the "seven plus or minus two chunks" of human memory (and its five second of transmission speed). Also, by assigning it a high order of complexity, the solution of a design problem would require the application of heuristic methods belonging to the new field of artificial intelligence. But despite any Promethean claims about AI, the computational clerk that would take over design could operate the very simple procedure described in the following lines in Python:

```
def addLoop(graph, vSet, vSub):
     selected = min( {el for el in vSet if el not in vSub}, key = lambda el : calculateGraphInfo(graph,vSet,vSub | {el}))
     return selected if calculateGraphInfo(graph,vSet,vSub | {selected}) < calculateGraphInfo(graph,vSet,vSub) else None

def subtractLoop(graph, vSet, vSub):
     selected = min(vSub, key = lambda el : calculateGraphInfo(graph,vSet,vSub - {el}))
     return selected if calculateGraphInfo(graph,vSet,vSub-{selected}) < calculateGraphInfo(graph,vSet,vSub) else None

def hillClimb(graph, vSet, vSub):

     while True:
          toAdd = addLoop(graph,vSet,vSub) if len(vSub) < len(vSet) - 1 else None
          if toAdd:
               vSub.add(toAdd)

          toSubtract = subtractLoop(graph,vSet,vSub) if len(vSub)>1 else None
          if toSubtract:
               vSub.remove(toSubtract)

          if not toAdd and not toSubtract: #if it could not improve
               break

     return vSub
```

Fig. 4: The hill-climbing algorithm. Code by the author

The code above (fig. 4) describes a *hill climber*, a type of algorithm used extensively in mathematical optimization methods. Its name refers to the heuristic it employs, which can be compared to finding a summit in a terrain by examining points immediately

29 Incidentally, Simon's idea were partly inspired by neoliberal economist Friedrich Hayek, who had also argued that the price system would overcome the limitations of individual rational choice. Herbert A. Simon, Models of Man: Social and Rational. Mathematical Essays on Rational Human Behavior in a Social Setting (New York/NY: Wiley, 1957).

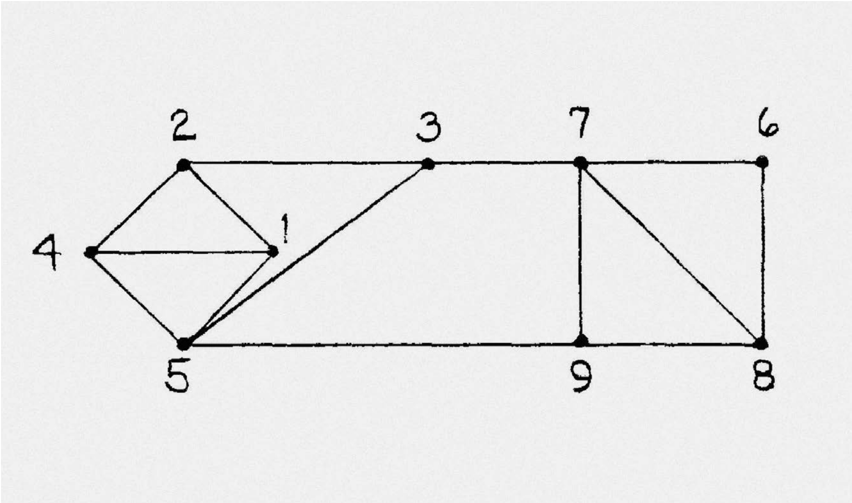

Fig. 5: Example diagram from the HIDECS 2 report, Christopher Alexander and Marvin Manheim

close to the present location, moving to the highest one, and repeating the operation until no higher points can be found. The hill top reached will be higher than its surroundings (a local maximum), but not necessarily the highest (a global maximum). Hill climbing belongs to a class of optimization techniques known as greedy algorithms, since these cannot consider trade-offs between temporary losses and longer term gains (the *hill-climber* cannot go down a valley to reach a higher peak). The limitations of greed as a strategy are compensated however by the simplicity of its implementation.

In the Python translation of HIDECS 2, this heuristic is implemented as follows: the hill climbing function, declared as *def hillClimb()*, takes three parameters as its input: a *graph*, describing the interdependencies between all the requirements; *vSet*, the actual set of requirements to be partitioned; and *vSub*, a subset of requirements, representing one half of a tentative partition. The function iteratively calls *addLoop*, which discovers whether the partition can be improved by moving any requirement to its *vSub* half; subsequently, *subtractLoop*, tests for improvements in moving some requirement from the *vSub* set to the other half. If no improvements can be made, the algorithm has found a relatively optimal partition and returns it to the main process, which will continue trying to further subdivide it. Otherwise, if improvements are still possible, it repeats the same process until no improvements are found. The scores for each partition, calculated through the *calculateInfo* function, describe how interdependent the two halves are, while the goal of the hill-climber is to find a cut in which the two halves are as interdependent as possible.[30] The testing of partitions against a value (equivalent to the height of a terrain), and its incremental improvement, is analogous to the described hill-climbing procedure. Below (fig. 6) is the result of applying the Python code to one of the graphs (fig. 5) from the research report.[31] That the graph did not correspond to a real problem or program is just another example of the split between sense and reference at work. The numeric meanderings of the hill climbing—or rather "hill descending," as the program tries to minimize a value—start from an arbitrary partition with indices {8, 3, 5} on one side and {1, 2, 4, 6, 7, 9} on the other. The printout shows the different tests and incremental improvement of the values (fig. 6).

The main process begins dividing all the requirements in half, using the hill climbing heuristic just described, and further applying the same procedure to each resulting partition, subdividing the requirements until no more subdivisions are possible. Code (fig. 4) and printouts (fig. 6) demonstrate how these prosaic "armies of clerks" reorganized what were once human capacities by: first, treating thought as labour that can be mechanized; second, pointing out the effective limits of human cognition in comparison with machines; and third, by arguing how the increasing complexity of intellectual tasks exceeds human cognitive capabilities, and thus requires the use of mechanized computational labour. In this redefinition of intelligence, the technocratic discourses of operations research, cognitive science, and artificial intelligence present both a problem—bounded rationality—and its solution, through the redistribution and incorporation

30 Alexander, Notes on the Synthesis of Form, 190.

31 Alexander and Manheim, HIDECS2, 6.

```
                                         requirements set A        requirements set B      Information value
-----------------------------------------------------------------------------------------------------------------------------------
Initial partition to test.                        {8, 3, 5}        {1, 2, 4, 6, 7, 9}      |                         |     0.003086

                                               {8, 1, 3, 5}   1 <- {2, 4, 6, 7, 9}         |                           |   0.004668
                                               {2, 3, 5, 8}   2 <- {1, 4, 6, 7, 9}         |                           |   0.004668
                                               {3, 4, 5, 8}   4 <- {1, 2, 6, 7, 9}         |                           |   0.004668
information value improved.                    {3, 5, 6, 8}   6 <- {1, 2, 4, 7, 9}         |                       |       0.000154
                                               {3, 5, 7, 8}   7 <- {1, 2, 4, 6, 9}         |                       |       0.000154
information value improved.                    {3, 5, 8, 9}   9 <- {1, 2, 4, 6, 7}         |                   |          -0.001890
Improvement found, use new partition:          {3, 5, 8, 9}        {1, 2, 4, 6, 7}         |                   |          -0.001890
information value improved.                       {8, 9, 5}   3 -> {1, 2, 3, 4, 6, 7}      |                 |            -0.003086
                                                  {8, 9, 3}   5 -> {1, 2, 4, 5, 6, 7}      |                     |         0.000000
                                                  {9, 3, 5}   8 -> {1, 2, 4, 6, 7, 8}      |                 |            -0.003086
                                                  {8, 3, 5}   9 -> {1, 2, 4, 6, 7, 9}      |                         |     0.003086
Improvement found, use new partition:             {5, 8, 9}        {1, 2, 3, 4, 6, 7}      |                 |            -0.003086
                                               {1, 5, 8, 9}   1 <- {2, 3, 4, 6, 7}         |                   |          -0.001890
                                               {5, 2, 8, 9}   2 <- {1, 3, 4, 6, 7}         |                           |   0.004668
                                               {5, 3, 8, 9}   3 <- {1, 2, 4, 6, 7}         |                   |          -0.001890
                                               {5, 4, 8, 9}   4 <- {1, 2, 3, 6, 7}         |                   |          -0.001890
information value improved.                    {5, 6, 8, 9}   6 <- {1, 2, 3, 4, 7}         |               |              -0.009877
                                               {5, 7, 8, 9}   7 <- {1, 2, 3, 4, 6}         |               |              -0.009877
Improvement found, use new partition:          {5, 6, 8, 9}        {1, 2, 3, 4, 7}         |               |              -0.009877
information value improved.                       {8, 9, 6}   5 -> {1, 2, 3, 4, 5, 7}      |         |                    -0.027778
                                                  {8, 9, 5}   6 -> {1, 2, 3, 4, 6, 7}      |                 |            -0.003086
                                                  {9, 5, 6}   8 -> {1, 2, 3, 4, 7, 8}      |                     |         0.000000
                                                  {8, 5, 6}   9 -> {1, 2, 3, 4, 7, 9}      |                     |         0.000000
Improvement found, use new partition:             {6, 8, 9}        {1, 2, 3, 4, 5, 7}      |         |                    -0.027778
                                               {1, 6, 8, 9}   1 <- {2, 3, 4, 5, 7}         |                   |          -0.001890
                                               {2, 6, 8, 9}   2 <- {1, 3, 4, 5, 7}         |                   |          -0.001890
                                               {3, 6, 8, 9}   3 <- {1, 2, 4, 5, 7}         |                   |          -0.001890
                                               {4, 6, 8, 9}   4 <- {1, 2, 3, 5, 7}         |                   |          -0.001890
                                               {5, 6, 8, 9}   5 <- {1, 2, 3, 4, 7}         |               |              -0.009877
information value improved.                    {6, 8, 9, 7}   7 <- {1, 2, 3, 4, 5}         ||                             -0.104321
Improvement found, use new partition:          {6, 8, 9, 7}        {1, 2, 3, 4, 5}         ||                             -0.104321
                                                  {8, 9, 7}   6 -> {1, 2, 3, 4, 5, 6}      |         |                    -0.027778
                                                  {9, 6, 7}   8 -> {1, 2, 3, 4, 5, 8}      |             |                -0.012346
                                                  {8, 6, 7}   9 -> {1, 2, 3, 4, 5, 9}      |     |                        -0.049383
                                                  {8, 9, 6}   7 -> {1, 2, 3, 4, 5, 7}      |         |                    -0.027778
No improvement, use previous partition:        {6, 8, 9, 7}        {1, 2, 3, 4, 5}         ||                             -0.104321
                                            {1, 6, 8, 9, 7}   1 <- {2, 3, 4, 5}            |           |                  -0.024113
                                            {2, 6, 8, 9, 7}   2 <- {1, 3, 4, 5}            |           |                  -0.024113
                                            {3, 6, 8, 9, 7}   3 <- {1, 2, 4, 5}            |   |                          -0.071335
                                            {4, 6, 8, 9, 7}   4 <- {1, 2, 3, 5}            |           |                  -0.024113
                                            {5, 6, 8, 9, 7}   5 <- {1, 2, 3, 4}            |       |                      -0.044599
No improvement, use previous partition:        {6, 8, 9, 7}        {1, 2, 3, 4, 5}         ||                             -0.104321
                                                  {8, 9, 7}   6 -> {1, 2, 3, 4, 5, 6}      |         |                    -0.027778
                                                  {9, 6, 7}   8 -> {1, 2, 3, 4, 5, 8}      |             |                -0.012346
                                                  {8, 6, 7}   9 -> {1, 2, 3, 4, 5, 9}      |     |                        -0.049383
                                                  {8, 9, 6}   7 -> {1, 2, 3, 4, 5, 7}      |         |                    -0.027778

best partition found by hill-climber:          {6, 8, 9, 7}        {1, 2, 3, 4, 5}         ||                             -0.104321
-----------------------------------------------------------------------------------------------------------------------------------
```

Fig. 6: Optimising a partition of a graph (fig. 5) by the Python version of HIDECS 2. Code by the author

of previous inalienable human constituents within their computational systems and assemblies. The new place of design in these apparatuses is apparent in the diagram that is the output of HIDECS 2 (fig. 7). It has become the fragmented task of resolving singular problems (in this case the conflicts between sets of requirements, grouped together in the diagram into columns) according to the dictates of the technical systems effectively distributing design as intellectual labour.

Output: not seeing the forest for the trees

"Design today has reached the stage where sheer inventiveness can no longer sustain it. To make adequate forms, one must be able to explore the relations between circumstances more fully

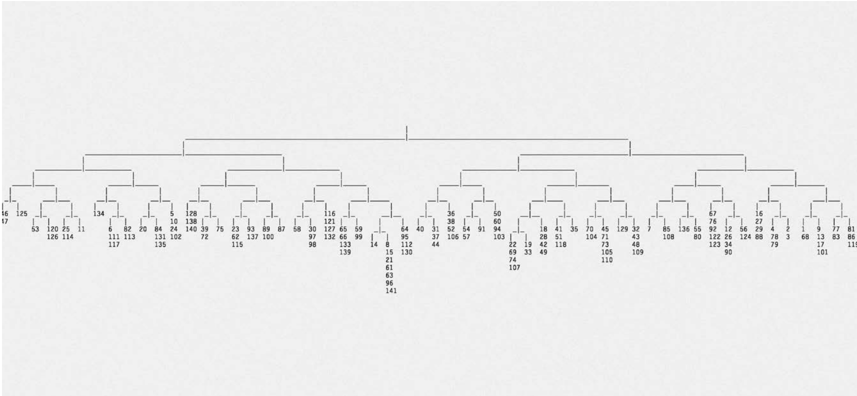

Fig. 7: Output of Python HIDECS 2: Hierarchical decomposition into subsets of the requirements for an Indian Village

than is done at present, so that the decision as to just where to apply precious and limited inventive power can be made. Fortunately, large computers and the techniques for data-processing have become generally available in the past decades."[32] Alexander defined the output of the hill-climbing procedure as "the program": a hierarchical decomposition of design requirements that could be tackled in a predetermined order, and which could be visualized as a tree. This program distributed design as cognitive labour so that intellectual resources could be used more effectively. Herbert Simon and his collaborator at Carnegie Mellon, political scientist James March had already applied a similar factorization to the whole organizational complex of bureaucracies and corporations, so that a number of nearly independent parts would make them "sufficiently simple to be encompassed by a human mind."[33] According to Simon, hierarchical structures could be found in biological form, in society and even in the structure of the universe. They defined an "architecture of complexity" that was either inherent in nature, or simply the result of human cognitive limits, placing non-hierarchical systems "beyond our

32 Chermayeff and Alexander, Community and Privacy, 161.

33 James G. March and Herbert A. Simon, Organizations (New York/NY: Wiley, 1958), 152.

capacities of memory or computation."[34] Organizational structures could become naturalized this way, either as an inherent property of the cosmos or as a category of cognition. This naturalization also made them prescriptive: corporations, urban proposals, and design practice should all follow this natural ordering principle. But it only took Alexander a couple of years to dismiss the hierarchical diagrams he had so vehemently defended and to present, with the same conviction, a "semi-lattice" as an abstract ordering principle in "A City is Not a Tree."[35] These semi-lattices were, unsurprisingly, nothing other than the output of the SIMPX and EQCLA programs of HIDECS 3, the successor to HIDECS 2.[36] In 1967, three years after the publication of *Notes* and on the other side of the Atlantic, Gilles Deleuze dissected what was then the dominant movement in continental philosophy in "How Do We Recognize Structuralism?" Deleuze proposed that what was specific to this movement was the introduction of the symbolic as a third order or regime, which mediated between the differentiation of the real and imaginary and became the substratum of both at the same time. In this symbolic regime, structural objects were defined by "elements which claim to account both for the formation of wholes and for the variation of their part." These elements have "neither extrinsic designation, nor intrinsic signification … they have nothing other than a sense: a sense which is necessarily and uniquely 'positional.'"[37] Deleuze's succinct description of structuralism explains the reason for Alexander and Simon's commitment to hierarchies and trees. The symbolic of mathematical formulas, programs, and software became the substratum of the real—the architecture of complexity—and of its incarnation into the imaginary in the form of projects and proposals. It also explains how easy it was to shift this commitment to new diagrams that, operating within the order of the symbolic, could

34 Herbert Simon, "The Architecture of Complexity," Proceedings of the American Philosophical Society 106, no. 6 (1962).

35 Christopher Alexander, "A City is Not a Tree" (paper presented at the Architectural Forum, 1965).

36 Alexander, HIDECS 3: Four Computer Programs.

37 Gilles Deleuze, Desert Islands and Other Texts, 1953–1974 (Los Angeles/CA: Semiotext(e), 2004).

restructure both the real and the imaginary, since their allegiance was not towards specific structures, but to the order of the symbolic manifest in the computer. Lazzarato has explained how sign machines like diagrams and programs "do not speak but function."[38] They make the symbolic operative, not as models or representations, but by producing and enacting the positional sense that Deleuze gave to structures. In the trees that are the output of HIDECS 2 (or the semi-lattices of HIDECS 3), this new sense of design is in its given position as a capacity irreducible to computation, but bounded and organized within a structure of control that distributes it as cognitive labour. Architects today do not use a design method that even Alexander renounced already in the preface to the 1971 edition of *Notes*. But schemes not too different from the diagrams of HIDECS 2 and HIDECS 3 now integrate architectural capacities into the workflows of building information modelling (BIM). According to its proponents in the software industry and architectural practice, BIM's unified digital models facilitate coordination between the increasingly large number of experts involved in building production, enabling "higher quality work, greater speed, and improved cost effectiveness for the design, construction, and operation of buildings."[39] Parametric design, another current digital design technology, has made complexity not just a problem to solve, but a sought-after effect; the generation of varying geometries implies impossible amounts of work if hand drawn, and their physical realization through robotic processes unachievable with traditional methods of mass production or by any artisanal means. Either as an unavoidable condition or as a desired characteristic, this complexity is today mediated through the same analytic and methodical factorization identified in HIDECS 2. In the case of BIM, through strategies for the management, distribution, and allocation of specialized tasks

38 Lazzarato, Signs and Machines, 115.

39 BIS Autodesk, "Building Information Modelling," Autodesk Inc. White Paper, San Rafael, CA (2002).

within the design and construction of a building; in parametric design, through the composition of procedures and algorithms (proprietary or often freely contributed by members of online communities) into digital workflows. Behind these current trends we can identify arguments similar to those of Alexander: that the use of computers leads to efficient ways of distributing design work, which is a necessary response to architectural production processes that are too complex to tackle without their mediation. The capacities that defined the figure of the humanist architect, disciplined through the different institutions that regulate the instruction of these capacities and their application in practice, have been factorized and redistributed into new positions by the computer, positions that are often literally those in front of a CAD terminal. These technical systems and structures distribute and integrate increasingly specialized competences to resolve what is presented as the inhumanly complex task of design. The insertion of this symbolic order of the computer also leaves architecture at the mercy of any future reorganizations, which tend to follow a logic of technological progress and obsolescence. Oblivious to the capacities of software as an operational ideology, we submit to the repositions and distributions they perform on us, and which are their "sense without meaning."

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GREGORY ELIAS CARTELLI

Machines, Fabrics, and Models

ARTORGA and Biology's Cybernetic Utopia

In the mid-1950s, the investment banker Oliver Wells, the operations researcher Stafford Beer, and the cybernetician Gordon Pask collaborated on an experimental publication, ARTORGA*. ARTORGA was a series of experiments that sought to revise cybernetics' disciplinary history, claiming its origins in biology rather than information theory and operations research. The project represented an effort to retain both biological complexity and organic matter in the conception and construction of organizational structures. ARTORGA's proposition of a textile logic of "fabric" can be read as a moment of resistance that prompts a reconsideration of how architecture's attention to the biotic was translated into the computational.*

An invitation

"The first organism will be one which helps to design itself. This and further papers will be the fabric of the organism. It is hoped that you will participate as part of this organism. (you are being invited to act like a cell in the organism)."[1]

Copies of this invitation, part of a three-page document titled "ARTORGA (ARTificial ORGAnism)," were mailed to roughly 4,000 specialists in biology, operations research, and electronics in December, 1958. The mimeographed pages detailed this organism's premise, technique, practice, and mode of development.

1 ARTORGA, no. 1 (December 1958): n. p.

ARTORGA was founded on the belief that a machine, which functioned as an organism, could be created by applying certain parameters onto material, broadly construed. In order to generate its techniques, ARTORGA utilized a non-deterministic approach. The invitation asked recipients what they considered to be the essential principles of life, what could be viable materials for its artificial versioning, and what role design played in evolution and growth: "is it necessary to predict the behaviour of the organism?"[2]

For ARTORGA's founders, the retired investment banker Oliver D. Wells, the operations researcher Stafford Beer, and the polymath cybernetician Gordon Pask, the answer to this question was resoundingly negative. Instead, they proposed that ARTORGA's behaviour be autonomic. ARTORGA's first monthly mailer, referred to as the organism's "communications," noted that it had "no specified aim other than to be"[3]; its sixth declared that its process was "to imitate the living, to develop slowly and with no specified goal."[4] Wells, Beer, and Pask framed the indeterminate teleology of the living as a fundamental technique in order to extrapolate the autonomy of biological life into a larger ideology of self-design, one intended to effect the materiality of the technological, the operation of the artifactual, and, ultimately, to prompt a reconceptualization of knowledge itself. A new form of the present, redefined and reoriented by a biological a-priori, would fulfil their vision of a world in which an inherent, albeit abstracted, humanism would counter the dehumanizing and, more importantly, inorganic processes of mechanization and automation. Operating across scientific, aesthetic, and industrial spheres, Wells, Beer, and Pask understood their biological retrenchment as a progressive position from which to reassert the importance of the organism, if not of a certain organicism.

2 Ibid.

3 Ibid.

4 ARTORGA, no. 6 (May 1959). For clarity, ARTORGA as an object will be referred to in the indefinite singular *it* and *its*. As a subject, with agency ascribed to Pask, Beer, and Wells, its pronouns will be *they* and *their*.

The various projects encapsulated under the title ARTORGA—from the investigation of the utility of organic fabric to the instantiation of the periodical's organismic network and to the production and sale of a device called the "Penrose Machine"—were all premised on the possibility of utilizing biological principles to generate new epistemologies. This was more than simply a restatement of the "elementary order" which characterized the mimetic behaviour of Organicism, a substitute for the unitary rhetoric of holism, or even a reference to the organizational paradigms developed during the 1950s, wherein series of agentive forces and objects were presumed to find coherence within a total form. Further, its brand of vitalism was not one derived from metaphysics or otherwise abstract or dematerialized principles, but, instead, was drawn from biological matter itself. ARTORGA's focus on the utility of the living can thus be linked to the impact of what period rhetoric would refer to as "biological thinking" or, as one of the group's members proclaimed, a "Bio-Logic."[5] However, the difference between life and knowledge was not as clear as it might appear. Ultimately, epistemology was to be seen as a biology unto itself as it was when Pask would mix their meanings by rhetorically posing the possibility of constructing machines that might induce "new kinds of biologies" and "bio-social engines" just before putting that theory into practice.[6]

A body

Premised on the possibility of autonomically generating organic principles for the production of "artificial organisms," ARTORGA's import rests in its recuperation of biology as a viable agent of design writ large. By departing from the mechanical and

5 Heinz von Foerster, "Bio-Logic," in Biological Prototypes and Synthetic Systems, eds. E. E. Bernard and M. A. Kare (New York/NY: Plenum Press, 1962). Von Foerster makes the case here for an understanding of the "fundamental principle of living things their capacity to form coalitions," a conception related to ARTORGA's work with "fabrics."

6 Gordon Pask, untitled notes, 1953; Gordon Pask Archive; The Archive of Complexity at the Institute of Contemporary History; Universität Wien, Austria; 11_32-199-1.

organizational bias of computation and Operation Research's concept of "command and control"—which was reflected in contemporaneous architectural discourse and practice through early parametric designs—ARTORGA represents a materially sensitive conception of computational architecture, one linked to the biological imaginary of the post-war period. For example, while the Italian architect Luigi Moretti was querying the relationship between form and structure, his system of ordered differences creating a proto-semiotics of design and his modified military equations generating curvilinear forms in a transparent mathesis of structure, Wells, Beer, and Pask were content to let the intractability of the organic drive their experimental procedures (fig. 1).[7] Their consideration of biological life as a method, rather than a model, provides a case that allows us to revisit and revise the aspirations of the assembly-driven superstructures of the 1960s.[8] Though during the tenure of ARTORGA's operation, Pask and Beer were not (yet) architects in the disciplinary sense, their work during this period can be used to rethink their later architectural projects, which have often been cast by architects and architectural historians as a valorisation of the technological, and as a dematerialization of the body for the sake of its structure. For instance, Pask's technical programming for Cedric Price and Joan Littlewood's Fun Palace was derived from his earlier work with the organic systems considered in ARTORGA's experiments. Beer's Cybersyn Project for the Allende regime in Chile was similarly premised on models of stability he viewed as fundamentally biological—going so far as to argue, in 1964, that cybernetics had "sprung from biology" instead of developing from information

7 Luigi Moretti, Exhibition of Parametric Architecture and of Mathematical and Operational Research in Town-planning (Milan: Palazzo dell'arte, 1960).

8 These vertical or horizontal superstructures and megastructures based on the grid as a principle of total design, by architects such as Ionel Schein, Claude Parent, Yona Friedman, et. al. represented the techno-imaginary of the "spatial urbanists" of the 1950s and 1960s as analyzed by the architectural historian Larry Busbea. Busbea remarks how the key programmatic ideals of these architects were "portability, transportability, movement, and adaptation." While similar in kind to the goals of ARTORGA and its biological architects, they differed vasty in method. See Larry Busbea, Topologies: The Urban Utopia in France, 1960–1970 (Cambridge/MA: The MIT Press, 2007).

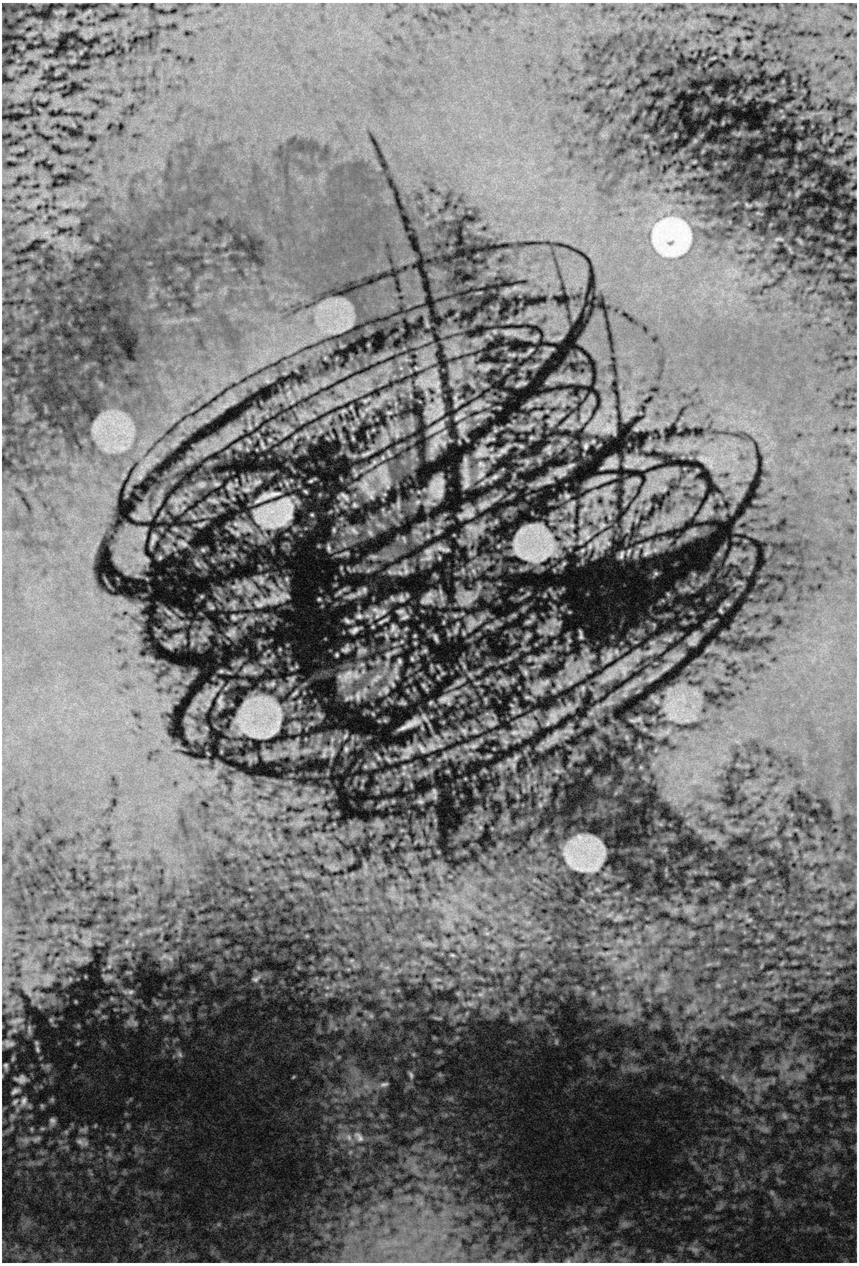


Fig. 1: Cover image of *ARTORGA*, no. 6 (May 1959). Source: *ARTORGA*, no. 6 (May 1959)

theory or operations research.[9] This disciplinary revision was rooted in the period's understanding of biological matter as a reparative media: a conceptualization of the generative potential of life.

These operations contrast conventional narratives concerning the emergence of information theory in the immediate post-war period. These narratives affirm that the repurposing of wartime technologies and disciplines for peacetime purposes led to the proliferation of informational representations of the organic body, which numerically and symbolically rendered its capacities and behaviours.[10] The premise and promise of these operations lay in their relationship to systems of control: the hope that yet another post-war reconstruction could be enacted. However, this time it would not be a reconstruction of the city or the state but a reconstruction of the self. As the historian of science Peter Galison notes, in the earliest strains of the cybernetic interdiscipline, it was not that humanism, physiology, or demography would define this new personhood, but rather that the overriding belief that servomechanical theory, the reduction of human agency to an almost behaviourist formula of mechanical inputs and outputs, "would become the measure of man."[11] Following on from this premise, the architectural historian Reinhold Martin has related

9 Stafford Beer, "The World, The Flesh, and the Metal: The Prerogatives of Systems," Nature 205, no. 2968 (1965): 234. See also Pamela M. Lee, Think Tank Aesthetics: Midcentury Modernism, the Cold War, and the Neoliberal Present (Cambridge/MA: The MIT Press, 2020). Eden Medina, Cybernetic Revolutionaries. Technology and Politics in Allende's Chile (Cambridge/MA: The MIT Press, 2011).

10 See Lily E. Kay, Who Wrote the Book of Life?: A History of the Genetic Code (Stanford/CA: Stanford University Press, 2000). For a more varied selection, see Bernard D. Geoghegan, "From Information Theory to French Theory: Jakobson, Lévi-Strauss, and the Cybernetic Apparatus," Critical Inquiry, no. 38 (Autumn 2011): 96–126. Geoffrey C. Bowker, "How to Be Universal: Some Cybernetic Strategies, 1943–70," Social Studies of Science 23, no. 1 (Feb. 1993): 107–127. Fred Turner, From Counterculture to Cyberculture, Stewart Brand, The Whole Earth Network, and the Rise of Digital Utopianism (Chicago/IL: University of Chicago Press, 2006).

11 Peter Galison, "The Ontology of the Enemy: Norbert Wiener and the Cybernetic Vision," Critical Inquiry 21, no. 1 (1994): 233. Bowker, op. cit. proposes the term "interdiscipline" to characterize the variety of professions, fields, and practices, that together composed "cybernetics." In adopting this term, I look to highlight the particular European formation of cybernetics which consisted of greater disciplinary variety than did the American branch which, as Galison notes, was primarily defined by servo-mechanical theory first developed within the American war-machine.

these base practices of cybernetic control to the development of "efficient mechanisms of self-organization... [which] helped invent new kinds of cities, new kinds of architectures, and with them a new 'self.'"[12]

But such a narrative relies on the fact that cybernetics not only predicated a collapse between the physical and the psychic, the interior and the exterior of the body, but a complete ontological revision of what a body was. This was a transformation that combined the dematerialization of the corporeal—its abstraction into numbers, diagrams, and algorithms—with a rematerialization of its operations as the mechanical realizations of "information" represented by those numbers, diagrams, and algorithms. Yet the dream of cybernetic interaction as a new politic often resulted in more dismal realities. The relegation of personhood to tabulated variables as a means of accessing a natural, thermodynamic conception of the operation and regulation of systems resulted in dehumanizing processes of corporate management and predefined methods of stimulus and response. Either way—materially or spiritually—the utopia of the computer obviated the body. As the literary scholar N. Katherine Hayles' investigation of how "information lost its body" to the advances of the post-war technosciences reminds us: "for information to exist, it must always be instantiated in a medium."[13] Yet this narrative proceeds along the lines of the progressive de-corporealization of information. As organic processes become mirrored by computational logics, the translation of life into operations loosens its relationship to matter, eliding the necessity of considering the materiality of living things. The homologies between the animal and the machine that had rooted the cybernetic interdiscipline's earliest text were soon replaced by computational logics.[14]

12 Reinhold Martin, The Organizational Complex: Architecture, Media, and Corporate Space (Cambridge/MA: The MIT Press, 2003), 7.

13 N. Katherine Hayles, How We Became Posthuman: Virtual Bodies in Cybernetics, Literature, and Informatics (Chicago/IL: University of Chicago Press, 1999).

14 Evelyn Fox Keller has traced the fluctuations of the ontological categories delimited by the cybernetics, from Kant to Maturana and Varela's Second Order Cybernetics in Evelyn Fox Keller, "Organisms, Machines, and Thunderstorms: A History of Self-Organization, Part One," Historical Studies in the Natural Sciences 38, no. 1 (Winter 2008): 45–75.

The realization of ARTORGA's organic ideology assists in the restoration of corporeality to Beer and Pask's computational "architectures," and to architecture itself, whose corporeal metaphors obviate material distinctions in the same way as cybernetics. Writing on the body in post-rationalist architecture, the architectural historian Anthony Vidler finds it "lost," an aporia he implies results from the atomizing ideology of deconstructionism.[15] While this departure from anthropometric rationalism can be understood as the emergence of the "body-as-organism," as the architectural historian Emmanuel Petit has described it, only a slightly more biologically affirmative interpretation of the networked "body without organs" is achieved.[16] Whether in Martin's portrayal of the subjecthood of the indistinguishable "self" or in Vidler's portrayal of architectonic and psycho-aesthetic dismemberment, architecture never loses bodily analogies, but it does indeed lose the body.

Accordingly, functioning as a pre-history to these events, which is also pre-architectural (though no less tectonic), ARTORGA departed from the consistent immateriality and absence of architecture's bodies by attending to the changing materiality of the informational body. Instead of rendering the biological in the terms of the mechanical, Wells, Pask, and Beer performed cybernetics' disciplinary exchange in reverse: attempting to model mechanical information systems in non-symbolic terms through the recruitment of biological models, and, more explicitly, organic matter. Exceeding metaphoric transposition, this inversion involved the recomposition of the material basis of the machine itself through the use of extant life-forms as constructional components. What this amounted to was an attempt to restore a body to cybernetics' informational schema. However, this body was not considered human (or intellectual), nor machinic (or computational), but simply biological.

15 Anthony Vidler, The Architectural Uncanny: Essays in the Modern Unhomely (Cambridge/MA: The MIT Press, 1992), 70.

16 Emmanuel Petit, "On the Entrails of Architecture's Organism," Perspecta, no. 42 (2010): 168–175.

An interview and an exhibition

In August, 1961, an image of two men standing on a hill in Hampshire, England accompanied the article "ARTORGA: une extraordinaire société scientifique" in the French popular-science journal *Science et Vie* (fig. 2). The interviewer, Gérald Messadié, was pictured looking down at a long horizontal object held by ARTORGA's financial manager, Oliver D. Wells. The object, named the Penrose Machine, consisted of a three-foot long L-shaped wooden bracket holding a series of identical wooden forms. The caption described how the device was used "to make the members of ARTORGA understand the simultaneously extremely simple and extremely complex principle of protein formation."[17] Wells used the magazine feature as a soapbox to proclaim ARTORGA's radical goals and deliver a condemnation of contemporary science. Targeting what he viewed as obsolete concepts: those which reinforced the "elemental splits" of mind and body, structure and function, animate and inanimate, and body and environment, Wells declared "We must reconsider everything."[18] Throughout the interview, he pushed against conventional cybernetic relationships between humans and machines, deriding the habit of fashioning thinking machines from the structure of the brain. He argued that to design a brain was to inherently constrain its operation. Picking a flower from the hillside and continuing his demotion of the status of machines based on humans, Wells ruminated: "this plant is not just an electronic wonder; by its agreement with its environment it is an admirable example of self-organization. It is from it that cyberneticians must be inspired."[19] For ARTORGA, the promise of cybernetics lay in understanding how organic fabric, rendered on a level that included the individual, societal, and environmental interactions of organisms, could be coupled to the artificial

17 Gérald Messadié, "ARTORGA: Une Extraordinaire Société Scientifique," Science et Vie (August 1961), 114. Translation author's own.

18 Ibid., 115.

19 Ibid.

Fig. 2: Cover image depicting Gérald Messadié, Oliver Dimock Wells, and the Penrose Machine. Source: "ARTORGA: Une Extraordinaire Société Scientifique," *Science et Vie* (August 1961)

systems and constructs of society in order to improve, or indeed replace, them.

The object in Wells' hands in Hampshire had first debuted at the London Institute of Biology's annual "Conversazione" in 1957, under the title "A Self-Reproducing Analogue" (fig. 3). Created

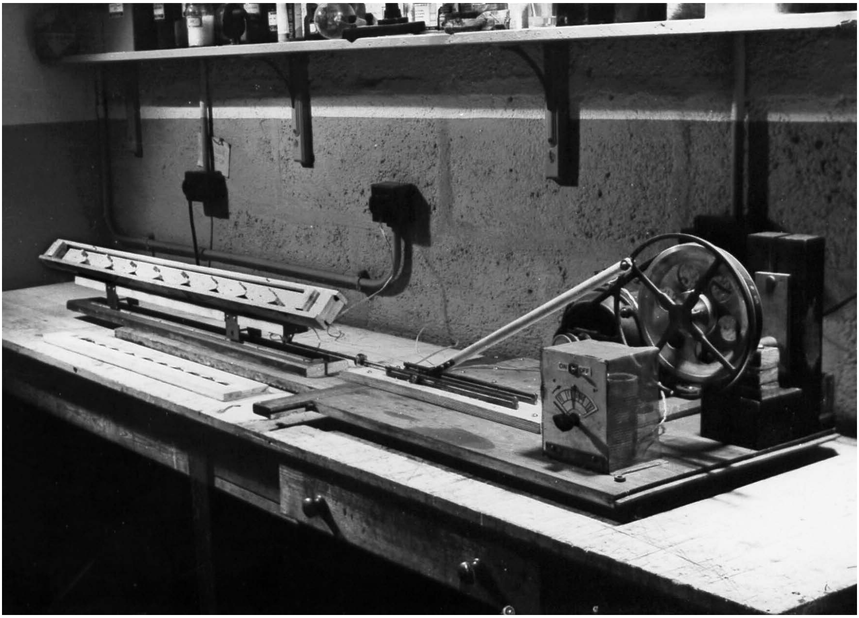


Fig. 3: Penrose's simple elements were arranged in their track and hooked up to a linear force applicator at his workshop in the Galton Laboratories. Source: Penrose Papers, UCL Special Collections; 2/12/16/4, 63r

by the geneticist Lionel Sharpless Penrose, the Penrose Machine was an object lesson which synthesized ARTORGA's project. It represented the process of pseudobiosynthesis, demonstrating "how objects with specified properties can be assembled so that they generate precise copies of themselves."[20] When arranged end to end and subject to lateral kinetic force, the blocks remained inert. However, when two blocks were manually joined before the application of force, the other blocks would respond to the composite by replicating its structure. The device thus represented both self-reproduction and self-organization. It combined in an

20 Institute of Biology, London Branch, "Details of Exhibits at the Conversazione," June 25, 1957; Penrose Papers, University College London; London, United Kingdom; 2/12/2/3, 39. See also, J.L. Cloudsley-Thompson, "Institute ofBiology Conversazione," Nature 180, no. 4581 (August 1957): 319.

inanimate object what for Wells, Beer, and Pask were the defining characteristics of organisms: the stability and viability provided by homeostasis and its transitive property of self-organization.

The conditions of the Machine's development reflected its ontological uncertainty. Rather than based on mathematical theorems, Penrose utilized John von Neumann's logical description of self-reproduction, the automata theory first articulated in 1948. The logical description of self-reproduction that von Neumann composed embodied a radically different conception of organic operations than information theory would have supplied. Though the Penrose Machine might have appeared to be nothing more than a demonstrative device, it reflected how complexity might be developed rather than structurally detailed. Instead of a series of equations representing a process, von Neumann's theory operated as a series of logical axioms that described an organism: a teleological system that was fundamentally related to the biological process that it was modelled from.[21] With von Neumann's theory as a foundation, Penrose's Machine allowed for the intractable nature of organic operations to become tacitly accessible, without recourse to mathematic or logical abstraction. Moreover, in its active wooden form, it represented a process as well as an object or an "artifact."

Accordingly, compared to the naturalistic representations of life that populated the exhibition hall, these wooden shapes must have seemed strikingly out of place. Yet, considering the Perspex economy of scientific models in post-war Britain, it would not have been so surprising to encounter inanimate objects that represented the critical components of biological life.[22] However, the Penrose Machine differed from the physical structures that proliferated in laboratories, journals, and television broadcasts in the 1950s. As a kinetic representation of a process, it possessed

21 See John von Neumann, Theory of Self-Reproducing Automata, ed. Arthur W. Burkes (Urbana/IL: University of Illinois Press, 1966).

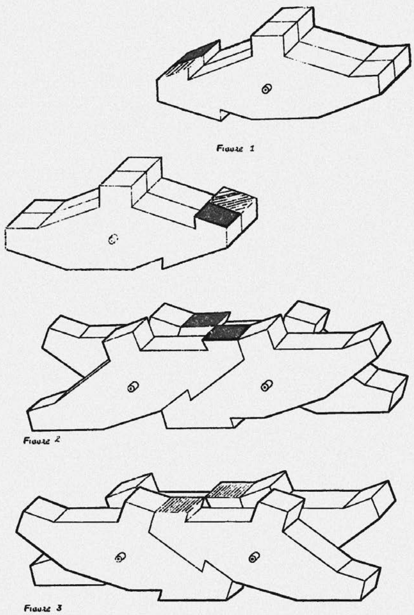
22 The term Perspex economy comes from Soraya de Chaderavian. See "Introduction" and "Models and the Making of Molecular Biology" in Models: The Third Dimension of Science, eds. Soraya de Chaderavian and Nicholas Hopwood (Stanford/CA: Stanford University Press, 2004), 1–19 and 339–369.

an animate nature of its own. Its appearance signalled how the abstraction of life into a formal operative theory could lead to its physical materialization in a mechanized form. What was most striking about the wooden blocks was how the agency of their procedural abstraction allowed the machine to be understood as neither artificial nor natural. It was instead widely considered as simply representative of a biological process.

Accordingly, the machine's form and operation align with how Judith Roof has depicted the popularization of biological disclosures as representing a merging of "element and principle": the convergence of a structure and its explanatory process that she first locates in the cultural effect surrounding the at once materialist, mechanical, and vital discovery of DNA's structure.[23] Roof extends this argument to the simultaneous development of structuralist paradigms in psychoanalysis and anthropology, illustrating the construction of a biologically-rooted genetic imaginary wherein nucleic acid is a "signifier par excellence," the centre of a seemingly endless series of binaries that it both justifies and generates. The subsequent proliferation of the Penrose Machine—sold via ARTORGA's network and popularized through numerous television programs—reflected the animate nature of its operation and affirmed the generative concept of life that emerged in this period, which the biologist François Jacob would also comment on (fig. 4). In 1970, tracing a history of biological disclosures, Jacob named the discovery of DNA in 1953 as the moment where reproduction supplanted generation as the defining capacity of organism, remarking on the discipline's newfound ability to "build its own truth" and create an "architecture of the living." Jacob further related this point to an epistemic shift: "a new way of considering objects, a transformation of the very nature of knowledge."[24]

23 Similar to the latitude of cybernetic concepts, Roof finds in DNA both the "self-identical functional structure" reflected in European structuralism as well as "the impress of emerging nonlinear modes of analysis" that marked the emergence of less dialectical modes of knowledge. Judith Roof, The Poetics of DNA (Minneapolis/MN: University of Minnesota Press, 2007), 32–35.

24 François Jacob, The Logic of Life: A History of Heredity, trans. Betty E. Spillman (New York/NY: Pantheon Books, 1973), 16.



ARTORGA SELF-REPRODUCING DESIGN OR DROGULUS

This design is an adaptation of the invention of Prof. L.S. Penrose of University College, London. If any of the units show difficulty in linking, please return them to us and we will replace them. These machines are described in New Biology No. 28 and also in the Scientific American of June 1959. The following extracts are taken from the Scientific American by kind permission of the publishers.

"The mass production of multiple copies of the same object by printing or by assembly of prefabricated parts is an event so commonplace that examples can immediately be called to mind. The reader has one at hand in the copy of Scientific American in which he reads these words. The idea of an object reproducing itself, however, is so closely associated with the fundamental processes of biology that it carries with it a suggestion of magic. Indeed, the construction of a machine capable of building itself might be judged to be impossible and to belong to the category of perpetual-motion engines. At the present time, however, advances in genetics are rapidly leading biologists to focus their attention upon the structure and function of self-reproducing molecular chains which, in the nuclei of living cells, preside over all their functional activities. The structure of these chains of nucleic acid is already quite well understood. But the general theory of self-reproduction, in which the replication of nucleic acid would represent a special case, has not been much investigated.

"One essential condition was to be that the units would not form self-reproducing machines just because they were moved about. They were to reproduce themselves only when the object to be replicated was introduced as a pattern for copying. The logic of this condition is to be found in William Harvey's maxim: Omne vivum ex ovo (in modern form: No life except from life). By definition, self-reproduction requires a "self" to be reproduced.

"This design provides a simple and convincing demonstration of artificial self-reproduction. Either type of seed may be introduced into the track; since they and their offspring are easily distinguished, it can be seen that each breeds true to type.

"Self-reproductive chains of mechanical units may help to explain the way in which nucleic acids in living cells actually replicate. But they are more likely to assist in the understanding of systems of simpler character, like those that must have preceded the nucleic acids in the evolution of life. These structures may have occurred in molecules composed of polysaccharides, amino acids or phosphates. At least we need not suppose that they were anything like as complex as the nucleic acids. Such organic counterparts of the self-replicating machine are not perhaps accessible to our observation today in nature. Charles Darwin suggested in 1871 that the spontaneous appearance of very elementary forms of life might still be occurring. But he also pointed out that if a protein compound ready to undergo complex changes were spontaneously produced in the present day, it "would be instantly devoured or absorbed, which would not have been the case before living creatures were formed""

INSTRUCTIONS.

1. Place six units in the track. See that they are held by the string and correctly aligned. The order is, in theory, random but, in fact, one or two pairs should have heads adjacent to one another, as in Fig. (1).

2. Shake gently horizontally, in the lengthwise direction. This demonstrates that the neutral units do not naturally link. Violent shaking, however, may produce a complex of a linked pair. This is self-reproducing but it has poor stability, as can be demonstrated by taking it out of the track and standing it on a flat surface.

3. Replace six units as before. Now construct a linked pair from the remaining two units, as shown in Fig. (2). Place this linked pair, as a seed, in the track and align it correctly with the neutral units by means of the string. Shake lengthwise, allowing collisions at both ends of the track. New linked pairs of the same kind as the seed will be produced. Demonstrate this by taking them carefully out of the track and standing them on a flat surface.

4. Break down the linked pairs and repeat the whole operation, using as seed a pair linked as in Fig. (3). This new organism will be copied by the neutral units instead of the previous one. Note that the organisms produced in the presence of seeds (2) and (3) are very unlikely to arise spontaneously but arise easily in response to their own prototypes.

We are also producing a large 3'0" class demonstration model with much larger plywood molecules. Price 3 gns. or $10 post paid.

March 20, 1960. Artorga Research Group, Beaulieu, Hants, England.

Manufactured by Allround Enterprise
Dibden Purlieu.

Fig. 4: Description and instruction sheet for the Penrose Machine written by Lionel S. Penrose for *ARTORGA*'s reproductions of Penrose's model, March 20, 1960. Source: *ARTORGA*, no. 16 (March 1960): n. p.

If von Neumann's automata theory gave the Penrose Machine a biological foundation, then, following Roof, Penrose's association of its operations to DNA's recombinant processes linked the biological to the epistemological.[25] In the model, systems of life were no longer simply rendered in the obscured interior of the cell, the diffracted crystallographic images of its molecules, or in the static ball and rod atomic models. Instead, the Penrose Machine enabled the critical processes of living things to be acted out and performed, facilitating an active engagement with representations of life's processes rather than simple

25 While at first Penrose refrained from specifying which biological procedure his machine represented, preferring the subjectless of analog relations, he would ultimately relate it to DNA in an unpublished paper. See Penrose Papers; UCL Special Collections; 2/12/18/13.

observation. This recuperation of cybernetic artifacts as containing an organic potential that complements the human, rather than a mechanical nihilism that subjugates it, supports a consideration of ARTORGA's methodology as fundamentally interactional: concerned with trans-material and trans-ontological collaboration, and not with flattening the biological into a machine. As Penrose was exhibiting his machines at the "Conversazione," Beer and Pask were in the midst of experimenting with organic analogues of mechanical systems through their work on "organizational fabrics" and "organic computers," a practice that they termed "applied cybernetics."[26] Despite their methodological and material differences, both would come to inform ARTORGA's initial performative and participatory structure, and in doing so, establish the foundation for its revisionist impulses.

A fabric

Reflecting the fragmentation of biology in the post-war period, what the historian of science Steve Heims has called the "invasion" of the discipline, ARTORGA's relationship to life was particularly marked by the development of cybernetics in Europe, which in contrast to its American contingent included more biologists than engineers. Wells, Beer, and Pask had met in 1956 at the inaugural "Congrès international de cybernétique" in Namur, Belgium, where they discussed the "terrific precision of genetic substances as machine tools."[27] It is in light of this prioritization of practical applications over conceptual development that ARTORGA's use of the term "fabric" in their initial invitation relates to the bio-cybernetic architectonics developed prior to the publication's existence. For, rather than an exploration of synthetic materials, or any static consolidation of warp and weft, the term "fabric" denoted the dynamic interlacing of life: the complex and collective cooperation of an aggregation of biological elements.

26 See Stafford Beer, Cybernetics and Management (London: The English Universities Press, 1959), 158.

27 ARTORGA, no. 2 (January 1959).

As originally formulated in the interwar period by the developmental biologist Paul Weiss, the metaphor of "fabric" countered the metaphoric mechanization of biologic processes—the translation of "facts into inorganic terminology."[28] Unlike the period's dominant metaphor of the crystal, the utility of the concept of fabric was in how it recognised structural rigidities within organisms as merely part of a larger plastic system, rather than as a totalizing organizational paradigm.

A question posed by Beer in 1954—"What kind of viable fabrics are glass and wire?"—matched his sentiments a decade later when he borrowed the title of J. D. Bernal's catechistic work of prospection, *The World, The Flesh, and The Devil* (1929), for a talk entitled "The World, The Flesh, and The Metal."[29] For Beer, metal—and, by association, machine materials—generated a psychological rigidity: an intellectual stasis engendered by disciplinary specialization and the corresponding loss of a "capacity for creative thinking"[30] that was not only due to the material's composition, but a result of what it composed. Organizational paradigms departing from machinic logic had led to a world of compressed structures: the regimentation and stratification immanent to industries and corporations. Accordingly, Beer's "World" was composed of geopolitical boundaries; his "Flesh" consisted of the pseudo-animate corporeality of firms and economics; and "Metal" itself denoted the manmade "machinery, artifacts, and devices" that populated the two.[31] To Beer, the present represented boundaries that were "too rigid," the ineffective

28 Paul Weiss, "Tierisches Verhalten als 'Systemreaktion.' Die Orientierung der Ruhestellungen von Schmetterlingen (Vanessa) gegen Licht und Schwerkraft," Biologia Gen. 1 (1925), 168–248. Cited in Donna J. Haraway, Crystals, Fabrics, and Fields: Metaphors that Shape Embryos (Berkeley/CA: North Atlantic Books, 2004), 147. As Haraway also argues, a focus on form in biological practice implicates an organicist perspective at work. See ibid., 58.

29 Beer recounts this query in Stafford Beer, "A Progress Note on Research into a Cybernetic Analogue of Fabric," ARTORGA, no. 40 (April 1962). See also Beer, "The World," and John Desmond Bernal [1929], The World, The Flesh and The Devil: an Enquiry into the Future of the Three Enemies of the Rational Soul (London: Verso, 2017).

30 Beer carried through this criticism from Bernal who, abdicating cognitive autonomy to physical and physiological factors, left the description of a psychological future to be generated by changes in the body and the world. See Bernal, The World, The Flesh and The Devil, 43.

31 Beer, "The World," 229.

compartmentalization of function, and a lack of organic behaviour within systems.[32] While this technological nihilism had been echoed by others, Beer proposed a practical solution that substituted the plasticity of the biological for the dogmatism of metal.[33] Though Penrose's intention was to mitigate the biological complexity of self-reproduction and self-organization by requiring only simple mechanisms, Beer and Pask did not want to reduce the complexity of living organisms, but to study and eventually create them. Their inquiries were impelled by a dissatisfaction with the limitations of conventional machine materials. From their perspective, the analogic replication of organic processes in synthetic materials might well serve to reproduce the isolated functions of organisms, but in no way could they reproduce the malleable behaviouristic and cognitive capabilities of their models: their ability to grow, adapt, and learn. Considering that automatic systems of production and prediction (from assembly lines to guided missiles) represented an unrelenting linearity, Beer and Pask viewed cybernetics as reliant upon only automatic functions that lacked the capacity to adapt or evolve in response to new or irregular stimuli.

In the attempt to overcome these limitations, they looked past machinery toward biological precedents. However, their recourse to organic life as a corrective to machinic procedures was not simply rooted in behaviouristic paradigms but was based on the material affordances and informational capacity of biological life. Considering these capabilities inherent to organic matter, Beer and Pask saw unlimited potential in the recruitment of a complexity that could not be engineered, a utilization of the world's pre-existing self-organizing systems. They hoped that their search, which looked for new fabrics, "the stuff of construction," and often living material, would uncover a viable organic machine.[34] Accordingly, commenting that "fixed circuitry is a

32 Ibid., 227.

33 This had been most clearly expressed in Jacques Ellul's 1954 description of the categorial imperative of mechanical techniques. Jacques Ellul, The Technological Society, trans. John Wilkinson (New York/NY: Vintage Books, 1964).

34 Ibid., 159.

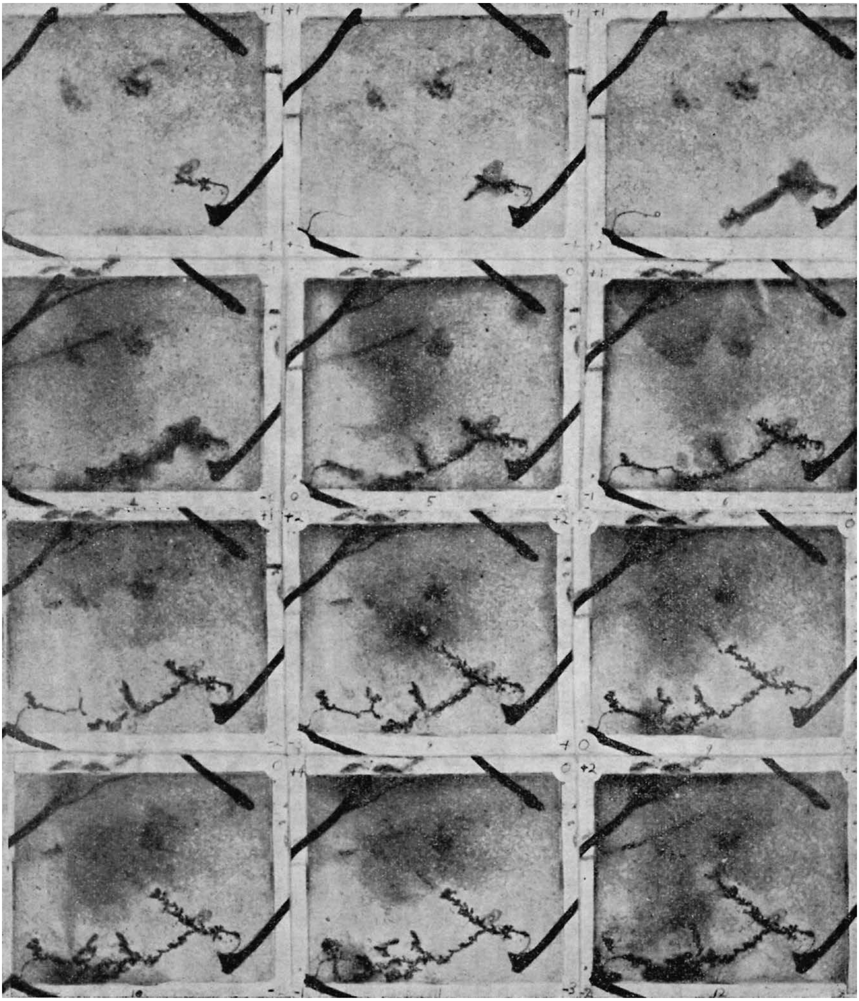


Fig. 5: Stages of growth in one of Pask's fungoid fabrics, "The idea of making such devices is entirely practical and the photographs shown indicate the physical character of a decision making system, several of which exist." Source: Fig. 6 in Gordon Pask, "The Growth Process in a Cybernetic Machine," in *Proceedings of the Second Conference of the International Association of Cybernetics, Namur* (Paris: Gauthier-Villars, 1960), 790–791

liability," and relating that fixedness to acts of conscious design, Beer summarized their project as an attempt to "constrain a high variety fabric rather than fabricate one by blueprint."[35]

35 Beer, "Progress Note," n. p.

Beginning in 1954, Beer and Pask recruited a series of life forms across taxa and superimposed the functions they wanted to model onto the active systems of the living. Preferring the "inherently organizing" and thus non-designed systems of organic life, they proceeded from "fungoids" (colloidal cell cultures), "animalcules" (the aquatic daphnia crustaceans), and "biological gas" (the eukaryote eugenia), to "social insects" (bees, ants, and termites), "vertebrates," and "human beings"[36] (fig. 5). Along the way, they catalogued the tendencies of each "fabric" in accordance with cybernetic rhetoric. Since each form of organic life possessed the basic criteria of living things: "variability," "self-replication," "self-organization" and "homeostasis," each could be viewed as a viable component of an organic machine. As the experiments progressed, Beer and Pask attempted to produce interfaces between the organic fabrics (as they termed the biological communities they created) and the mechanical systems that they envisioned as their enclosures.[37] Though the fabric formed by each experimental subject varied in terms of its overall organization and operation, each was intended to act as an organic modulator: a processing system able to cope with external complexity. They were to perform as animate regulating bodies coupled to a device that would render the variables of inorganic systems into organic stimuli. Transposing the natural stability of the organic to the artificial, the device would respond in kind to the fabric's behavioural response, bypassing the need for symbolic or linguistic translations.[38]

These manipulations of fabric reflect an ecological understanding of world systems, the entangled and irreducible economies of

36 Ibid.

37 Ibid. Through material and environmental interference, from the deposition of metallic filings or the institution of environmental systems—from mazes to stimulus-response tests—Beer and Pask attempted to ascertain how inherent behavioral responses could unknowingly, and without quantification, process received stimuli.

38 Beer, "Progress Note." The afterlives of these experiments in Beer's industrial practice was explored by Andrew Pickering in "The Science of the Unknowable: Stafford Beer's Cybernetic Informatics," Kybernetes 33, no. 3/4 (2004): 499–521. Pickering has also advanced a performative-ontological theory of material agency within scientific practice, using applied cybernetics as an example of what he refers to as the "mangle." See Andrew Pickering, The Mangle of Practice: Time, Agency, and Science (Chicago/IL: The University of Chicago Press, 1995).

nature and society whose 19th century roots lie in what the historian of science Lynn Nyhart has termed a "practical naturalism."[39] Yet ARTORGA's revision of their discipline's material basis called into question what the cultural anthropologist Stefan Helmreich has recently problematized as the relationship between life forms and forms of life: the naturalization of a biopolitical continuity that presumes a causal and structural relationship between "embodied bits of vitality" to the "social, symbolic, and pragmatic ways of thinking and acting that organize human communities."[40] In Pask's formulation, the idea that a new biology could emerge from the structural-material employment of the biological life in artificial systems represents the naive fallacy that characterized the vulgar materialism of organicism's holism. However, as Beer and Pask combined the engineering and construction of life forms with observational practices, which for them entailed not only the classificatory urge of the naturalist but the interactionism of a field biologist, they began to shift how the processes and organizations of life forms were understood. Explicating this methodological hinge, Penrose himself noted: "we construct objects with properties like living things… examine them carefully, observing their abilities and limitations, and study their natural history."[41]

A language

As Pask argued in 1960, in order to study the self-organization of fabrics one must inherit the "interactive aspects of natural history," what he described as the "art of knowing an animal, almost

39 Nyhart introduces this term while tracing the emergence of an ecological understanding that characterizes the "biological perspective" of the discipline's origin. Lynn K. Nyhart, Modern Nature: The Rise of the Biological Perspective in Germany (Chicago/IL: University of Chicago Press, 2009).

40 Stefan Helmreich, Sophia Roosth and Michele Friedner, "What Was Life? Answers from Three Limit Biologies," in Sounding the Limits of Life: Essays in the Anthropology of Biology and Beyond (Princeton/NJ: Princeton University Press, 2016), 1–16.

41 Lionel S. Penrose, "Automatic Mechanical Self-Reproduction," Lecture, University College London, January 14, 1958; Penrose Papers, UCL Special Collections; 2/12/7/4, 26. The lecture notes would be turned into the article "Automatic Mechanical Self-Reproduction" New Biology 28, no. 92 (1959), the publication of which was delayed because of a strike.

by living the part of the animal."[42] This self-reflexivity formed the operative basis of ARTORGA's publication, with each recipient of the mailer "like a cell in the organism," recalling its initial invitation. Within its first year, however, ARTORGA had to face the problems involved in "growing the principles of design." Each of the monthly iterations of its first twelve "communications" varied in content, structure, layout, and even binding and paper stock. Consisting of often purposefully inchoate discourse, the opacity of the statements, suggestions, and axioms that populated its pages over the first year reflected the publication's concern with how the parameters of its materiality would be discursively framed. The initial invitation had elaborated that the "words and written materials"—described as "relatively unformed fabric"—should serve the same function as "valves, circuit diagrams, cell boundaries, or enzyme systems."[43]

ARTORGA's method therefore reflected the material specificity of fabric (centred on the capabilities of organic matter) and its critical operative difference from biology's dissections and cybernetics' constructions. Departing from the reduced and enclosed bodies of fungoid networks and aquarium tanks, ARTORGA began to utilize the substrate of the world itself. This enlargement required a reconsideration of how the immanent principles of the organic could operate within a body that lacked any localized biological model. While ARTORGA still imposed its method on existing systems, these were now the geopolitical networks of modernity rather than delimited and controlled environments. More simply put, its paper moved through the post. Ostensibly two discrete "fabrics" emerged here. One, language, acted as the semantic fulfilment of the relationship between the form-giving function of "genetic substance and machine tools" that Beer, Pask, and Wells had discussed; the other, the postal service, indicated the spatial extent of its body. Accordingly, rather than the utility of the organic, here issues of language and information

42 Gordon Pask, "The Natural History of Networks," in Self Organising Systems, eds. M. C. Yovits and S. Cameron (London: Pergamon Press, 1960), 235.

43 ARTORGA, no. 1 (December 1958).

were prioritized in terms of correspondence and self-description. Indeed, by proposing the term "fabric," Weiss had also been concerned with obtaining a true description, a parallelism between language and reality.[44] Reflecting ARTORGA's continuous attention to the biological, language was primarily considered in terms of inter- and intra-organismal communication, rather than being subsumed into incorporeal concepts of code.

From ARTORGA's first communication, its pages contained suggestions about the effect of specialized scientific terminology on the description and performance of artificial functions. Ultimately, ARTORGA rejected the adoption or adaptation of existing languages for the same reason its founders had avoided pre-determined designs and functions. If metal, glass, and wire were programmatically overdetermined materials, then extant languages similarly contained built-in predispositions of value and order. Instead, ARTORGA underscored the need to develop a new language. Only one generated autonomically, and so without design, could oppose existing semantics and semiotic structures, and begin to accomplish the epistemological revision Wells had argued for. Accordingly, ARTORGA's founders viewed its indeterminate program as a proven biological technique—as they noted: "most organisms start each generation with a minimum of assumptions."[45]

Yet the linguistic experimentation evidenced in each issue—the mixtures and misuses of syntax, semantics, and semiotics—would never cohere. ARTORGA instead decided to recruit an existing model of biological processes to further materialize their language. They selected the Penrose Machine. This choice was in fact a commodification. Announced in its pages in January 1960, the machine's form was utilized not only as a communicative medium, but also as a representation of ARTORGA's process

44 See the continuation of this argument in Paul Weiss, "Perspectives in the Field of Morphogenesis," The Quarterly Review of Biology 25, no. 2 (June 1950): 177–198. See also Weiss, "Organic Form: Scientific and Aesthetic Aspects," Daedalus 89, no. 1 (Winter, 1960): 177–190.

45 ARTORGA, no. 8 (July 1959).

and a reflection of its structure. However, it was the model's materialization of the descriptive function of language that ultimately impacted ARTORGA's epistemological goals.

Penrose's models had been popularly extolled for their relevance for chemical, biological, logical, and mechanical processes. Wells, Beer, and Pask applied this lability of meaning to ARTORGA's models, which were anti-categorical, neither machine nor organism, and reflected processes of self-reproduction and self-organization. Regardless of whether such a positioning was understood as reductionist, or, more positively, rudimentary, it was particularly valuable for ARTORGA, which had recently published such sentiments as "perhaps the single cell is already too far advanced!" and "certainly one would want to go back way down the evolutionary scale, back to a non-verbal world of pictures."[46]

This is not to say that concepts of self-reproduction and self-organization were absent from ARTORGA's linguistic goals. By opposing the material logics of metal, and by reverting the concept of the organization to the organism and the corporation to the corporeal, they sought to generate objective biological truths from a collation of human and organic subjectivities, rather than accepting analogical principles gained from computational similarities. Viewing biological processes as universalized procedures allowed Beer, Pask, and Wells to attempt to redefine the binaries inherited from dualistic conceptions of the world that sought to create discontinuities in an autonomous and autonomic natural order.

An unfinished process

That a paper publication, with dreams of an organic existence (corporealized through mimeographed pages) would become a platform from which to argue for a new standard of scientific practice founded on systemic thought—free from the strictures of convention or any pre-set design processes—seems like an

46 ARTORGA, no. 6 (May 1959); and ARTORGA, no. 9 (August 1959).

unlikely transformation, and one very far from ARTORGA's initial intention of solving the "practical problems" of organization and strategy. However, in Wells' hands the Penrose Machine was not simply a model of protein formation, but ultimately something both simpler and more complex; ARTORGA was decidedly not non-deterministic but relied on the appearance of flexibility; and Wells was not a scientist, or a businessman, but a mixture of both. The appearance of all three in Hampshire in 1961, despite their different goals, would seem to implicate the presence of a template or structure, or at the very least a shared ideology. Though this ideology was fundamentally a materialist one, its reactionary aspects were necessary in order to maintain a connection to the organic body across cybernetics' metaphoric, morphic, and analogic transformations, and its own machines, fabrics, and models.

At the end of the 1961 interview in *Science et Vie*, ARTORGA's project was summarized as "the will to triumph over mathematical and systemic thought, and the desire to understand nature as it is, and not as it is conceived of." The non-cognitive approach implicit in these closing lines dovetails with the "concrete" epistemology later put forth by Francesco Varela, himself a member of ARTORGA's "organism." Varela's framework consisted of "knowledge built from small domains," from an organism's "readiness for action," which constituted an "unruly conversation" from which a "cognitive moment can come into being."[47] In ARTORGA we witness the proposal of a relationship to the living that departs from a post-Cartesian perspective, one which understood the world not as pre-given, but as continuously enacted and performed by material assemblages of organic and inorganic life: a non-decomposable creative act, and an utopia without controls.

However, ARTORGA never reached a conclusion. In 1972 it ceased publication, having only repeatedly redefined the terms of its own operation. Yet to think of its fundamentally biotic method

47 For the embodied theory of cognition that supports this claim, see Francisco Varela, "The Re-Enchantment of the Concrete," in Zone 6: Incorporations, eds. Sanford Kwinter and Jonathan Crary (New York/NY: Zone Books, 1992), 320–340.

of epistemological generation is to recognize the emergence of a bio-technical form of knowledge that embraced the variability of life on its own. The less didactic variant of self-organization, is, of course, autopoiesis, a term which references not only autonomic action, but the relationship between poetics and structure, the result of its play on binaries. Beer, Pask, and Wells' consideration of replicative and organizational processes of biological life as universalized procedures—derived from the conception of intractable organic rather than machinic logics—was foundational to ARTORGA's attempt to redefine the binaries inherited from dualistic conceptions of the world. Employing what we might now call a biopoetics as the rudiment of the operation of world-systems, ARTORGA's experiments in the late 1950s highlight the still seemingly intractable issue of discriminating between the fundamental binaries of our world, while signalling the potential of fabrics to provide alternative visions of life based in the labile operations of the autonomous techniques of biological life.

In introducing ARTORGA's method as a biological technique, I have attempted to track their departure from conventional cybernetic practice through their projects and constructions and highlight how the procedures they initiated within fabrics, machines, and models retained the corporeality of the organic body, even as the body as a cybernetic model itself became impinged upon by informational representations. While ARTORGA was never meant to construct a building *per se*, its attempts to construct an organization, to grow principles, and constrain fabrics are part of the same ideology that informs architecture's continuing fascination with biology as a cure-all for design. While the etymological connection between fabric and fabrication indicates their basic compositional similarities, the active agency of fabrication implies the need to create de novo, while fabric itself signals the underlying structural framework of nature, which exists and persists without any intentional intervention. Although terms like art and artifice become muddy when practically applied—for fabric is always fabricated in some fashion—they are distinguished by their agency. This is the difference between how a structure develops and how it is constructed. Accordingly, the fabrics, machines, and models of ARTORGA depict the generative architectonics of life—the principles, programs, and procedures of living structures—as the basis of a universal epistemology, a way of knowing connected to the very mode by which we as humans are able to process knowledge, one defined by the interaction between parts: structure working itself out, rather than being worked out.

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KAMAN LAM

C. H. Waddington's Biological Science of Human Settlements

1963–1978

It is impossible to approach urban development without considering biology—such was biologist C. H. Waddington's provocative gift to ekistics, the endeavour to found a science of human settlements. Despite being historically overlooked, his efforts to rethink urban development through developmental biology (and epigenetics), its reasoning, methods, and models remain further pointers to the alignment of architecture practices with biological sciences and technologies. This paper presents an array of biological premises he posited to help advance hypotheses to which a pluralistic-scientific attitude towards utopianism can contribute.

"It is often said today that… man is passing into a new phase of civilization which will be based on something other than the simple physical science. The candidate usually put forward to take over the dominant role is described sometime as Automation or… Communication Science. There is, however, a case for arguing that the fact of Automation or Communication is less important than what the systems are automated to do… and that the science which will contribute the content of the new civilization, even if not the tools, of the new civilization will, and perhaps should, be biology."
C. H. Waddington[1]

1 C. H. Waddington, ed., Biology and the History of the Future. An IUBS/UNESCO Symposium (Edinburgh: Edinburgh University Press, 1972), 1.

Introduction

Today, in times of bio-medical emergency and climate crisis, biological thoughts on mutation, extinction, population, organization, evolution, control or resilience could not be more influential in the time present, in continuum with a time past and time future. Even when past speculations were far ahead of their time, the prophecies might be fulfilled in the coming generation—what might a biological civilization that encompasses a biological architecture be like?[2]

In the heyday of all-inclusive complexity sciences, "renaissance biologist" C. H. Waddington (1905–1976) was impetuously engaged in a search for answers[3]—in 1963, he became part of an exhaustive effort to reform architecture into a biologically-conscious science of human settlements known as ekistics.[4] Distinguished scientists, such as he, viewed themselves as the conduit to the latest scientific consensus in support of planning practices.[5] Waddington, a prominent geneticist, embryologist, process philosopher, art theorist, futurologist, and one of the most original thinkers in biology in the 20th century, not only devoted himself to this joint effort, but also leveraged the ekistics group as a platform to discuss a pluralistic-scientific attitude towards "utopian" visions. Fellow biologist Ruth Sager put it in a nutshell: "The purpose… is 'to use biology (its principles, and examples; and reasoning and applications) to save the world', in just the same way that Buckminster Fuller's purpose is 'to use

2 Note that architecture, urbanism, city, urban planning, urban design, town planning, human settlements, urban and world development are different derivations of this paper's subject matter. These terms will be used interchangeably to avoid historical jargon and to present a fluid contemporary view.

3 Jonathan M. W. Slack, "Conrad Hal Waddington. The Last Renaissance Biologist?," Nature Reviews Genetics 3, no. 11 (2002): 889–895.

4 "[Foreword]," Ekistics 35, no. 209 (1973): 174–176.

5 Ibid. These scientists include Neo-Darwinist Theodosius Dobzhansky, microbiologist and environmentalist Rene Dubos, physicist Chris Pratt, anthropologist Margaret Mead, immunologist Jonas Salk, and more. Each had commented on the thematic of ekistics with reference to the latest scientific consensus in their fields, notably those influenced by complexity sciences. Their degrees of participation at ekistics' yearly symposia and research projects varied. Waddington was the most diligent symposia attendant among the natural scientists, with only one recorded absence between 1963 and 1972.

architecture (and principles of design) to save the world.' But Fuller's has been written up and organized while Wad[dington]'s idea has not—and could be."[6]

Saving the world may be an exaggeration. Yet, Waddington was certainly a radical—always abreast if not ahead of the latest trends. In life sciences, Waddington is best remembered for his synthesis of genetics, embryology (developmental biology), evolution, and environment into an approach called epigenetics. Still, it is his lesser-known synthesis named "human ecologies" that a transdisciplinary history of urbanism and science should bear his name: *it is impossible to approach urban development without considering biological sciences*.[7] Continual transformation towards mechano-organicism or techno-diversity require a response from architectural disciplines.[8] Waddington's ekistics brings us to the very frontline.

The elusive role of biology in architecture and urbanism

Biology and architecture are traditionally rather disparate fields; even when the relationship between them has been explored, it has dominantly been metaphorical and rarely material or

6 Waddington, Biology and the History of the Future, 5.

7 "Waddington, Conrad Hal, 1905–1975 (embryologist and professor of animal genetics, University of Edinburgh)," The University of Edinburgh Archives Online, last modified 2018. Accessed October 5, 2021. https://archives.collections.ed.ac.uk/agents/people/219?&filter_fields[]=primary_type&filter_values[]=archival_object. Waddington's biology-informed synthesis was first given a general name, "Man Made Future," then "Human Ecology." Both refer to the research institution he founded at Edinburgh University. What connected both initiatives of the biologist with architectural cultures was the point that the world is a man-made artifact, which was in line with media theorist Marshall McLuhan's insight that the end of nature is the birth of ecology.

8 Yuk Hui, Recursivity and Contingency (London: Rowman & Littlefield Publishers, 2019). Mechano-organicism refers to philosopher of technology Yuk Hui's characterization of cybernetics, where the cybernetic machine is capable of absorbing contingency and operating in recursivity; both he concludes to be the key driving forces of an organicist system. Hui argues that cybernetics' agenda to acquire a kind of organicity in machines has been fulfilled in present day's totalizing smartification projects; the task of a philosophy of technology is to fragment totalizing systems, to return them to localities, and to unite moral and cosmic order through technical activities—what Hui calls a techno-diversity of cosmotechnics. Waddington's speculations on future roles of bio-technologies could be seen as a resistance to technological singularity and an argument for techno-diversity.

methodological. While modern art/architecture acquired a considerable part of its material cultures from modern sciences, the pronounced preferences were in mechanicism or reductionism.[9] Reductionist sciences found expressions in the New Objectivity movement in modern art and architecture: pure geometries, glass, concrete, etc., in their search for atomic purity, sterile and static.[10] Biological thoughts appear at the other end of the disciplinary spectrum: cities have been likened to human bodies or organisms throughout history.[11] These metaphors suggest that cities could be interpreted as developing organisms, whose parts belong to a regulatory whole. The actual introduction of biologically-inspired methodologies was bought about by biologist-planner Patrick Geddes: cities were considered akin to a good biological system that animates its uses in all their inter-relatedness, discoverable via civic survey.[12] The biological, human and social (built) world were reciprocal evolutionary forces functioning at a local scale.[13] This notion was picked up by urban critic Lewis Mumford, who extended it into a theory of social organicism in which the biotechnic society shall put technics into the service of organic humanity.[14] Part developmental (city as organism), part evolutionary (the evolution of city and life) and part organizational (interrelated regional order), the possible roles of biology became widely promoted in the golden years of mid-20th century urban planning.[15] Waddington, "a biologist primarily interested in processes in

9 C. H. Waddington, Tools for Thought (New York/NY: Basic Books, 1978), 23.

10 C. H. Waddington, The Scientific Attitude (West Drayton: Penguin Books, 1948), 61–63.

11 Michael Bally and Stephen Marshall, "Centenary Paper: The Evolution of Cities: Geddes, Abercrombie and the New Physicalism," The Town Planning Review 80, no. 6 (2009): 551–574.

12 C. H. Waddington, The Man-Made Future (New York/NY: St. Martin's Press, 1978), 152. Volker M. Welter, Biopolis: Patrick Geddes and the City of Life (Cambridge/MA: MIT Press, 2002), 69–71.

13 Bally and Marshall, "Centenary Paper," 556.

14 Lewis Mumford and Langdon Winner, Technics and civilization (Chicago/IL: The University of Chicago Press, 2020).

15 Gwen Bell and Jacqueline Tyrwhitt, Human Identity in the Urban Environment (London: Penguin Books, 1972). From the popularization of green belts in post-war Britain, the radical proposals in Japanese Metabolism to Paolo Soleri's Arcology, a sentiment of the time was that naturalistic thinking might at a minimum thwart urban sprawl through counter-regulatory mechanisms, and, maximally, that it might trigger a reorganization of life through conscious physical planning.

biology of either development or of evolution," would continue to advance the position of biology with the help of an ally.[16]

A science of human settlements of evolutionary origins

For the prolific architect-planner Constantinos A. Doxiadis, evolutionary thinking seemed the primary means to predict the future and to act upon it.[17] In his 1969 Nobel lecture he declared planetary urbanization inevitable.[18] Exponential population growth, the influx of labour to cities and the demand for a roof and a living presented, in his view, a bio-evolutionary problem of unprecedented complexity, and yet, certainty. To prevent urban chaos, he mobilized scientists in a joint effort to establish a multi-disciplinary approach to planning extending from physical aspects to concepts in geography, economics, and the social sciences, to which he gave the name "ekistics," the Greek equivalent to "Raumordnung" and "Landesplanung."[19] Planning was conceived of as the systematic act of balancing elements in the formation of settlements, namely man, shell, society, nature, and networks (fig. 1).[20]
Doxiadis' emphases on evolution were underpinned by the popular science writings of *The Modern Synthesis* proponent Julian Huxley.[21] Huxley was dubbed "the statesman of (biological)

16 C. H. Waddington, "Space for Development," Ekistics 32, no. 191 (1971): 268–269.

17 Doxiadis' lecture was titled "The Future of Human Settlements," in The Place of Value in a World of Facts. Proceedings of the Fourteenth Nobel Symposium, Stockholm, September 15–20, 1969, eds. Arne Tiselius and Sam Nilsson (Stockholm: Almqvist & Wiksell, 1970), 331.

18 Ibid., 309.

19 John G. Papaioannou, "C. A. Doxiadis' early career and the birth of ekistics," Ekistics 72, no. 430/435 (January-December 2005): 13–17.

20 Constantinos A. Doxiadis, Architecture in Transition (New York/NY: Oxford University Press, 1969), 178.

21 Constantinos A. Doxiadis, Ekistics: An Introduction to the Science of Human Settlements (London: Hutchinson, 1968), 42–43. C. Kenneth Waters and Albert Van Helden. Julian Huxley. Biologist and Statesman of Science. Proceedings of a Conference Held at Rice University, 25–27 September 1987 (College Station/TX: Texas A & M University Press, 2010). Huxley's evolutionary theory postulated that the forces driving the slow, devious process of lower-level species' evolution towards higher complexities should be attributed not to orthogenesis (Geddes' interpretation) but a synthesis of natural selection, inheritance theory and genetics, all of which contributes to an evolutionary progress.

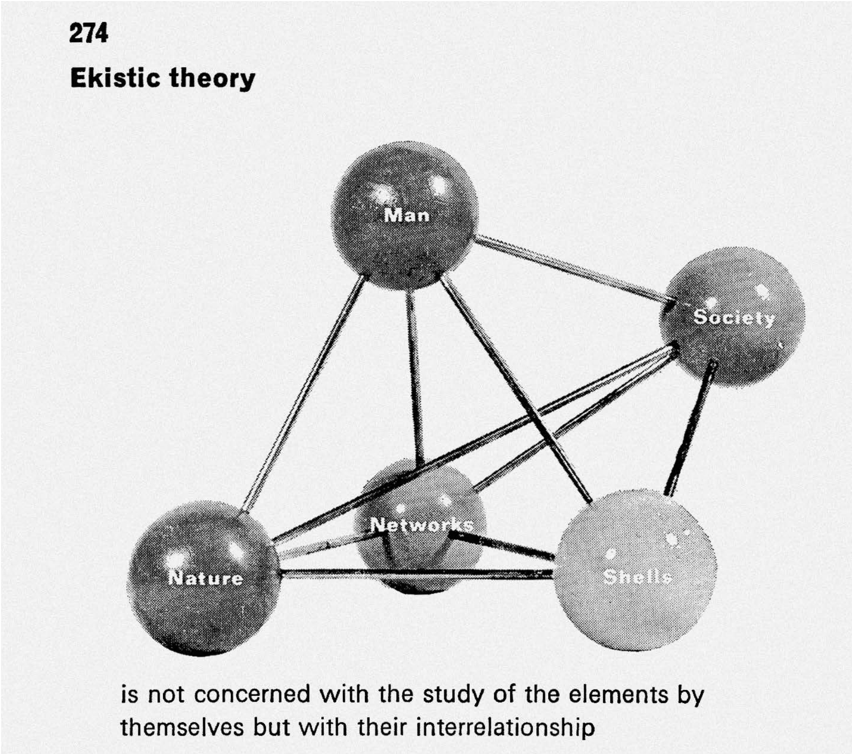


Fig. 1: Ekistics theory claims to study the interrelationship of the five ekistics elements: Man, Nature, Society, Shell and Networks. Source: Doxiadis, *Ekistics*, 285. Dt. UrhR: Constantinos and Emma Doxiadis Foundation

sciences" whose contribution to 20th century biology spanned from cofounding the discipline of evolutionary biology and popularizing science to public politicking for the cause of evolutionary humanism—the quasi-religious call for humankind to seize control of their evolutionary future.[22] The corollary of this was Doxiadis' imperative to control the evolution of physical settlements over future millennia. He also espoused Huxley's rudimentary classification of organisms: cells are first-order biological individuals, bodies second-order ones, and human societies, like

22 Julian Huxley, Evolution in Action (Harmondsworth: Penguin Books, 1968). Julian Huxley, The Uniqueness of Man (London: Readers Union, 1943), 141, 245.

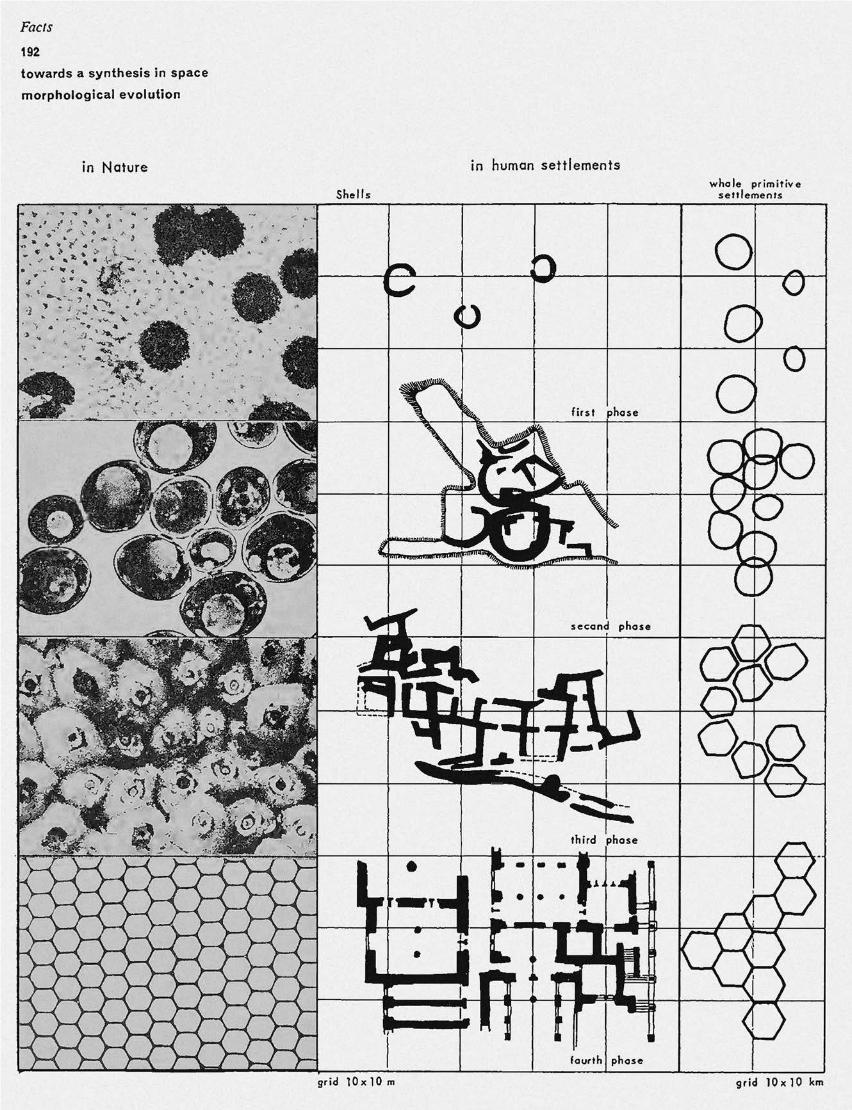


Fig. 2: Organization of settlements in evolution. Source: Doxiadis, *Ekistics*, 206. Dt. UrhR: Constantinos and Emma Doxiadis Foundation

beehives, third-order, which led him to see *human settlements as biological societies* (fig. 2). Similarities between organisms and cities could then be drawn, for example, the digestive system and

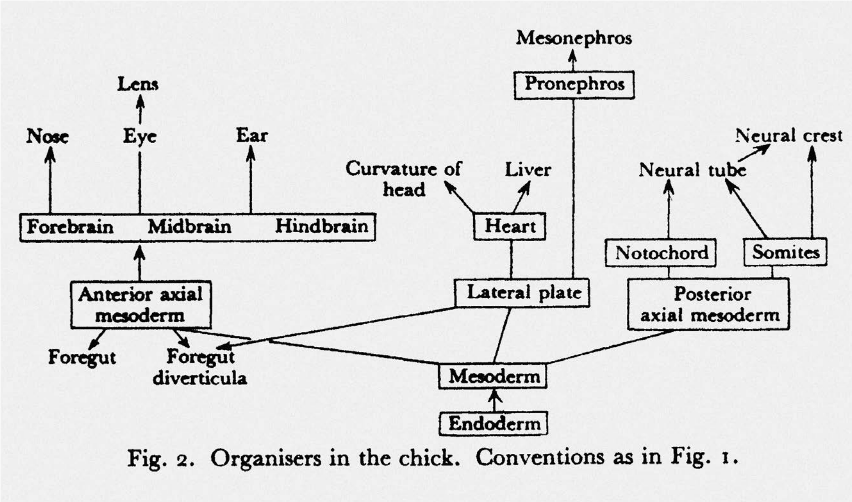


Fig. 3: Organizers, or inducing agents, in the development of the chick from bio-chemical states to body parts. Source: Waddington, *Organisers and Genes*, 12. Reproduced with permission of Cambridge University Press

the sewage system.[23] Along with the five principles of settlement formation and *Central Place Theory*, these concepts became the cornerstones of ekistics, and the basis on which Waddington would intervene.[24]

From developmental biology to epigenetics through the advances of Waddington

While evolution forms the keystone of any grand biological treatise, the developmental and organizational branches of biology may offer a better entry into understanding individual organisms via a threefold inquiry: what does organization mean in biology? What is a developmental system? Implicitly, how does the environment impact life?

23 Doxiadis, Ekistics, 42–43.

24 The five principles of Ekistics are: (1) maximization of potential contacts, (2) minimization of effort in terms of energy, time, and cost, (3) optimization of human's protective space, (4) optimization of the quality of a human's relationship with their environment, and (5) optimization in the synthesis of all principles.

The first answer may be found in Waddington's formative years in developmental biology.[25] The approach of the time, labelled organicism, emphasized the complex inter-relatedness of the developing parts of organisms in *forward* processes.[26] One observed the physico-chemical entities in embryos and their *organizing relationships*—"the nature of the networks of interactions which are involved in the *processes* by which a collection of cells becomes organized into an organ with a unitary character"[27] (fig. 3). Secondly, the notion of a developmental system posits that biological organization can only be profitably discussed in developmental terms, in the process of change.[28] Differing from Huxley's hierarchical classification, Waddington's visions for an evolutionary theory were based on those interactions between developmental processes (fig. 4).[29]

Drawing on the above, Waddington presented an alternative theory of the interrelations between environment and life: epigenetics. It stresses that non-genetic influences such as environment and locality could be causative factors in biological development, specified later as the activation of genomes.[30] A feedback relationship between environment and genes is thus formulated, and is best illustrated by a multi-layered "inscription"[31]: the epigenetic landscape, first pictured as branching creeks and watershed (fig. 5), then as the

25 Waddington was then a junior member of the Theoretical Biology Club at Cambridge.

26 Donna J. Haraway, Crystals, Fabrics, and Fields: Metaphors of Organicism in Twentieth-Century Developmental Biology (New Haven/CT: Yale University Press, 1976), 4–6.

27 Waddington, Tools for Thought, 21. C. H. Waddington, "Chapter 5.5: Whitehead and Modern Science," in Mind in Nature: Essays on the Interface of Science and Philosophy, ed. John B. Cobb and David Ray Griffin (Washington: University Press of America, 1977), 143–146.

28 C. H. Waddington, "Evolution of Developmental Systems," Nature, no. 147 (1941): 108–110.

29 Waddington, "Evolution of Developmental Systems," 109. Huxley, The Uniqueness of Man, 141, 245.

30 C. H. Waddington, "Canalization of development and the inheritance of acquired characters," Nature, no. 150 (1942): 563–565. One of Waddington's most famous experimental findings was bithorax mutation in drosophila (second thorax segment and second set of wings) after ether treatment of the egg.

31 Bruno Latour, "Visualisation and Cognition. Drawing Things Together." Avant, no. 3 (2012): 207–257. Following sociologist of science Bruno Latour, the epigenetic landscape could be considered a mobile inscription device that allows theory to migrate beyond its initial fields.

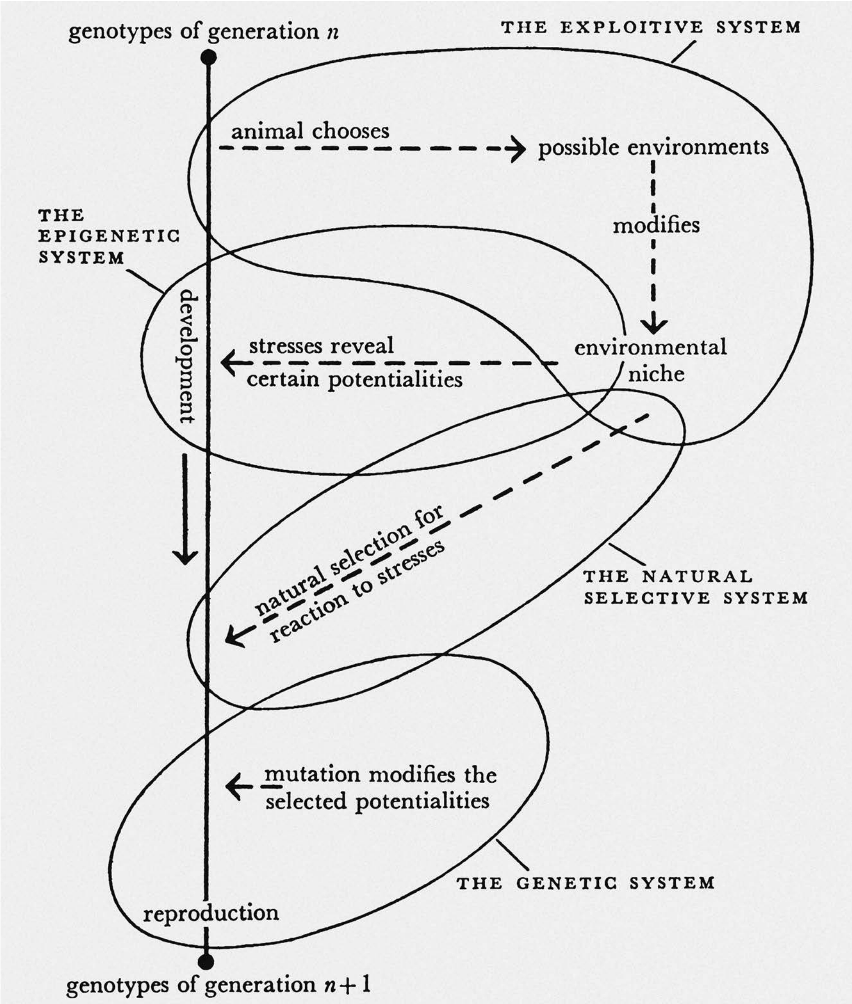


Fig. 4: The logical structure of the evolutionary system: "Changes in gene frequency between successive generations involve the operation of four subsystems: the exploitive, the epigenetic, the natural selective, and the genetic." Source: C. H. Waddington, *Evolution of an Evolutionist*. Edinburgh: Edinburgh University Press, 1975, 57. Reproduced with permission of the estate of C. H. Waddington: Caroline Humphrey & Dusa McDuff

stenographic landscape and network (figs. 6–7), and finally, as attractor surfaces backed up by the mathematics of topology.[32] The epigenetic landscape has since been applied to simulate various developmental phenomena, from neuro development to social-developmental landscapes in cultural anthropology, while the theory remains a guiding framework for research on genetic-environmental interactions in, for example, environmental toxicology.[33] It also invokes an alternative ecological awareness, in that building and mining activities, or worsening habitation conditions on earth, could potentially impact local population epigenetically—a bodily embodiment of ecological change.

Epigenetic systems beyond biology

The question whether urban organization mirrors biological organization or epigenetic development calls for nonliteral thinking, since one cannot discuss genetics, reproduction or heredity in its usual sense in architecture, unless the material context of what we mean by it could be reimagined from scratch.[34] A partial assessment of the significance of Waddington's theories was given by historian of biology and philosopher Donna Haraway, who claimed that Waddington's biggest contribution in developmental biology was in promoting it almost as a Structuralist philosophy.[35] More precisely, epigenetic interactions provided—similar to what homeostatic regulation did in general system theory—a basis for Waddington's theory of progressive systems.[36] Progressive systems preserve stable flows, tend not to have an end-state, and

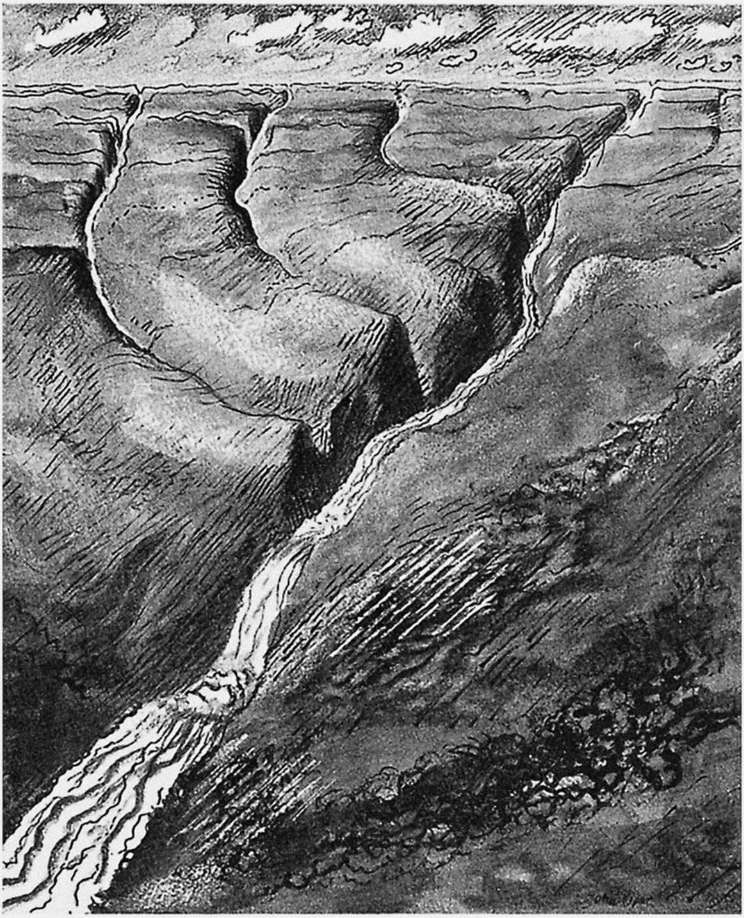
32 C. H. Waddington, Organisers and Genes Cambridge (Cambridge: Cambridge University Press, 1940), frontispiece. C. H. Waddington, The Strategy of the Genes. A Discussion of Some Aspects of Theoretical Biology (London: Routledge, 2014), 29, 45. Waddington, Tool for Thoughts, 105–112.

33 Jan Baedke, "The Epigenetic Landscape in the Course of Time. Conrad Hal Waddington's Methodological Impact on the Life Sciences," Studies in History and Philosophy of Science. Part C, Studies in History and Philosophy of Biological and Biomedical Sciences 44, no. 4 (2013), 756–773. Lok Ming Tam et al., "Arsenite Binds to the Zinc Finger Motif of TIP60 Histone Acetyltransferase and Induces Its Degradation via the 26S Proteasome," Chemical Research in Toxicology 30, no. 9 (2017): 1685–1693. One example of "epigenotoxicity" can be found in how arsenic exposure in drinking water affects epigenetics through degrading TIP60 proteins (DNA repair proteins).

34 Present-day biofabrication endeavours to recharter architectural materials, construction methods and standards from the bottom up. The historical milieu to which ekistics belonged was not ready for such disruption. The broad applicability of existing standards in the developing world had higher priority.

35 Haraway, Crystals, Fabrics, and Fields, 16.

36 Ludwig von Bertalanffy, General System Theory: Foundations, Development, Applications (New York/NY: George Braziller, 1969),160–163.



THE EPIGENETIC LANDSCAPE

From a drawing by JOHN PIPER

Looking down the main valley towards the sea. As the river flows away into the mountains it passes a hanging valley, and then two branch valleys, on its left bank. In the distance the sides of the valleys are steeper and more canyon-like. (See p. 91.)

Fig. 5: The initial conception of the Epigenetic Landscape as depicted by artist and friend John Piper. Source: Waddington, *Organisers and Genes*, frontispiece. Reproduced with permission of Cambridge University Press

exhibit two main behaviours: diversification/branching and stabilization (fig. 8).[37] For Waddington, the growth of towns into cities

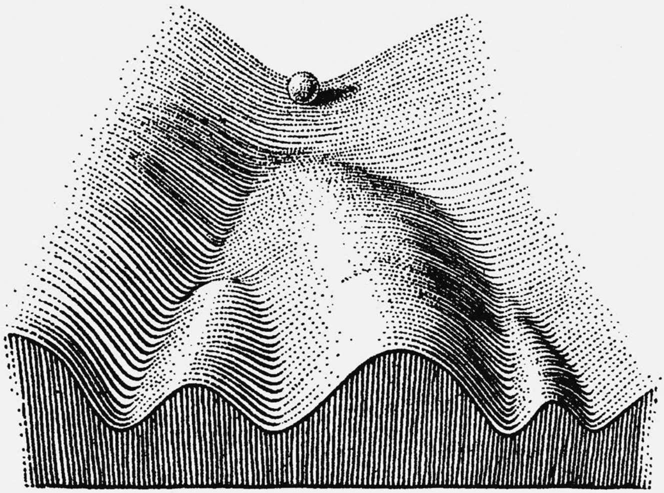


FIGURE 4

Part of an Epigenetic Landscape. The path followed by the ball, as it rolls down towards the spectator, corresponds to the developmental history of a particular part of the egg. There is first an alternative, towards the right or the left. Along the former path, a second alternative is offered; along the path to the left, the main channel continues leftwards, but there is an alternative path which, however, can only be reached over a threshold.

Fig. 6: Epigenetic Landscape from above. Environmental stimulus drives alteration in the landscape. Alternative pathways are formed in correlated push-pull efforts in the underlying, mutating genetic system (Fig. 7). The sphere poised at the top, which could represent part of the cell, limbs, organs or that of generations of the same species, slope down to the *canalized/stabilized* developmental pathway (chreod) natural selection favours. Source: Waddington. *The Strategy of the Genes*, 29. Reproduced with permission of Taylor & Francis through PLSclear

fits the definition, in that multiple sub-centres and subsidiary paths will be developed after some form of stability is challenged, but haphazard sprawl will be stabilized via a natural selection of pathways and an eventual deceleration.[38] Today, seeing urbanization as progressive systems may help us picture those otherwise mostly invisible sociological questions: how does different activities create trajectories for altering the characters of cities,

37 Waddington, Tools for Thoughts, 103–116.

38 Ibid., 109–110.

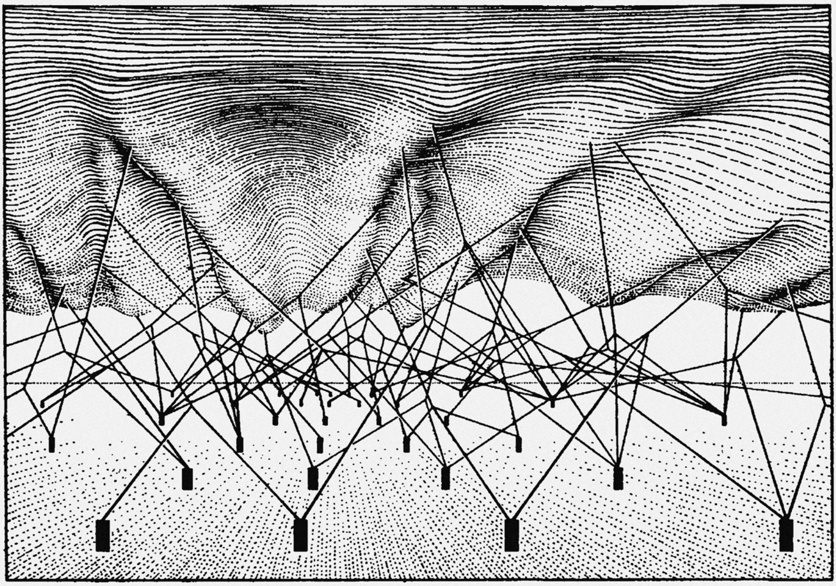


FIGURE 5
The complex system of interactions underlying the epigenetic landscape. The pegs in the ground represent genes; the strings leading from them the chemical tendencies which the genes produce. The modelling of the epigenetic landscape, which slopes down from above one's head towards the distance, is controlled by the pull of these numerous guy-ropes which are ultimately anchored to the genes.

Fig. 7: Epigenetic Landscape from below. The pegs represent genes and the guy-ropes the chemical tendencies that the genes produce. Source: Waddington, *The Strategy of the Genes*, 45. Reproduced with permission of Taylor & Francis through PLSclear

e.g. from xenophobic to cosmopolitan? Architects may as well wonder: along the developmental process, could a new architectural *plasticity* that which responds to both environmental stress and loops of changes in population be defined?[39]

39 Humphrey, Caroline, "A Nomadic Diagram: Waddington's Epigenetic Landscape and Anthropology," Social Analysis 63, no. 4 (2019): 118. The word "plasticity" is borrowed from anthropologist Caroline Humphrey's interpretation.

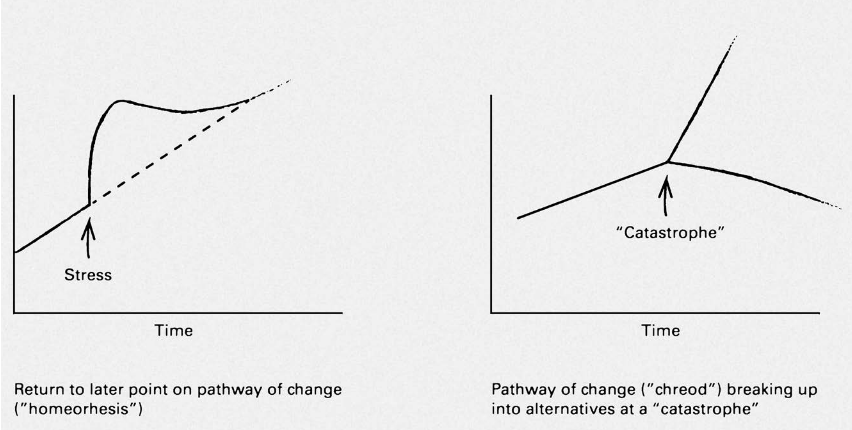


Fig. 8: To control the developmental pathway of a progressive system concerns diverting or differentiating the course of ongoing activities. Waddington's concept of "homeorhesis" (a word which means preserving a flow) suggests change tends to be buffered or absorbed. However, when stability is at risk or at a "catastrophe," developmental pathway is likely to break up into canalized alternatives. Source: C. H. Waddington, "Thinking about Complex Systems." Ekistics 32, no. 193 (1971): 412

Biologically-inspired methodologies of ekistics in practice

As a testbed, the masterplan of Islamabad presents an exemplar of ekistics' biologically-inspired ideas, although it is unclear whether Waddington actually had any impact on the project.[40] Doxiadis attempted to plan the new capital of Pakistan multi-dimensionally by establishing a branching methodology to guide him through decisions (fig. 9).[41] In terms of growth, by building a new centre approximate to the existing one, a symbiotic relationship was created where the new city could absorb infrastructure from the old, eventually forming a two-nucleus capital. In comparison to star-shaped or concentric forms, a directional grid was considered the most advantageous for future expansion. As for the construction process, priority was given to housing lower-income groups—the builders—rather than to governmental

40 Constantinos A. Doxiadis, "Islamabad: The Creation of a New Capital," The Town Planning Review 36, no. 1 (1965): 1–28.

41 Ibid.

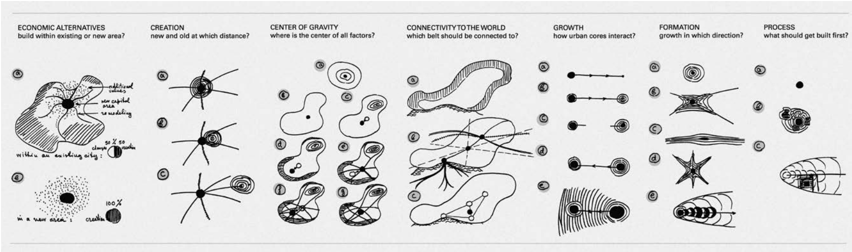


Fig. 9: The branching methodology underlying the design of Islamabad. Source: collage made by author. Diagrams: Doxiadis, "Islamabad," 1–28. Reproduced with permission of Constantinos A. Doxiadis Archives. Dt. UrhR: Constantinos and Emma Doxiadis Foundation

headquarters, since Doxiadis considered builders to be better developmental agents for the city. Reversing the order might have risked the emergence of slums.

By branching out options and following the most sensible stream, an inclusive design came into being: the multi-core dynapolis on a directional city grid, its growth symbiotic with the existing city of Rawalpindi and a national park (fig. 10). These interrelationships were pivotal to the capital's development.[42] It should be noted, however, that these design alternatives are essentially adaptations from Doxiadis' principles, *the evolutionary urban cores*, rather than from unique findings via surveys or experiments.[43]

A biological science of human settlements through Waddington's perspectives

The promise of approaching the subject of human settlements as a *science* evinced a preoccupation beyond the design of city forms, but with establishing a firm justification system, "the organized attempt… to discover how things work as casual system."[44] A clear objective of Doxiadis was to mirror the achievements

42 When compared to equally top-down plans of Brasília or Chandigarh, the ecological and economic sensibility in Islamabad's is an apparent attribute to the capital's prosperity today.

43 Doxiadis' lifelong biology-inspired principles included seeing the cohabitation of humans and machine as unhealthy (for example, open sewers or exposed wires), and the idea of a directional "Dynapolis." Doxiadis, Architecture in Transition, 99–107.

44 Waddington, The Scientific Attitude, x.

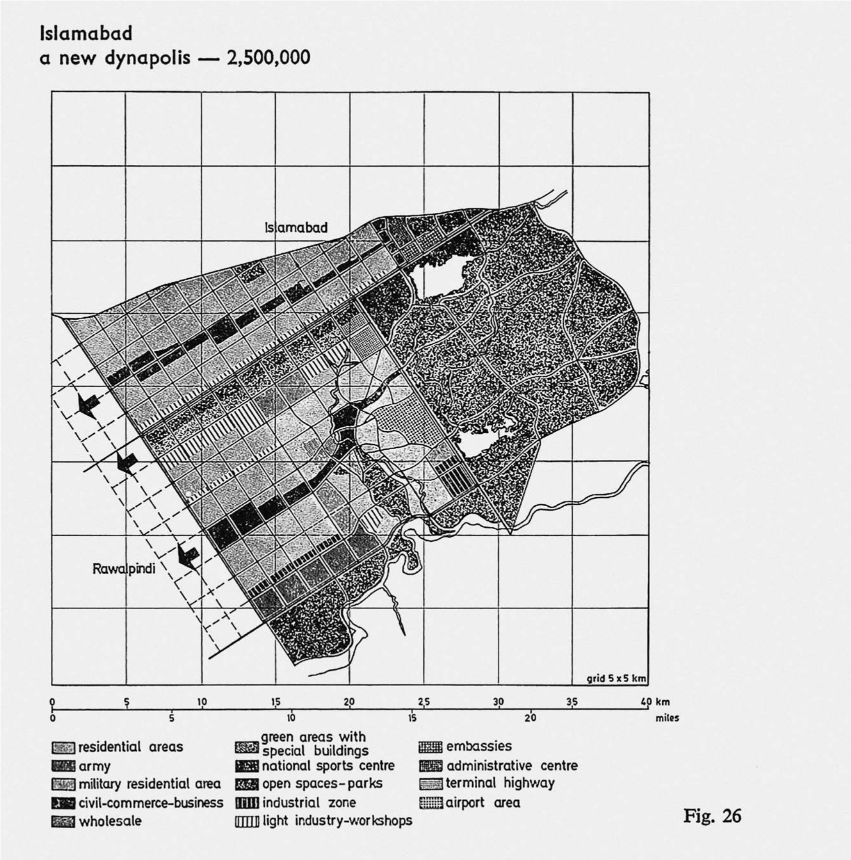


Fig. 10: Doxiadis Associates' masterplan of Islamabad, consisting of a national park, a central green corridor and two uni-directional urban cores. Source: Doxiadis, "The Future of Human Settlements," in *The Place of Value in a World of Facts*, 330. Dt. UrhR: Constantinos and Emma Doxiadis Foundation

made by modern sciences, in particular medicine, which meant that universal urban problems could be cured by tested solutions, and that the outcome of a top-down masterplan could be predicted. This led to an obsessive practice of diagrammatic explanation based on inductive generalization.[45]

45 For a comprehensive account of ekistics' merits and limitations in architectural and urban design see, Panayiota I. Pyla, "Ekistics, Architecture and Environmental Politics, 1945–1976. A Prehistory of Sustainable Development." (PhD diss., Massachusetts Institute of Technology, 2008).

Waddington, although respectful of the architect's practical work, thought artists/architects ought to embrace the sophistication and contemporaneity of a newer scientific paradigm, where *chance* and *indeterminacy* are among the fundamentals of reality.[46] He had earlier conceived that good town planning is, like gardening, "the art of making things grow healthily in the right places."[47] The analogy implies that good planners assign agencies, maintain growth, intervene only occasionally, and embrace unforeseen disturbances; from the viewpoint of a developmental biologist even, a new potentiality would arise after every mutation.[48] Waddington had hoped that the "scientific architects," in their quest for data or other justifications, would not overlook scientists' capacity to seize on new aspects of reality[49]—for example, much more imaginative forms of nature-culture in relation to the process of urbanization.[50] The capacity of ekistics became limited as it rarely questioned its self-generated certainties, nor seized the *chance* to design feedback-generating experiments out of profitable discussion; for example, Waddington's suggestion to synchronize planning with biological phases of human communities (fig. 11).[51]

To reveal those overlooked potentials in his collaboration with Doxiadis, Waddington would dedicate his last years to writing about complex systems, under which the matter of human settlements belongs.[52] For Waddington, the collaboration between biology and the science of human settlements necessitated not a

46 C. H. Waddington, Behind Appearance. A Study of the Relations Between Painting and the Natural Sciences in this Century (Cambridge/MA: MIT Press, 1970), 3–4.

47 Waddington, The Scientific Attitude, x, 69.

48 Waddington, Behind Appearance, 106–107.

49 Ibid., 100.

50 Waddington, The Man-Made Future, 165.

51 Waddington, "Man Is a 'Multi-Shellular' Organism," Ekistics 32, no. 191 (1971): 278. The lack of experimentation in ekistics was hugely dissimilar from the group's contemporaries, like architect Frei Otto's collaboration with biologist Johann Gerhard Helmcke or architect Paolo Soleri's collectively designed and built colossal structure in the name of arcology. Frei Otto and Berthold Burkhardt, Occupying and Connecting: Thoughts on Territories and Spheres of Influence with Particular Reference to Human Settlement (Stuttgart: Edition Axel Menges, 2009). Paolo Soleri, Arcology: The City in the Image of Man (Cambridge/MA: MIT Press, 1969).

52 The two textbooks on complex systems are *Tools of Thoughts* and *The Man-Made Future*.

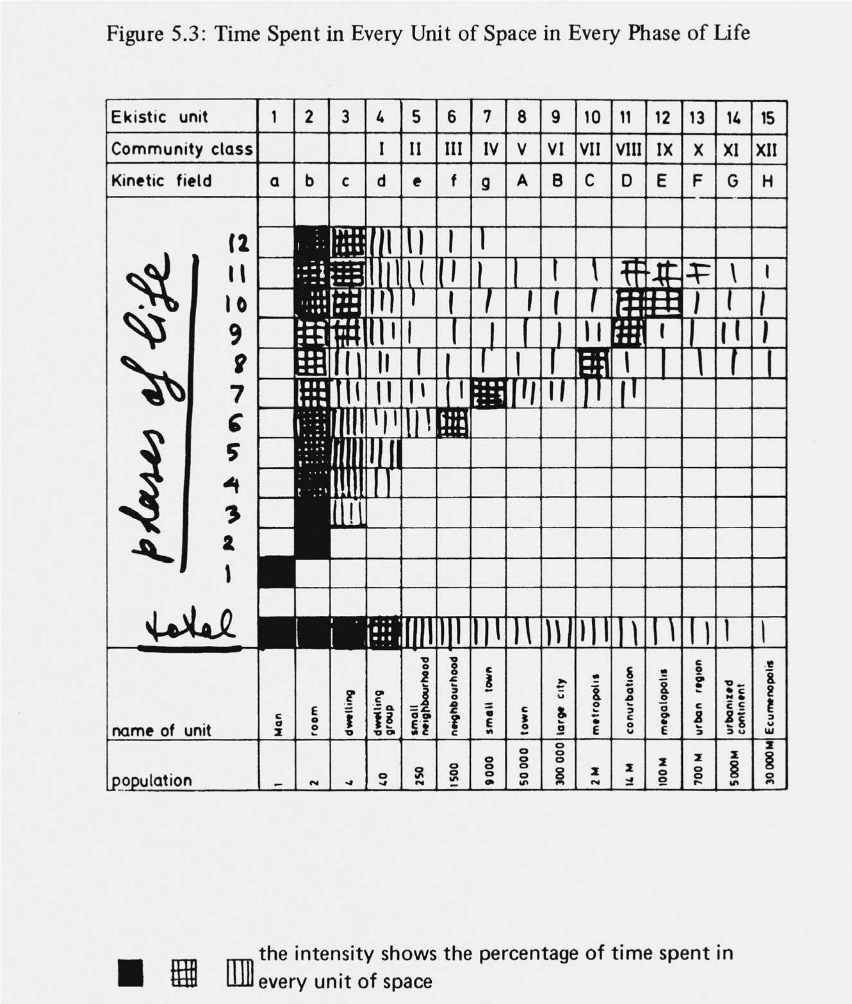


Fig. 11: Intended to apply the botanical or zoological method of taxonomy on the subject of human settlements, Doxiadis proposed a classification grid, known as the Ekistics Grid, divided into the five ekistics elements on a y-axis, matched by a logarithmic scale of population size, on the x-axis. This basic method of classification was used in every analysis or project. Demonstrated is the ekistics grid adapted to Waddington's suggestion to synchronize spatial needs with different phases of life. Source: Constantinos A. Doxiadis, *Anthropopolis. City for Human Development*. New York/NY: Norton, 1975, 107. Dt. UrhR: Constantinos and Emma Doxiadis Foundation

question of how to plan better, but *how to connect planning with the developmental assets of all the world's biological systems*—a set of postulates which will be detailed as follows.[53]

Urban development is mutational: reassessing Central Place Theory

A radical picture of urban development cannot omit the perspective of architect Justin Blanco White, Waddington's wife, and her exposure to some of Doxiadis' dogmas.[54]
As network-technology-impinged decentralization portends death for traditional urban centres, the validity of ekistics' Central Place Theory immediately comes into question. Envisioned by geographer Walter Christaller, Central Place Theory overlays equations and geometrical figures above a large region, and helps evenly distribute the most economically favourable central places, commodity hubs, and urban services. Doxiadis adhered to this model throughout his career, while Blanco White thought its validity had a lifespan.[55] A discussion she had with Christaller would lead to the notion of a centre as a transient concept; one regional pattern superseded by another in successful regional development (fig. 12).[56] By extension, this points to the need to evaluate spaces in terms of their evolutionary values in different configurations.

53 Waddington believed that countless facets of ekistics' concerns demanded biological reasoning and applications beyond the self-restricted realm of physical planning. This view has been referenced by urban theorists as a critique of physicalism: "a perspective that assumed social problems might be solved by manipulating the physical built environment." Erik H. Erikson et al., "Discussion." Ekistics 35, no. 209 (1973): 197. Bally and Marshall, "Centenary Paper," 551.

54 Waddington's knowledge of the architectural profession should be attributed to his wife, architect Justin Blanco White, later the Super-intending Architect of the Scottish Development Department, who occasionally accompanied him to ekistics' Delos meetings. Blanco White was a significant architect-intellectual: she was the daughter of feminist writer Amber Reeves (1887–1981), part of the first generation of female architects and at the centre of student activism at the Architectural Association (AA) where she studied from 1929 to 1934. After AA, Blanco White belonged to a group of practicing feminist architects who "were determined to use their skills as architects for the public good, joining with social reformers in other disciplines (health, housing, welfare) to develop prototypical solutions to the pressing social problems of their day." To this end, she took a post with the Civil Service in Edinburgh where "she played a significant role in the research, design and development of policy for statutory development plans for Scottish cities and boroughs during the 1950s." Elizabeth Darling, "Introduction to the Lives of Women in the Architectural Profession: Justin Blanco White," in Oxford Dictionary of National Biography, last modified July 11, 2019. Accessed October 5, 2021. https://www.oxforddnb.com/view/10.1093/ref:odnb/9780198614128.001.0001/odnb-9780198614128-e-112261.

55 Walter Christaller, R. I. Wolfe and M. J. Blanco White, "Regional Location of Settlements," Ekistics 20, no. 119 (1965): 223–233.

56 Ibid., 233.

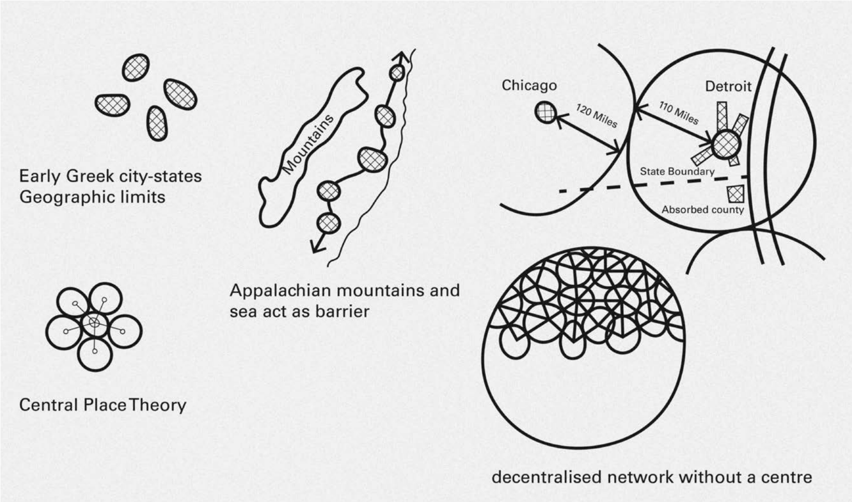


Fig. 12: Diagrams of Central Place Theory and alternative regional patterns in discussion, from city-states towards a connected world where absolute centres are absent. Source: Walter Christaller, R. I. Wolfe and M. J. Blanco White, "Regional Location Of Settlements," in *Ekistics* 20, no. 119 (1965), 233

The emphasis on transience echoes Waddington's question about urban mutation: is the construction of new centres, replacing old ones, a natural selection and hence evolution?[57] He answered in the negative, based on his knowledge that new towns are usually built on the experience of the old, not rebuilt from scratch according to a different pattern, or a set of alternatives to be naturally selected as a biological organism does. He concluded that the replacement of old towns with new ones could function like bone growth, where tissues are removed and added simultaneously in a coordinated way.[58]

Development concerns biological population and organization without compulsion

Waddington made clear within ekistics that a scientific approach to planning almost without exception deals with statistics and

57 C. H. Waddington, "Space for Development," Ekistics 32, no. 191 (1971): 268.

58 Ibid., 269.

population; one must know what the valid conclusions one can draw are, and what are not.[59] Further, since thinking on the level of population rather than the individual was one of the biggest advances in developmental biology, architects ought to adopt this viewpoint by mobilizing the populace in their design: "a population has got to have internal variability to provide resources that can respond to changing circumstances (by utilizing one or another of the many diversities)."[60] He hinted at self-help in housing or, in the case of the Tennessee Valley Authority's watershed resource management, a collective method of long-term investment of a magnitude comparable to money.[61]

Questions of population cannot evade socio-political implications: being or gangs? Pet or pests? On one occasion, Waddington proffered a suggestion for tackling population explosion in postwar India (fig. 13)—adding reversible contraceptives to salt to temporarily sterilize the whole population, and make exceptions only by application.[62] The involuntary measure would have violated every freedom. One is compelled to ask: does biopower in a Foucauldian sense draw a too-fine line between managing a population statistically and managing human societies *zoologically* and dictatorially.[63] A significant number of today's problems lie in the biosphere, where regional control might be hoped for, but no conventional model of democracy can easily adapt to the radicality of benevolent biocontrol.

Speaking of benevolent control, Waddington questioned whether organization without compulsion is possible.[64] He argued strongly in the affirmative for the biological world, saying: "There is no compulsion with an embryo which organizes it. There is a human idea of organization, drawn from the model of the army

59 Ibid.

60 Ibid., 213.

61 R. C. Quinn et al., "Points Made in Discussions," Ekistics 32, no. 191 (1971): 301. Waddington, The Scientific Attitude, 151.

62 Waddington, The Man-Made Future, 30.

63 Michel Foucault, Michel Senellart and Graham Burchell, The Birth of Biopolitics. Lectures at the Collège de France, 1978–79 (New York(NY: Palgrave Macmillan, 2011).

64 Discussion at Delos, "Biological and Psychological Considerations Of Groupings," Ekistics 28, no. 167 (1969): 241–243.

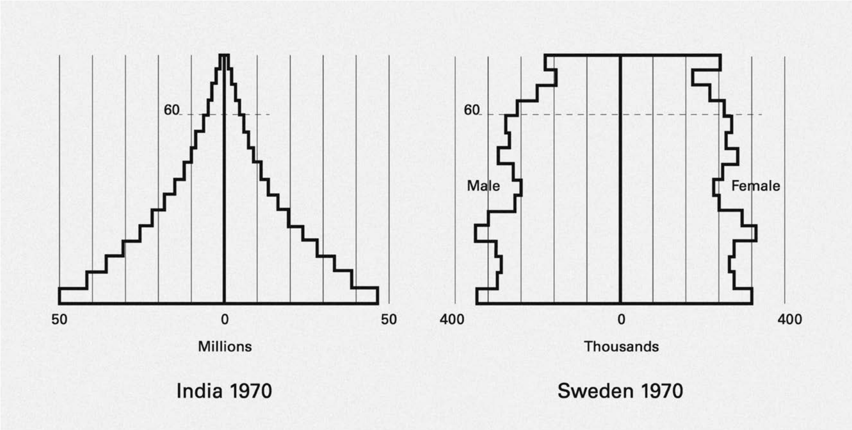


Fig. 13: Age distribution diagram of Indian and Swedish population in 1970. In comparison, note the fertility rate and shorter lifespan in the former. Population base could serve as good indication of structures of needs as well as labour in particular societies. Source: Waddington, *The Man-Made Future*, 23. Figure adapted from the original source by author

or the church. It is a totally non-biological type of organization. Biological organization… depends on participation between the components, which interact with one another in a very intimate way, so that you can't really separate them."[65]

As a precursor to the idea of the "hive mind" in cyberculture of the 1990s—today widely applied in silicon valley's corporate culture, the notion of biological organization still holds untapped potentials for architectural practices.[66]

65 Waddington et al., Biology and the History of the Future, 55–56.

66 Kevin Kelly, Out of Control. The New Biology of Machines, Social Systems, and the Economic World (Reading/MA: Perseus Books, 1995), 9–25. Decades after Waddington's speculations, the 1990s witnessed a new form of cyberculture that converged the communal counterculture of the 1970s with the latest scientific technologies into a biologically inspired techno-utopianism. After the first Artificial Life Conference at the Santa Fe Institute, which sat at the intersection of biology and informatics, Whole Earth Review's and Co-Evolution Quarterly's editor Kelvin Kelly summarized the circle's calls to rethink the natural and socio-economic worlds as connected information networks in his acclaimed book Out of Control. Kelly hailed the phenomenon of "hive mind" as an emblem of a new form of social organization; it refers to swarm intelligence of bees or ants, where rules applied on individuals can generate distributed, decentralized, collaborative and adaptive behaviors of a powerful social whole. An opinion of Kelly and his contemporaries was that a new socio-economic order (or corporate culture) modeled on hive systems computationally could bring about unprecedented socio-technical progress.

Development is instructional

Another thesis of Waddington's was that instruction (or algorithm) is a far more appropriate formulation than information to use in connection with developmental or evolving systems.[67] He explained, "one gets a better idea of the real nature of complex systems we actually come across if one thinks of them, not in static terms of the amount of information they contain, but by asking the more dynamic question, how much instruction was necessary to produce them, or what instructions do they tend to impose on their surroundings?"[68]
In genetics or epigenetics, the capabilities of organisms or living systems could be enhanced through bio-computing.[69] In planning, bio-computational thinking may connote outlining those *vernacular* as well as interventional technologies that serve as instruction about the generation of design, whose systemic capacity is "grown" and belongs to the entire developmental system.

Industrial development through microbiology

The possible application of microscopic biotechnologies in urban or rural development was seriously considered by Waddington and his circle. A discussion on energy and technological development at Delos 10, for example, offered an approach for transforming industrial landscapes through molecular biology.[70] Removed from the rest of the discussion on expanding energy availability through renewable sources, Waddington attempted to disrupt typical mindsets by asserting that we may want to take a new look at those energies uninteresting to anthropocentric economic

67 Waddington, Tools for Thoughts, 140–145. Erich Jantsch and C. H Waddington, Evolution and Consciousness. Human Systems in Transition (Reading/MA: Addison-Wesley, 1976): 247–250. Waddington et al., Biology and the History of the Future, 37.

68 Waddington, Tools for Thoughts, 145.

69 Jantsch and Waddington, Evolution and Consciousness, 247–250. "Understanding Biological Computation," Microsoft Innovation. Accessed October 5, 2021. https://innovation.microsoft.com/en-us/biological-computation.

70 Robert Anderson et al., "Energy resources for development," Ekistics 34, no. 203 (1972): 240.

development, but of value to organisms. Waste heat produced by physics-based industrial models but below an economical threshold could be absorbed into biological systems and diverted to bio-chemical produce, see for instance the growth of algae, rubber, penicillin, hydrochloric acid, yeast, and many other types of protein. Pervasive applications of molecular biology could penetrate into sterile industrial landscapes and turn them into shared production sites of biological life, human and machine, and "when the world's chemical productive industries progress from the Paleo-technic stage of high-temperature energy input to the Neo-technic stage of applied molecular biology, the world's industrial energy balance sheet will look very different."[71] In development and for everything in general, Waddington argued that biology offers a rationale of participation and organization over maximization.[72]

Other radical proposals by Waddington and his network to transform urban and rural development included solid-state enzyme reactors for agricultural nitrogen fixation or edible protein production, microbial techniques in industrial gel filtration, even carbon-to-protein conversion through pervasive cultivation of *spirulina platensis.*[73] These ideas were well-received among some planners, since discoveries in microbiology likely affect not just humankind's survival, but may very well affect the location, size, and distribution of urban and rural settlements too.[74] A study of the inter-relationship between discoveries in one field and activities in others may help ekistics or architecture cultures in general redefine their goals and go further.[75]

71 Ibid.

72 Waddington et al., Biology and the History of the Future, 35–36.

73 The proposals mentioned above were made by industrial microbiologist Carl-Göran Hedén. Ibid., 12–21.

74 Dix, Gerald, "Some Ecological Aspects of Coastal Development," Ekistics 49, no. 293 (1982): 102–107.

75 Ibid.

Utopian visions as evolutionary functions in the pluralistic-scientific attitude and socio-genetic system

Our revisiting of the latent connections between biology and architecture is directed towards a central objective: what are our best chances towards realizing socio-political ideals, or urban utopia, via biological thinking? In answering this, Waddington's predilection for Whitehead's philosophy would likely lead him to prefer process-oriented approaches over superstructural notions:[76] the profound function of a scientific attitude of mind, and the evolutionary-ethical function of a socio-genetic system. In *The Scientific Attitude*—his eponymous view that sciences contribute to social reorganization in its most creative tasks—Waddington argued that an increase in scientific control over human's surroundings is an inevitable evolution of sciences, "whose final standard of value is an observed process of evolutionary advance, it judges things not for themselves, but only for which they produce on the rate of advance."[77] Specifically, he gave the examples of a large-scale but regionally coordinated organization, a decentralization of technology, and compromised privacy for the sake of control, as technical extensions of the scientific attitude.[78] The other thesis, derived from *The Ethical Animal*, is the notion of an interconnected "socio-genetic system" (the mechanism of social teaching and learning) which passes on ethical codes (biological wisdom) that constitute a secondary mechanism by which evolutionary advances can be bought about, perhaps in the form of an epigenetic landscape.[79] Combined, one function of sciences and socio-genetic ethics is to create flexible criteria for assigning higher values to those

76 Waddington would likely identify superstructural notions such as "ideals" or "discourse" as "fallacies of misplaced concreteness" in A. N. Whitehead's philosophy of science. Waddington, Tools for Thoughts, 24–25. Alfred North Whitehead, Science and the Modern World. Lowell Lectures 1925 (Cambridge: Cambridge University Press, 1929), 64–72.

77 Waddington, The Scientific Attitude, vii, 171, 172.

78 Ibid., 23, 152–154.

79 C. H. Waddington, The Ethical Animal (London: Routledge, 2016), 29.

activities that encourage forward progress, both of the socio-genetic system (below), and of the changes in the grade of human organization which that system causes (above).[80] Architecture—if understood to be about the control and organization of the physical environment a pluralistic-scientific attitude could create, in addition to its ethical function in the socio-genetic evolution of humans, the ethical animal—was precisely Waddington's example of one of the highest-value activities where coordinated evolutionary advances were and are still called for.[81]

Conclusion

Restructuring architectural practices as a biologically-conscious science remains an enormously challenging undertaking by today's standards. In the heyday of the complexity sciences and their claims of applicability across subject matter, ekistics' and Waddington's historical endeavours demonstrated the very ideal of systemic control, and the political will to divert a discipline as self-absorbed but responsibility-laden as architecture, to the openness of science where dogmas can be and were debated. The reasoning and techniques of biology offer at the very least a chance for modern art and architecture to break away from the fixated material cultures the modernists acquired from the physical sciences. In the better cases of Geddes and Mumford, the evolution of cities and life were considered reciprocal, thus forming the evolutionary, developmental, and organizational bases of an organicist approach to planning. These lines were pursued by Doxiadis on a universal scale with reference to Huxley's evolutionary theory and were exemplified in Islamabad where processes, interrelations, or evolutionary pathways were incorporated in the design process. Despite the practical success of this project, Waddington's interest was in a genuine conceptualization of a possible science via insights from developmental biology and epigenetics, which would illuminate the potentials of identifying urban development processes as biological developmental ones,

80 Ibid., 204.

81 Ibid., 217.

whose organization, course, and interactive dynamics could be described and prescribed though the kind of experimentation ekistics lacked. As a result, many of Waddington's ideas on ekistics are fragmentary—but advanced— speculations, for example, that regional patterns are transient in mutation; that seeing architectural development from the perspective of biological population and organization gives biopolitics a design function; that algorithm-environment interaction begins with formulating instructions; that microbiology offers a radically different rationale to the design of industrial landscapes; and that ultimately, to get in closer proximity to utopian visions, we need to install sets of earthy, process-oriented and sciences-embodied functions in our practices, those that will control and facilitate the inherent evolutionary mechanism of (post-)humanity, namely, the socio-genetic system of the ethical animals, whose ways of life are still to be architected.

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NATHALIE KERSCHEN

Towards a New Understanding of the Animal

Drawing from the phenomenological tradition in architecture, this paper critically engages with the Cartesian concept of the "animal-machine," embedded in contemporary bio-inspired approaches to computation. The translation of animals' morphological properties and behaviour into algorithms, or the use of living animals during the fabrication design process, created innovative design and "new materials." This paper will contextualize these developments alongside the history of architectural computation and cybernetics. Yet it will also challenge the assumptions underlying these new methods. Using phenomenology and recent advances in embodied cognition, I will present an alternate account of the animal, one that conceives of the animal as a living being within its Umwelt [milieu].

Introduction

Since the 2000s, thanks to the rapid development of computing hardware and software, architects have questioned Nature through the lens of computation.[1] Architect's design of complex geometries and their production of "new materials" (such as composite fibre materials) through scripting techniques and customized robotic fabrication[2] have enabled what Neri Oxman, architect and leader of the Mediated Matter Group at

1 I write Nature with a capital letter to challenge the reduction of its essence to mere "matter" in the Cartesian sense of the term.

2 Jan Knippers and Achim Menges, "Fasern neu gedacht – Auf dem Weg zu einer Konstruktionssprache," Detail, no. 12 (2015): 1241.

the Massachusetts Institute of Technology (MIT), calls the "reexamin[ation of] nature's well-kept secrets."[3] Characteristic of these "new ways of thinking about form and its generation"[4] are architects' combination of computation as a form-finding technique with data gathered through scientific observation. These bio-inspired approaches to computation integrate information on "natural systems," translating functional and mathematical principles from biomimetics, synthetic, theoretical, and/or evolutionary biology into form-finding algorithms. Some architects have even transferred their studies on animal behaviour into code or script. They have developed empirical in-house experiments with plants and animals to generate data used for their computational design processes. These recent developments, combined with a file-to-factory approach, have sparked renewed interest in the cybernetic and systems culture of the post-war era,[5] and have propelled the animal forward as a "driver" of design.

The diving bell spider and the ICD/ITKE Research Pavilion (2014–15)

The growing interest in the living organism is demonstrated by the fibrous composite pavilions built by students of the Institute for Computational Design and Construction (ICD) and the Institute of Building Structures and Structural Design (ITKE) at the University of Stuttgart from 2012 to 2015.[6] Of particular interest

3 Neri Oxman, "Per Formative: Toward a Post-Formal Paradigm in Architecture," Perspecta 43 (2010): 20.

4 Ibid., 26.

5 Several important historical studies on computation and architecture in the wake of the Second World War have been published recently. For instance, Orit Halpern, Beautiful Data: A History of Vision and Reason since 1945 (Durham: Duke University Press, 2014). Molly Wright Steenson, Architectural Intelligence: How Designers and Architects Created the Digital Landscape (Cambridge/MA: MIT Press, 2017). Theodora Vardouli, "Graphing Theory: New Mathematics, Design, and the Participatory Turn" (PhD diss., Massachusetts Institute of Technology, 2017).

6 The ICD is led by architect Achim Menges and the ITKE by engineer Jan Knippers. As indicated on their website, designing and constructing a "full scale research architectural prototype" constitutes an integral part of the two-year Master program ITECH. See "International M.Sc.Programme: ITECH | Brochure 2020–21," Institute for Computational Design and Construction, University of Stuttgart. Accessed August 1, 2020, https://www.icd.uni-stuttgart.de/public/ITECH/ITECH_Brochure.pdf.

Fig. 1: View of the ICD/ITKE Pavilion 2014–15 in front of the University of Stuttgart, Germany, 2015. Source: reproduced with permission from the ICD/ITKE, Dt. UrhR: ICD/ITKE University of Stuttgart

to my investigation is the last pavilion in this series (2014–15),[7] which was modelled on the behaviour of the diving bell or water spider (*Argyroneta aquatica*).[8] The ICD/ITKE 2014–15 pavilion (fig. 1) consisted of a load-bearing structure made of composite fibre materials and a transparent Ethylene tetrafluoroethylene (ETFE) membrane.[9] This quasi-pneumatic structure spanned

7 In total, three fibrous composite pavilions, built between 2012 and 2015, drew inspiration from biological “role models.” While the 2012 pavilion builds on “the structural performance through changes in fibre arrangement, density and orientation” of a lobster’s exterior skeleton, the 2013–14 pavilion was modelled according to biomimetic principles underlying the fibre organization in the beetle’s elytron or wing case. See Knippers and Menges, “Fasern neu gedacht,” 1241–1242. I will use the term “role model” in the sense meant by the ICD in this article. For more, see Menges et al., “Behavioral Design and Adaptive Robotic Fabrication of a Fiber Composite Compression Shell with Pneumatic Formwork.” (Presented at the ACADIA 2015: Computational Ecologies, Cincinnati, Ohio, 2015), 298.

8 The *Argyroneta aquatica* spends most of its time underwater. To survive in fresh water, the animal builds a “diving bell” and fills it with dissolved oxygen. It uses the fine hair which covers its abdomen and rear legs to transport oxygen from the water’s surface to its underwater habitat. The bubble remains open at the bottom and consists of silk fibres that the animal spins around aquatic plants. See Roger Seymour and Stefan Hetz, “The Diving Bell and the Spider: The Physical Gill of Argyroneta Aquatica,” The Journal of Experimental Biology 214, no. 13 (2011): 2175.

9 Knippers and Menges, “Fasern neu gedacht,” 1241–1242.

7.5 meters. To construct it, 45 kilometres of carbon fibres were covered with epoxy resin and placed onto a weather-resistant membrane.[10] According to the design team, each fibre was individually positioned by a robotic arm from within an enclosed and pre-pressured ETFE space. This air space served as a "formwork" (mould) until the membrane and the fibres merged into a self-supporting structure of qualitatively differentiated fibre composite filaments.[11]

The pavilion mimics the transparent skin of the spider's underwater silk bubble, which reminds visitors of the animal's natural habitat (fig. 2). However, the commonalities between the spider's aquatic "dome" and the ICD/ITKE pavilion extend beyond formal and structural analogies, to encompass what Knippers and Menges call a "contemporary approach to architectural biomimetics."[12] This method seeks to transfer "the [biological] principles underlying the creation of structural forms" to the digital design process.[13] Although the overall goal was "to create a wide range of performative geometries with minimal material investment,"[14] the ICD/ITKE's design and construction process differed from previous pavilions. For the 2012 and 2013–14 pavilions, the designers focused on the morphological (that is, the shape and structural) characteristics of an animal's bodily constitution to generate its form and determine its materiality.[15] However, this time the team also concentrated on the "set of behaviors that the spider employs, the order of the construction sequence, and the hierarchical arrangement of fibers which exhibit performative structural characteristics."[16] In collaboration with biologists from the University of Tübingen,[17] the designers examined the "underlying behavioral patterns and design rules" of the spider's natural

10 Ibid., 1242.

11 Menges et al., "Behavioral Design," 298.

12 Jan Knippers and Achim Menges, "Fibrous Tectonics," in Material Synthesis: Fusing the Physical and the Computational (London: John Wiley and Sons, 2015), 45.

13 Knippers and Menges, "Fasern neu gedacht," 1241.

14 Menges et al., "Behavioral Design," 298.

15 Knippers and Menges, "Fibrous Tectonics," 45.

16 Menges et al., "Behavioral Design," 299.

17 Knippers and Menges, "Fibrous Tectonics," 45.

Fig. 2: Close-up view of the *Argyroneta aquatica* in its underwater bell, ICD/ITKE Pavilion 2014–15, Germany, 2015. Source: reproduced with permission from the ICD/ITKE, Dt. UrhR: ICD/ITKE University of Stuttgart

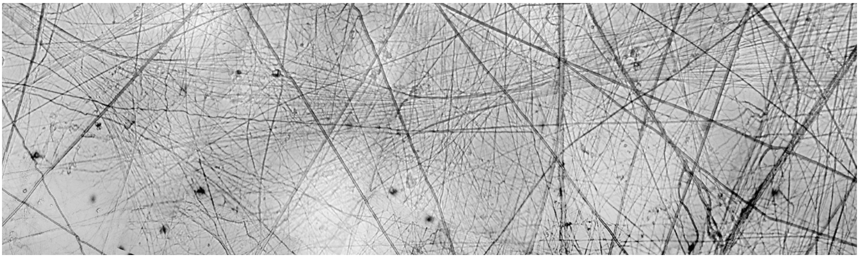

Fig. 3: Microscopic image of the water spider's silk fibre net, ICD/ITKE Pavilion 2014–15, Germany, 2015. Source: reproduced with permission from ICD/ITKE, Dt. UrhR: ICD/ITKE University of Stuttgart

silk-laying process to stabilize the bell structure of its underwater habitat.[18] For example, they differentiated between the performance of compact fibre arrangements that retain oxygen, fibres that branch, and fibres that solidify the overall structure by filling the surfaces in-between the branches[19] (fig. 3). Once the necessary data was extracted from the biomimetic analysis, they "abstracted" this information into a set of form-finding algorithms to generate the pavilion's overall geometry.[20] Other material, structural, and technical constraints affected the final shape of the pavilion. As the designers emphasize in one of their publications, the maximum reach of the six-axis robot, the geometrical properties of the structure, and the behaviour of the inflated ETFE membrane during the fibre placement had an impact on the pavilion's form and materiality.[21]

The biomimetic approach did not stop at the structural level. The designers also translated the spider's spinning behaviour into a "cyber-physical production system" for fibre placement.[22] Embedded within this technical expression is a cybernetic feedback circuit. An interface directly links the "computational

18 "ICD/ITKE Research Pavilion 2014–15," Institute for Computational Design and Construction, University of Stuttgart, accessed July 21, 2021, https://www.icd.uni-stuttgart.de/projects/icditke-research-pavilion-2014-15/.

19 Achim Menges et al., "Fibre Placement on a Pneumatic Body Based on a Water Spider Web," in Material Synthesis, 63.

20 Menges et al., "Behavioral Design," 299.

21 Ibid., 298, 300.

22 Achim Menges, "The New Cyber-Physical Making in Architecture," in Material Synthesis, 28.

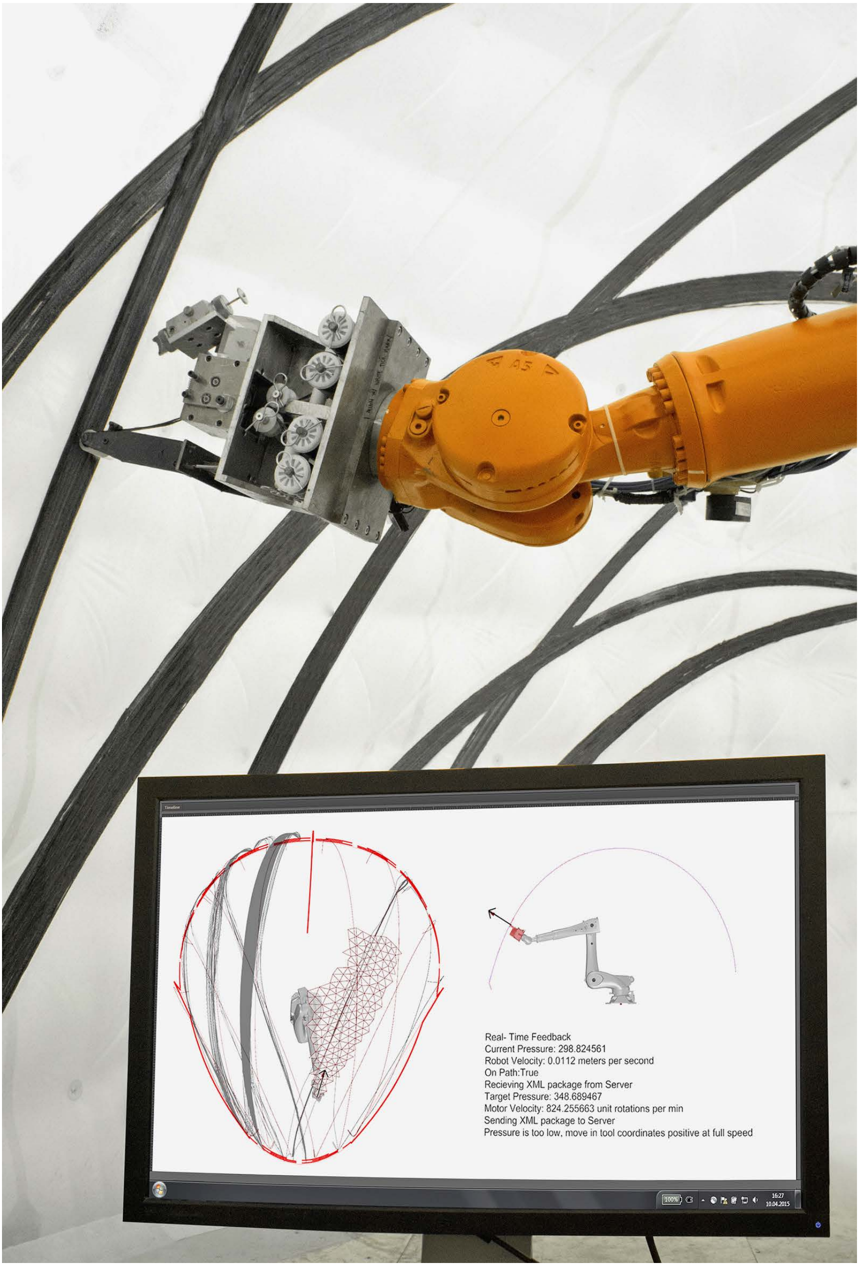

Fig. 4: View of the robotic fibre layering process from within the enclosed ETFE structure, ICD/ITKE Pavilion 2014–15, Germany, 2015. Source: reproduced with permission from ICD/ITKE, Dt. UrhR: ICD/ITKE University of Stuttgart

system"—the digital matrix containing all the information about the pavilion's geometrical, structural, and material properties—to the robotic fabrication process. This is what Menges calls a "physical system"[23] (fig. 4). Key to the success of this "behaviour-based approach" was a computational tool developed by the designers.[24] This "agent" mediated in "real time" between the robot's pressure sensors and effectors, the pavilion's simulated geometry, and its changing form as wet carbon fibres were placed onto the temporary ETFE mould.[25] As its creators describe, "[s] imilar to the spider, a digital agent navigate[d] the surface shell geometry," and constantly adjusted the design system to the fabrication process's environmental, structural, and material constraints.[26]

Silkworms, Silk and the Mediated Matter Group (2013)

Around the same time, another compelling research project, the Silk Pavilion, was built by the Mediated Matter Group (MMG) under the direction of architect Neri Oxman at MIT.[27] Sharing an interest in "new materials" with the ICD/ITKE, the Boston group has experimented with fibre materials, computation and robotic fabrication processes since the lab's foundation. In contrast to their German peers, however, they have taken a further step by examining "the relationship between digital and biological fibre-based fabrication on an architectural scale."[28] They have developed new fibre composites by combining naturally fibrous

23 Ibid., 32.

24 Ibid.

25 Menges et al., "Behavioral Design," 298, 302.

26 Institute of Computational Design and Construction, "ICD/ITKE Research Pavilion 2014–15."

27 The Mediated Matter Group was part of the Media Lab at the MIT. The Media Lab grew out of the Architecture Machine Group that ran from 1967 to 1985 under the guidance of Nicholas Negroponte and Leon Groisser. See Steenson, Architectural Intelligence, 165.

28 Neri Oxman et al., "Silk Pavilion: A Case Study in Fibre-Based Digital Fabrication," in FABRICATE: Negotiating Design & Making, ed. Fabio Gramazio, Matthias Kohler, and Silke Langenberg (London: UCL Press, 2017), 248.

materials (among them, cellulose, chitin and pectin) with additive manufacturing techniques to produce natural biopolymers, as seen in the Aguahoja I pavilion's vertical leaf-like structure (2018).[29] For the Silk Pavilion,[30] a suspended half-dome made of natural and synthetic silk fibres, the group studied the behaviour of the living silkworm (*Bombyx mori*) to generate the pavilion's geometry and materiality before putting the animal to work as a "biological multi-axis multi-material 3D 'printer'" during the production process.[31]

As the design team notes in their 2014 conference paper "Silk Pavilion: A Case Study in Fibre-Based Digital Fabrication,"[32] they developed a multi-step process. First, the designers conducted empirical research into the silkworm's spinning characteristics during the pupae stage before translating their findings into an actual pavilion. In a laboratory setting, they traced the animal's path using magnetometer motion sensors attached to the silkworm's head during a three-day spinning period. They also analysed the cocoon's morphological properties by producing high-resolution images with an electron scanning microscope and microtomography. Additionally, they experimented with the environmental conditions surrounding the silkworm's spinning process, inciting the animal to produce horizontal "patches" for the pavilion instead of its natural cocoon form. Using data from the tests, the MMG developed a computational tool that generated both the geometry of the pavilion's temporary structure and the synthetic "thread geometry" which underlaid the silkworms' future filaments.[33] The goal, as the designers write elsewhere,

29 Neri Oxman and The Mediated Matter Group, "Aguahoja I," in The Neri Oxman Material Ecology Catalogue, ed. Emily Hall and Jennifer Liese (New York/NY: The Museum of Modern Art, 2020), 75.

30 A newer version of the Silk Pavilion was on display as part of the exhibition "Neri Oxman: Material Ecology" at the Museum of Modern Art in New York in 2020. Instead of presenting a dome-shaped pavilion, this time the team opted for a form based on hyperbolas. For further information, see Oxman and The Mediated Matter Group, "Silk Pavilion II," in The Neri Oxman Material Ecology Catalogue, 106–115.

31 Oxman et al., "Silk Pavilion," 249.

32 The description of Silk, including the methods and techniques used by the MMG, in this section are based on Oxman et al., "Silk Pavilion," 248–255, unless indicated otherwise.

33 Ibid., 251.

was to improve "the structural performance and material optimization of robotically deposited fibre structures"[34] by developing a parametric matrix that grouped together physical, biological, and material constraints in one system.[35]

Once the primary geometry was defined, the team began to fabricate the suspended dome, a process realized in two phases. However, before placing the silkworms to spin, the MMG had to build a temporary framework. This structure consisted of 26 polygonal aluminium frames that were each covered with synthetic silk thread by a CNC machine following the computer-generated spinning path. Not until the temporary structure was suspended and the aluminium frames released were the approximately 6500 silkworms, on the verge of pupation, installed, one by one, at the base of the pre-spun dome. For ten days, the animals almost closed the pre-designed gaps between the computationally-simulated and numerically-positioned threads.[36] Migrating from the bottom towards the top of the structure, mostly selecting the shady areas, the silkworms progressively covered the dome's surface with naturally positioned "skin," before being taken off the pavilion after two to three days to finish the natural process of their metamorphosis.[37]

On the animal's status in bio-inspired approaches to computation

Although promising in terms of formal and material innovation, these bio-inspired approaches to computation and robotic fabrication hardly enhance our conception of the animal as a *living being*. On the contrary, they only increase our confusion. Comparing the spider's spinning efforts to maintain an adequate oxygen level within its underwater bubble to the feedback loops

34 Neri Oxman et al., "Biological Computation for Digital Design and Fabrication" (eCAADe 2015 – 33rd Annual Conference, Vienna University of Technology, 2015), 1.

35 Oxman et al., "Silk Pavilion," 250–251.

36 Note that the designers installed a safety net underneath the suspended structure in case the silkworms fell.

37 Oxman et al., "Silk Pavilion," 254.

exchanged between "computational systems" and robotic arms, or equating the silkworms' spinning activity to "biological systems… that 'compute,'"[38] reduces animals to machines. However, in contemporary design cultures, this Cartesian conflation has been taken for granted. This begs the question: Do architects, who adopt these techniques, not only *form*, but also *deform* our conception of animals when they emulate what Merleau-Ponty calls the "objective body," or the body as determined by the sciences, instead of the "phenomenal body,"[39] that is, the lived body as it moves and perceives within its surroundings? Even if I present an alternate approach to the Cartesian concept of the "animal-machine,"[40] one that builds on the animal's "phenomenal body" in Merleau-Ponty sense, my goal in this paper is not to define what animality *per se* is. Rather, what drives my inquiry is whether the mischaracterization of the animal body as a design instrument points towards a deeper problem in architectural theory and practice, a problem originating in the idea of "architecture as biology"[41] or "architecture as science."[42]

38 Oxman et al., "Biological Computation," 1.

39 "[T]he phenomenal body [is] the body insofar as it projects a certain 'milieu' around itself, insofar as its 'parts' know each other dynamically and its receptors are arranged in such a way as to make the perception of the object possible through their [embodied] synergy." See Maurice Merleau-Ponty, Phenomenology of Perception, trans. Donald A. Landes (Abingdon: Routledge, 2012), 241.

40 In *Treatise of Man*, Descartes described the functioning of the animal and the human body in purely mechanical terms. See René Descartes, "Treatise on Man," in The World and Other Writings, trans. Stephen Gaukroger (Cambridge: Cambridge University Press, 2003), 99–170.

41 According to the architectural scholar Catherine Ingraham, the reification of the animal through the sciences can be traced back to the Renaissance. However, it was not until the advent of the positive sciences, for example, 19th century biology and psychology, that a scientific conception of non-human beings was systematized. See Catherine Ingraham, Architecture, Animal, Human: The Asymmetrical Condition (London: Routledge, 2006), 18.

42 Similar to Ingraham, the architectural scholar Alberto Pérez-Gómez notes that, although the idea of architecture "as applied science" has become "institutionalized" during the 19th century, its origins go back as far as the epistemological changes in Cartesian philosophy and Galilean science. See: Alberto Pérez-Gómez, "Architecture as Science: Analogy or Disjunction?" in Timely Meditations: Selected Essays on Architecture, vol. II (Montreal: RightAngle International, 2016), 63–64.

The "new" in computational architecture?

Before elaborating on the animal's entwinement with the new sciences and computer environments,[43] I will briefly contextualize present-day claims about novelty in computational design involving biomimetics and/or bionics, and the relationship between architecture, biology, and computation. Despite the overwhelming literature on "paradigm shifts," "turns" and "digital revolutions" popular within the architectural community over the last thirty years,[44] the use of computers, sensors, and effectors, such as the ones employed in the ICD/ITKE pavilion's fabrication process, is not new *per se*. The architectural scholar Larry D. Busbea, for instance, links the mechanisms underpinning the ICD/ITKE's 2016 Elytra Filament Pavilion to the 1970s "responsive environments" movement, which emerged in the wake of architects' growing interest in computation, cybernetics, and the body's physical surroundings.[45]

Using animals and plants as architectural role models is not a recent novelty, either. According to the architect and theorist Philippe Steadman, the idea of "biotechnics" or "biotechnique" emerged in the 1920s and 1930s when architects used "the engineering of nature" to enhance the "structural, mechanical, even chemical, and electrical" properties of the built environment.[46] As he explains, the goal behind this design approach was to extract

43 I use the term "computer environments" as a derivative of SEEK's other title, "Life in a Computerized Environment," in the "Software" exhibition catalogue. I will return to this idea when discussing SEEK. See Software – Information Technology: Its New Meaning for Art (New York/NY: The Jewish Museum, 1970), 20.

44 For example: Mario Carpo, The Second Digital Turn: Design beyond Intelligence (Cambridge/MA: MIT Press, 2017). Peter Eisenman, "Visions Unfolding: Architecture in the Age of Electronic Media," in The Digital Turn in Architecture 1992–2012, ed. Mario Carpo (Chichester: Wiley, 2013), 16–27. Charles Jencks, The New Paradigm in Architecture: The Language of Post-Modernism (New Haven/CT: Yale University Press, 2002).

45 By "responsive environments," Busbea means "technologically mediated spaces that alter their physical or ambient properties based on various inputs or status changes." These changes are mainly computer-controlled. See Larry D. Busbea, The Responsive Environment: Design, Aesthetics, and the Human in the 1970s (Minneapolis/MN: University of Minnesota Press, 2020), 89–90, 124–125. Note that the 2016 pavilion by the ICD/ITKE is a more elaborate version of the 2014–15 pavilion in terms of a "behaviour-based approach" to computational design.

46 Philip Steadman, The Evolution of Designs: Biological Analogy in Architecture and the Applied Arts (London: Routledge, 2008), 153.

from Nature "a great variety of 'inventions,' [already] embodied in the designs of organs or in the adaptations of the limbs" that have evolved under evolutionary stresses, and, therefore, were proven to be efficient.[47] These early attempts to "copy" Nature, Steadman elaborates, resulted in enormous progress in the aviation sector, before this body of knowledge was absorbed by the recently founded field of "bionics"—a new science that emerged in the 1960s and was particularly embraced by proponents of cybernetics and information theory.[48] Since then, he concludes, the focus has shifted away from empirically observing plants and animals and towards an "abstract and codified… generalized theory of behaviour," while the functioning of Nature and human-made mechanisms has become "interchangeable."[49]

Even before the bio-technical approach discussed by Steadman, architects were turning to the natural world to find precedents for their designs. Architectural historian Adrian Forty draws a parallel between the 19th century conception of biological "function" and the performance of bodily organs with 19th century architects' use of these functionalist metaphors.[50] In *Architecture, Animal, Human: The Asymmetrical Condition*, the architectural scholar Catherine Ingraham makes a similar point. She, too, traces biology's encroachment into architecture, and vice versa, to the 19th century, when historians of architecture and biologists began to appropriate one another's metaphors, using "structure, typology, organization, evolution and development," in their respective disciplines.[51] This tendency to conflate biology with architecture, and the organic with the inorganic, Ingraham argues, has regained momentum with the advent of computation as an architectural design technique.[52] Ingraham does not discuss the ICD/ITKE or MMG's bio-inspired approaches to computation *per se*,

47 Ibid.

48 Ibid., 161.

49 Ibid., and 162.

50 Adrian Forty, "Function," in Words and Buildings: A Vocabulary of Modern Architecture (New York/NY: Thames & Hudson, 2000), 175, 177–178.

51 Ingraham, Architecture, 23.

52 Ibid., 26–27.

instead focusing on the intertwined development of computation, cybernetics and genetic biology through the lens of the human body.[53] However, she points to the risks inherent in a "mechanization of the flesh" which may arise when architects stop differentiating between "biological life and machine life and the idea of an informational system that acts as an 'organic system.'"[54]

To return to "novelty," what may have changed when it comes to bio-inspired approaches to computation are the new technological possibilities which have allowed architects to conduct proto-scientific experiments in-house. Architect's acquired data can be instantly implemented into robotically-fabricated products, which enables them to override the traditional division of labour between design, fabrication, and construction phases, another new possibility of the digital age. According to Hensel and Menges, "a decisive shift away from biological metaphor and superficial biomorphism towards a literal biological paradigm for a performance-orientated architecture" has influenced the design process, too.[55] This development is tied to sophisticated technological apparata, such as the electronic scanning microscope or microtomography used for the observation of animals and plants. Moreover, computing power and computation as a design technique have facilitated the transfer of data from one discipline to another. Knippers could not be more correct when he attributes the success of "computational" over "physical form-finding" processes to the "'digital model' [as] a common basis for the exchange of knowledge across the disciplines… enabl[ing] direct communication between, so far, widely separated fields of science."[56] This particularly applies to the information exchange between biology, architecture and engineering.[57]

53 Ibid., 305.

54 Ibid., 302, 307.

55 Michael Hensel and Achim Menges, "The Heterogenous Space of Morpho-Ecologies," in Space Reader: Heterogeneous Space in Architecture (Chichester: Wiley, 2009), 208.

56 Jan Knippers, "From Minimal Surfaces to Integrative Structures – The SFB-TRR 141 in the Light of the Legacy of Frei Otto and the SFB 230 'Natürliche Konstruktionen,'" in Biomimetic Research for Architecture and Building Construction, ed. Jan Knippers, Thomas Speck and Klaus G. Nickel (2016), 8–9.

57 Ibid., 9.

Also noteworthy is that scripting as a design technique and digital fabrication processes have become more accessible in universities over the last decades.
However, the philosophical foundations undergirding the living organism conceived of as an "animal-machine" have certainly not evolved. According to Steadman, the roots of the animal's "mechanization" in architecture, which is pervasive in biomimetics and bionics, have their origins in *the biological idea* of an "organism as machine" that first emerged in the wake of Cartesian philosophy, before being adopted by 19th century biologists.[58]

The cybernetic "animal-machine"

The philosophical and biological lineage of the Cartesian "animal-machine" can still be felt in contemporary architecture. While "the commonalities between computation and biology run deep,"[59] so do those between systems thinking, cybernetics and the life sciences, as Ingraham pointed out.[60] Consider cybernetics, which originated in the wake of the Second World War. Its theory was based on the idea of the animal as a Cartesian "animal-machine" or "automaton,"[61] functioning as mere "mechanism" without a "rational soul."[62] The title of Norbert Wiener's notorious book *Cybernetics or Communication and Control in the Animal and the Machine* provides a compelling example of this reduction of animals to machines. Likewise, Walter Cannon's biological concept of "homeostasis," which describes "those processes through which the material and energetical situation of the organism is maintained constant,"[63] has been widely used

58 Steadman, Evolution, 11, 13.

59 Christina Cogdell, Toward a Living Architecture: Complexism and Biology in Generative Design (Minneapolis/MN: University of Minnesota Press, 2019), 4.

60 Ingraham, Architecture, 320.

61 Norbert Wiener, Cybernetics or Control and Communication in the Animal and the Machine (New York/NY: MIT Press, 1961), 40.

62 Peter Harrison, "Descartes on Animals," The Philosophical Quarterly 42, no. 167 (1992): 223–224.

63 Ludwig von Bertalanffy, General System Theory: Foundations, Development, Applications (New York/NY: G. Braziller, 1973), 78.

in cybernetics to describe the "self-regulation" and "feedback" mechanisms that operate in machines and animals.[64] Biologist and system theory founder Ludwig von Bertalanffy attempted to break away from this mechanistic conception of the animal by advancing an "organicist position"—the idea of an "organism as a whole or system,"[65] but his efforts did not succeed. Although Bertalanffy posited "the organism [as] a basically *active* system [emphasis mine]"[66]; in *General System Theory*, he applied the same logico-mathematical formulations and principles that governed non-living "systems" to "living systems."[67] In other words, despite his biological and philosophical attempts to do otherwise, he still reduced the living animal to a set of abstract and disembodied "relations."

These early attempts at "cybernetics to appear as a unified theory of behavior of living organisms and machines, viewed as systems governed by the same physical laws"[68] and architects' post-war experiments with computers will clarify the status of the animal in my initial case studies: the MMG's use of silkworms as "printers" or "systems" to realize the Silk Pavilion, or the diving bell spider's behaviour as a role model for the design of the 2014–15 research pavilion, which formed a "cyber-physical systems" in the sense meant by Menges. To address the conflation of animals and machines, I will discuss one of the first computer-controlled environments in the history of architecture, which tested the interactions between computers, animals—used as stand-ins for humans—and robots to generate spatial designs: SEEK.[69]

64 Ibid., 15–16.

65 Ibid., 12.

66 Ludwig von Bertalanffy, Problems of Life: An Evaluation of Modern Biological Thought (London: Watts, 1952), 18.

67 Von Bertalanffy, General System Theory, 13, 153.

68 Roberto Cordeschi, "Cybernetics," in The Blackwell Guide to the Philosophy of Computing and Information, ed. Luciano Floridi (Malden/MA: Blackwell Publications, 2004), 186.

69 This has been confirmed by the contemporary scholar Theodora Vardouli, who writes that SEEK "invoked, conflated, embodied cybernetic experiments with living beings and the relentlessly abstract 'blocks worlds' settings proliferating in AI machine-learning trials." See Theodora Vardouli, "SEEK," in The Architecture of Closed Worlds: Or, What Is the Power of Shit?, ed. Lydia Kallipoliti (Zürich: Lars Müller Publishers, Storefront for Art and Architecture, 2018), 116.

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Gerbils, SEEK and the Architecture Machine Group (1969–70)

SEEK is the title of an installation created by students of the Architecture Machine Group (AMG), under the direction of Leon Groisser and Nicholas Negroponte, for the 1970 "Software" exhibition at the Jewish Museum in New York.[70] The term also refers to the agent of this project: a "sensing/affecting device"[71] or robotic arm hovering above an elevated "building-block city."[72] This quasi-architectural space was filled with two-inch blocks covered with metal foil[73] and enclosed by a glass frame to contain its inhabitants:[74] gerbils, chosen because of their "curiosity"[75] and their physical resemblance to laboratory rats.[76]

Equipped with sensors and effectors, and connected to an Interdata processor, SEEK's robotic arm operated like "[f]ingers into the real world" responding to the gerbils' actions.[77] The electromagnetic device towering above the animals' new habitat had a dual purpose. Firstly, its sensors and effectors allowed SEEK to detect, move, pick up and rearrange the cubes. Secondly, the mechanism was designed to deal with "unexpected events."[78] In Groisser and Negroponte's words, SEEK's goal was to "show how a machine handled a mismatch between its model of the world and the real world – in this case, five hundred metal-plated cubes."[79] It was the gerbils' role, as Negroponte emphasizes, to provoke these conflicts,[80] and, in doing so, to challenge SEEK's

70 Nicholas Negroponte, Soft Architecture Machines (Cambridge/MA: MIT Press, 1975), 47.

71 The Architecture Machine Group as cited in Noah Wardrip-Fruin and Nick Montfort, "Software," in The New Media Reader (Cambridge/MA: MIT Press, 2003), 253.

72 Leon Groisser and Nicholas Negroponte, Computer Aids to Participatory Architecture (Cambridge/MA: Massachusetts Institute of Technology, 1971), n.p.

73 Negroponte, Soft Architecture, 47.

74 Software – Information Technology, 22.

75 Negroponte, Soft Architecture, 47.

76 Vardouli, "SEEK," 116.

77 The following description of SEEK, including the AMG's methods and techniques, is drawn from Groisser and Negroponte's grant proposal, unless indicated otherwise. SEEK as cited in Groisser et Negroponte, Computer Aids, n.p.

78 Ibid., n.p.

79 Negroponte, Soft Architecture, 47.

80 Ibid.

"computed remembrances."[81] However, the little mammals, usually known for their "docile" and "quiet" nature,[82] far exceeded the designers' expectations for anticipated "mismatches," along with SEEK's memory processing capacities.

Ironically, Negroponte and Groisser's characterization of the gerbils as "dwellers… with their own ideas of where things should be" could not be more accurate.[83] Despite the architects' expectations that this experiment would demonstrate SEEK's capacity to respond to the animals' action, the gerbils never accepted their new environment. How could they? SEEK was not designed to respond to the animals' behaviour. SEEK's purpose, as previously mentioned, was not to harmoniously interact with the animals, but to prove the machine's capacity to respond to "inconsistencies" caused by users of its *own* kind.[84] This discrepancy concerning the real "protagonist" of the experiment may explain the chaotic and unforeseeable events that followed.

Technically, SEEK operated in one of six modes: "generate, degenerate, fix it, straighten, find, error detect."[85] As Groisser and Negroponte explain, the system mainly ran in "fix it mode" which dealt with the cubes' orientation and placement.[86] Generally, SEEK was able to differentiate between "slightly askew" and "substantially dislocated" cubes, which could be either "realigned" or "placed (straight)" during the gerbils activities.[87] For a worst-case scenario in which the cubes were "way out of line," the designers configured SEEK to switch to "straighten mode"; it would carry the cubes to the "straightener"—a box within the box capable of

81 SEEK in Groisser et Negroponte, Computer Aids, n.p.

82 Maryanna F. Fisher and Gerald C. Llewellyn, "The Mongolian Gerbil: Natural History, Care, and Maintenance," The American Biology Teacher 40, no. 9 (1978): 558.

83 SEEK in Groisser et Negroponte, Computer Aids, 76.

84 Negroponte emphasized that "SEEK's role is to deal with these inconsistencies … inasmuch as the actions of the gerbils are not predictable and the reactions of SEEK are modeled on a probabilistic basis programmed specifically to correct or amplify (not both) gerbil-provoked dislocations." See Groisser and Negroponte, Computer Aids, n.p

85 Ibid., 138.

86 Ibid., 140.

87 Negroponte, Soft Architecture, 47.

setting the blocks in the right position.[88] If the cube remained misaligned, the computer would "turn… on a vibrator" to solve the problem.[89] Yet despite its variety of "modes," SEEK could not handle the gerbils. They soon became distressed by the robotic arm. It did not take long until the installation turned into a catastrophe for both the museum and the animals.[90] Disorientated by SEEK's actions, the gerbils eventually attacked the device[91] before turning on each other.[92]

While for Negroponte, "SEEK exhibit[ed] inklings of responsive behaviour" in a quasi-architectural setting,[93] others were more critical of the project. On the gerbils' discomfort, pioneer of information technology Ted Nelson wrote: "I remember watching one gerbil who stood motionless on his little kangaroo matchstick legs, watching the Great Grappler rearranging his world. Gerbils are somewhat inscrutable, but I had a sense that he was worshipping it. He did not move – until the block started coming down on top of him."[94]

Although the system was equipped with an "error mode" to signal problems in the computers' hardware and software,[95] and Negroponte warned of poorly designed machines' inherent risks,[96] SEEK simply went out of control. The communication between the machine and the animals broke down. Yet SEEK did not fail to engage with the gerbils solely due to a lack of technological advancement. Rather, the SEEK debacle occurred because of the logic embedded in SEEK's program: the idea that any user's "performance of actions" can be broken down to the "behaviour" of a Cartesian "automat[on]" as described by Wiener.[97]

88 SEEK in Groisser et Negroponte, Computer Aids, 140–141.

89 Ibid., 141.

90 Noah Wardrip-Fruin and Nick Montfort, "Software," 247.

91 Vardouli, "SEEK," 116.

92 Noah Wardrip-Fruin and Nick Montfort, "Software," 247.

93 SEEK in Groisser et Negroponte, Computer Aids, n.p.

94 Ted Nelson as cited in Wardrip-Fruin and Nick Montfort, "Software," 247.

95 SEEK in Groisser et Negroponte, Computer Aids, 142.

96 Steenson, Architectural Intelligence, 186.

97 Wiener, Cybernetics, 42–43.

In post-war cybernetic circles, it was common to compare the "behaviour" of living organisms to "living machines,"[98] and to describe the animal functioning as an "input-output relation" between an object, its environment, and a "goal" to be achieved.[99] Therefore, from a cybernetic viewpoint, the gerbils "perform[ed]" well within SEEK's feedback-driven environment. They attained the designers' "goal" by creating unforeseen "events" for SEEK. From an alternate viewpoint, SEEK illustrated the limits of the cybernetic conflation of animals and machines. It showed that the gerbils did not "regulate" their behaviour to suit their environment: an abstract space of geometrical forms and mechanical displacements. Neither did SEEK "self-regulate." How could it? SEEK was programmed to respond to the "model" of "gerbil-machine" or "user-machine" behaviour, but not to actual living beings. In other words, its "model," which determined its behaviour towards users' actions, lacked a holistic understanding of what a living being is.

This is significant because "architecture machines" were not intended to encompass every kind of machines. They were "intelligent" machines. They exemplified a particular "behaviour," designed to form a "symbiosis… through the dialogue" with their users.[100] As Groisser and Negroponte write: "The prime function of the machine is to learn about the user… whatever knowledge the machine has of architecture will have been imbedded [sic] in it; the machine will not 'learn' about architecture. The machine will indeed build a model of the user's new or modified habitat. But it is simultaneously building a model of the user and a model of the user's model of it."[101]

The "architecture machine's" (intelligent system) capacity to develop what the contemporary architectural historian Molly W. Steenson calls the "model of models" or "metamodel"[102] of its

98 Wiener, Cybernetics, xv, 39, 43.

99 Arturo Rosenblueth, Norbert Wiener, and Julian Bigelow, "Behavior, Purpose and Teleology," Philosophy of Science 10, no. 1 (1943): 18.

100 Nicholas Negroponte, The Architecture Machine (Cambridge/MA: MIT Press, 1970), 1, 9.

101 SEEK in Groisser et Negroponte, Computer Aids, 7.

102 Steenson, Architectural Intelligence, 172.

users' actions is Cartesian in principle. Consequently, each time contemporary designers use present-day computational design techniques and fabrication processes, they revive the cybernetic idea, essentially Cartesian idea of the "animal-machine." They do this in two ways: firstly, by the methods and techniques they use; secondly, by the way they represent animality.

The animal's Umwelt in Merleau-Ponty

As SEEK reveals, the animal is neither an "animal-machine" nor a Cartesian "automaton." On the contrary, as the French philosopher Maurice Merleau-Ponty observes, "the animal body is a relation to an *Umwelt* [milieu] circumscribed by it, but without its knowing (*N*, 216)."[103] In the second and third courses of *Nature* (1957–58, 1959–60), Merleau-Ponty makes a compelling argument for the ontological difference between machines and organisms, despite our "natural tendency" to think of the animal body in mechanical terms (*N*, 150). He reminds us that the philosophical and scientific conflation of "life" and "artifice" is human made (*N*, 162). At the end of his critique of the first cybernetic robots, he notes that confusion between what is alive and what is not can be traced to a "sort of drunkenness of thought" (*N*, 162) which appeared after the advent of Cartesian philosophy. Merleau-Ponty argues that the idea of the (animal) body as a "mechanism" not only led to the disappearance of the lived body, but also to a denial of "artifice" itself, which was henceforth "posited as nature" (*N*, 162). Against the cybernetic conception of the "animal-machine," Merleau-Ponty maintains that although "[t]he machine *functions*, the animal *lives* – that is, it restructures its world and its body [emphasis mine]" (*N*, 162) according to its surroundings.

103 This section of the article is based on Merleau-Ponty's posthumously published course notes on the theme of Nature, held at the Collège de France between 1956–60, with particular reference to the second and third courses. Although the notes are attributed to the philosopher, the first (1956–57) and second (1957–58) course were recorded in students' notes. Only the third course (1959–60) consists of Merleau-Ponty's original notes. For clarity, the in-text citation includes the exact reference whenever possible by using the capital letter *N* and the page number in brackets. See: Maurice Merleau-Ponty, Nature: Course Notes from the Collège de France, ed. Dominique Séglard, trans. Robert Vallier (Evanston/IL: Northwestern University Press, 2003).

The philosopher ascribes foundational importance to the "animal body" as the condition which enables its existence-in-the-world, and to the "relation" it forms with its natural surroundings. Its living body is "a body that moves [and] a body that perceives" (*N*, 209). It engages in a "relation of meaning" to its surroundings or *Umwelt* (*N*, 175). For Merleau-Ponty, this corporeal relation between the animal and its surroundings cannot be equated with a cybernetic feedback loop connecting an organism to an environment, which remains "exterior" to the animal's experience (*N*, 14). Neither does the animal body perceive its *Umwelt* as a "goal" to attain (*N*, 175). On the contrary, through its bodily constitution: that is, through its nervous system and motor capacities, the animal body *actively* explores its "milieu," and, in doing so, provokes a quasi-reaction from it. In the philosopher's words: "There is no stimulation from the outside that had not been provoked by the animal's own movements. Each action of the milieu is conditioned by the action of the animal; the animal's behaviour arouses responses from the milieu. There is an action in return for that made by the animal." (*N*, 175)

Merleau-Ponty's philosophical understanding of the "relation" between the animal body and its surroundings builds upon the notion of *Umwelt* put forward by the early 20th century zoologist Jakob von Uexküll. Along the same lines, Merleau-Ponty argues that *Umwelt* only emerges at the intersection between the animal's movements, its perceptions, and its surroundings (*N*, 175). For Merleau-Ponty, *Umwelt* is not put "in front of" the animal body like an object, nor does it act as "cause" (*N*, 178) as stipulated by cybernetics. Neither is it merely a philosophical "principle" (*N*, 177). Instead, *Umwelt* "emerges" between the animal body as it is lived and "a milieu of events … which opens on a spatial and temporal field" (*N*, 177). Merleau-Ponty also likens this form of attunement between the animal body and its surroundings to Uexküll's famous expression of "the unfurling of an *Umwelt* as a melody that is singing itself" (*N*, 173).

Aside from its expressive dimension, melody, for Merleau-Ponty, has above all a philosophical meaning. "[W]hen the melody begins," he writes, "the last note is there, in its own manner. In a melody, a reciprocal influence between the first and last note takes place, and we have to say that the first note is possible only because of the last, and vice versa" (*N*, 174). The melody describes a reciprocal "relation" between a beginning and its end, without, as the scholar Véronique M. Fóti clarifies, reducing it to a linear sequence of events.[104] For Merleau-Ponty, the melody only comes into existence during the embodied act of singing or humming: that is, when "the melody is incarnated and finds in the body a type of servant" (*N*, 174). The animal's relationship to its *Umwelt* is similar: both produce each other mutually. By shifting the focus from the animal body as "mechanism" to the animal body's corporeal experience *in relation to* its surroundings, Merleau-Ponty's philosophical interpretation of *Umwelt* challenges the Cartesian concept of the "animal-machine."

Embodied approaches to animal cognition

Recent findings on embodied approaches to animal behaviour and cognition seem to confirm Merleau-Ponty's conception of animality. In *Beyond the Brain*, the anthropologist Louise Barrett builds upon various case studies to demonstrate that animal perception is "an active process […] and not merely a passive reception of information from the environment" as SEEK previously conveyed.[105] Animal behaviour, animal "intelligence," and "flexible behaviour," she counters, result from the animal's genetic baggage, which defines its morphology, and the "mutual relationship" between its brain, its perception and movement, and its environment.[106] Similar to Merleau-Ponty's philosophical description, Barrett writes that the animal's "psychological processes are 'embodied': they are not somehow things that 'float free' from the animal, but are firmly grounded in the physical actions of the

104 Veronique M. Fóti, Tracing Expression in Merleau-Ponty: Aesthetics, Philosophy of Biology, and Ontology (Evanston/IL Northwestern University Press, 2013), 77.

105 Louise Barrett, Beyond the Brain: How Body and Environment Shape Animal and Human Minds (Princeton/NJ: Princeton University Press, 2015), 22.

106 Ibid., 76–77, 79.

animal body both as it observes other animals, and of course, as it moves around the world itself."[107]
Barrett adds that the animal's actions do not take place in a vacuum. She stresses the impact of the environment on the animal's behaviour. Building upon Uexküll's pioneering work, the anthropologist confirms that *Umwelt* is a useful concept to determine "both the scope and the limits of species' flexibility, while at the same time preventing us from getting too big for our boots; we, too, have to recognize the limits of our own umwelt [sic]."[108] Against the "mechanization" of animals, she invites us to consider them in their totality, including their *Umwelt*. Until then, Barrett concludes, we risk "asking scientific questions that simply reflect our own concerns" instead of getting to know the "animal's experience of the world" in a non-epistemological way.[109]

Conclusion: Utopia Computer?

This article has critically discussed the link between cybernetics and the Cartesian concept of the "animal-machine" which have guided contemporary bio-inspired approaches to computation. While the projects examined have provided insights for form-finding techniques and material fabrication processes, they still operate on the Cartesian premise that Nature is a mere "resource" (*res extensa*) at humans' disposal, which is problematic. This is best exemplified by architects' conception and use of animals as machinelike "systems," "printers" and "computations" to realize their computationally-driven designs. Whether their methods and techniques are a form of scientism, as Cogdell suggests in her recent book on complexity in architecture,[110] or whether the choice of their words is mere rhetoric intended to target a certain audience, is not the topic of my inquiry. Rather, what is at stake is *architecture's* conception *as biology qua computation*, and the

107 Ibid., 35–36.

108 Ibid., 81.

109 Ibid., 3, 145.

110 Cogdell, Toward a Living Architecture, 33–34.

ideological distortions this position causes to our perception of Nature.

Consider Oxman's suggestion to view "Nature as client."[111] Her position makes the Silk Pavilion look like "nice" in the face of the environmental challenges, to borrow an expression from philosopher Timothy Morton.[112] However, despite laudable intentions, it fails to overcome the object—subject dichotomy undergirding the concept of the "animal-machine." Yet how could it have been otherwise when computer usage has become synonymous with Oxman's "new ways of thinking" about design, and architecture has become synonymous with "architecture machines" in the sense meant by Negroponte? SEEK's failure to understand the animals' actions as qualitatively different from the computer's automatic processes shows that the computer's Cartesian framework has "disappeared" behind computational architecture's utopian intentions.[113] As Barrett reminds us, post-war computer development was driven by John von Neumann's metaphor of the "brain as computer," which led to the computational model of cognition.[114] While this contributed to the digital computer's success, Barrett stresses that it also "generated a view of cognition as a process that has no real link to the body or the outside world, taking place purely in the brain alone."[115] In other words, it only perpetuated the Cartesian split between "mind" (*res cogitans*) and "matter" (*res extensa*) by turning the functioning of the "animal-machine" into a variant of the "thinking machine," to use Alan Turing's expression.[116]

111 Paola Antonelli, "The Natural Evolution of Architecture," in The Neri Oxman Material Ecology Catalogue, 20.

112 Timothy Morton, Dark Ecology: For a Logic of Future Coexistence (New York/NY: Columbia University Press, 2016), 21.

113 Here I refer to Merleau-Ponty's idea of the disappearance of the "artificial" as discussed earlier. For more, see Merleau-Ponty, Nature, 162.

114 Barrett, Beyond the Brain, 121. The computational or representational model of cognition builds upon the premise that the brain functions similarly to a computer that processes information. Mental processes are conceived of as "computations made by the brain using an inner symbolic language." See Evan Thompson, Mind in Life: Biology, Phenomenology, and the Sciences of Mind (Cambridge/MA: Belknap Press of Harvard University Press, 2007), 4–5.

115 Barrett, Beyond the Brain, 124.

116 Alan Turing, "Computing Machinery and Intelligence," in The New Media Reader, ed. Noah Wardrip-Fruin and Nick Montfort (Cambridge/MA: MIT Press, 2003), 51.

I want to address another utopian moment in this article: namely, the conflation of biology and Nature. Although biology provides invaluable insights into the natural world, we should remain wary of directly applying its methods, techniques, and theories to architecture as a "driver" of architectural form and materiality. Biology is not Nature. Nor should scientific constructs and technologies, which are enabled by human experiences of *Umwelt*, falsely reduce animal or human embodied experience to scientific data alone. The projects I have discussed were achievable because architects equipped with scanning electron microscopes and other apparata zeroed in on the material properties and behaviours of animals at a microscopic level to "abstract" information. Even if the animals directly participated in the process, they did so in our *Umwelt*, but not necessarily in theirs. While scientific, technological, and computational methods certainly enabled the design of these pavilions and installations, they also consolidated the myth of the "animal-machine."

However, this subjugation of living beings, and, by extension, of Nature, to architects' intentions seems increasingly problematic considering the environmental challenges we face, and architects' responsibility to provide a habitat for *all*. Put differently, the bio-inspired approaches to computation bear the question how architects intend to tackle the ecological crisis. Will they simply use technology elevated to a "second nature" to produce designs that emulate a disembodied and disembedded attitude towards human and non-human life? Or, alternately, will contemporary architects aim at creating an architecture of "ceaseless exchange and oscillation between milieu and body"[117]: that is, an architecture that addresses *Umwelt* as it is lived?

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117 Ingraham, Architecture, 6.

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DONAL LALLY

All that Is Solid Melts into the Cloud

The data centre is the infrastructural backbone of Cloud computing. By 2027 data centres will come to consume 31% of Ireland's total electricity demand. However, the Cloud metaphor draws the public's attention away from the fossil-fuel derived energy used to operate and maintain their environmental controls and from the vast quantities of resources that make this kind of architecture. This article attempts to dispel the techno-utopian fantasy that is the Cloud by typologically connecting the data centre to historic fire-burning infrastructural typologies.

"In Bedlam hell is brilliant, a fire in the head.
The men I worked among worked in hell–
moon men I called them, phases of the moon.
hey'd stand all day in fire and stoke and dip and pour
and go home white as potter's clay.
I have seen the furnaces in the picture, the furnaces at Bedlam.
The night sky is torrential, a red and yellow storm,
the silhouette of buildings like a house on fire,
Yet the horses with the wagon in the foreground,
Make the scene almost pastoral…"
Stanley Plumly[1]

It is a hot July day in Dublin. A technician removes a glove and presses her palm against a biometric scanner. Her masked companion pushes open the unlocked door—breath turns cloudy. The

1 Stanley Plumly, "'Coalbrookdale at Night' by Phillipe Jacques de Loutherbourg," The Georgia Review 37, no. 1 (1983): 190.

server hall is deep and wide. The low ceiling is a complex matrix of ducting and lighting. The floor a chessboard grid of floor tiles. The ice-cold air and the all-encompassing machinic din palpable through the technician's protective suits. Their destination is an empty caged room at the far end of the hall. Outside the cage lies a stack of cardboard boxes containing server cabinets, servers, and cables. They are employees of a computer game development company and the first clients to call this space home. Via CCTV, a security guard watches the two figures work, slowly freezing in sub-zero temperatures.

A data centre is a building designed to safely house and operate computer systems and associated equipment. Once a company's data centre could be stored in a cabinet, as computational needs expanded over time, they grew to fill entire floors. Now, a data centre is commonly the size of a warehouse, can demand as much electricity as a small city, and consume as much water as a large town.[2] The term "data centre" can be understood as a catch-all for many different operational modes; each mode has a different level of overlap with the public and private sphere. Broadly speaking, the fundamental architectural figure of a purpose-built data centre, that of a large non-descript shed, remains consistent across each mode. A data centre should be understood as more than a discrete and immutable architectural object. Virtualised infrastructures have enabled global connectivity via a vast constellation of discrete data centres, each linked through a planetary-scale network of on-land and subsea cabling, creating the connected computational network commonly referred to as the *Cloud*. When utilising virtual infrastructure, a data centre can extend across multiple public and private Clouds to the edge of a network (or networks) through mobile devices and embedded computing. Depending on the operator, two different data centres' architectural and infrastructural requirements may be quite different to one another. For example, the NSA or the Pentagon

2 Killian Woods, "Data centres use same amount of water as large towns," Business Post, June 14, 2020.

will have more stringent security requirements than a colocation data centre; a company such as Netflix may require more complex content delivery infrastructures. A colocation (colo) data centre hosts client's servers and networking equipment by renting out the physical space, power, bandwidth, IP addresses and cooling systems to their clients and provide security systems to protect against outages. The server hall in a new colo essentially starts out as an empty refrigerated room. As new customers rent space to install their servers, the hall slowly warms up with the heat of the additional computational exhaust. The server hall's cooling systems are tasked with maintaining an ambient temperature somewhere between 15–22°C. A cooling mechanism failure would lead to a system crash, or, as in the Bangkok Bitcoin mine, can lead to an inferno.[3] Data centres are responsible for up to 1.5 per cent of global electricity use,[4] forty per cent of which is used for cooling server halls.[5]

The Cloud

In recent years ethical questions around how our behavioural data is harvested and commodified have occupied a central role in public debate. However, there is a growing public interest in *the what*, *the where*, and *the how* of data storage and circulation. The Cloud is the metaphor used to describe the computer servers, their attending software, and data archives, that are accessed through the Internet. The Cloud is where your Facebook, Instagram, and Twitter posts live. The Cloud is a heterogeneous assemblage drawn together from rare earth minerals: coal, oil, and gas, and renewable energy infrastructures: subsea cable networks, data centres, on-land fibre optic cables,

3 Rich Miller, "Fire at Bitcoin Mine Destroys Equipment," November 6, 2014. Accessed August 19, 2020. https://www.datacenterknowledge.com/archives/2014/11/06/fire-bitcoin-mine-destroys-equipment.

4 Eric Masanet et al., "Recalibrating Global Data Center Energy-Use Estimates," Science 367, no. 6481 (2020): 985.

5 X. Zhang et al., "Cooling Energy Consumption Investigation of Data Center IT Room with Vertical Placed Server," Energy Procedia 105 (2017): 2048.

ethernet cables, and domestic routers, all knitted together by complex supply chains and hidden labour practices. The Cloud, a metaphor that points to something remote, ethereal, and not of us, successfully renders the vast material networks that support the internet invisible to our collective imagination. It is a metaphor that is convenient for those providing industrial Cloud computing services, but, it is also convenient for us, as it alienates users from the environmental consequences of being online. The Cloud is the new industrial sublime; a paradigm-shifting technological achievement that should be understood as the latest instalment in the violent story of industrial progress. The Cloud is dirty; it is made of smoke. This article examines how the utopian fantasy of the Cloud is perpetuated; by using both theory and fiction it attempts to make visible some of the material and spatial conditions caused by the Cloud.

The techno-mysticism of the Cloud

The prevalent PR representations of a data centre are carefully mediated imaginaries. The well-publicised and iconic interior space foregrounded in public relations imagery is called white space (figs. 1–2). The white space is where the server cabinets live and where the computational heat needs management. Therefore, it is the most energy-intensive space in a data centre. For sociologist Alexander Taylor, the white space is one of purity and potential that "plays an important role in mediating and transforming popular imaginaries of the Cloud."[6] The white space is portrayed as a ripe and usable space designed to attract investors. For journalist Andrew Blum, a "data centre is designed for machines, but the customer is a person, and a particular kind of person at that… a data centre is designed to look the way a

6 A.R.E. Taylor, "The Technoaesthetics of Data Centre White Space," Imaginations Location and Dislocation, Global Geographies of Digital Data, no. 8-2 (2017). Accessed August 19, 2021. http://imaginations.glendon.yorku.ca/?p=9947.

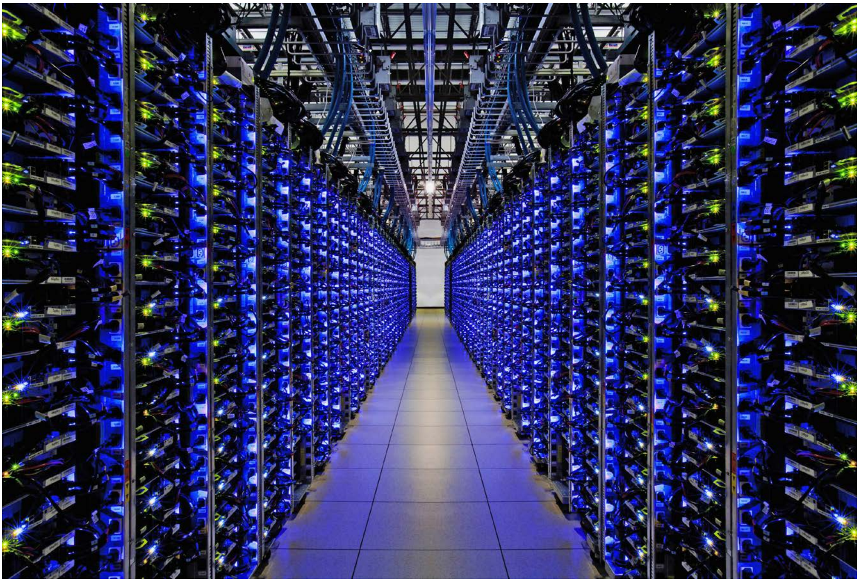

Fig. 1: White Space, Google Data Center Server Room, Douglas county, Georgia, USA. Source: https://www.google.com/intl/de/about/datacenters/gallery/#douglas-county-servers, protected by copyright

data centre should look, only more so: like something out of The Matrix."[7] Jay Adelson, the founder of the Equinix Global Internet Business Exchange, describes the performative aspect of the interior, "If you brought a sophisticated customer into the data centre and they saw how clean and pretty the place looked—and slick and cyberrific and awesome—it closed deals."[8] These cyberrific white space interiors are represented as providing a hermetically sealed, retro-futuristic environment, free from disease (cyber warfare, viral attacks) and free from human occupation. Statistically, humans represent the likeliest cause of data centre downtime. For Taylor, this design aesthetic is grounded in an imaginary of techno-nostalgia, one that referenced the popular science fiction cinema of the 20th century, for example, "THX1104"; "The Matrix"; and "2001: A Space Odyssey."[9]

7 Andrew Blum, Tubes: Behind the Scenes of the Internet (London: Viking, 2012), chap. 3, Kindle.

8 Ibid.

9 A.R.E Taylor, "The Technoaesthetics of Data Centre White Space."

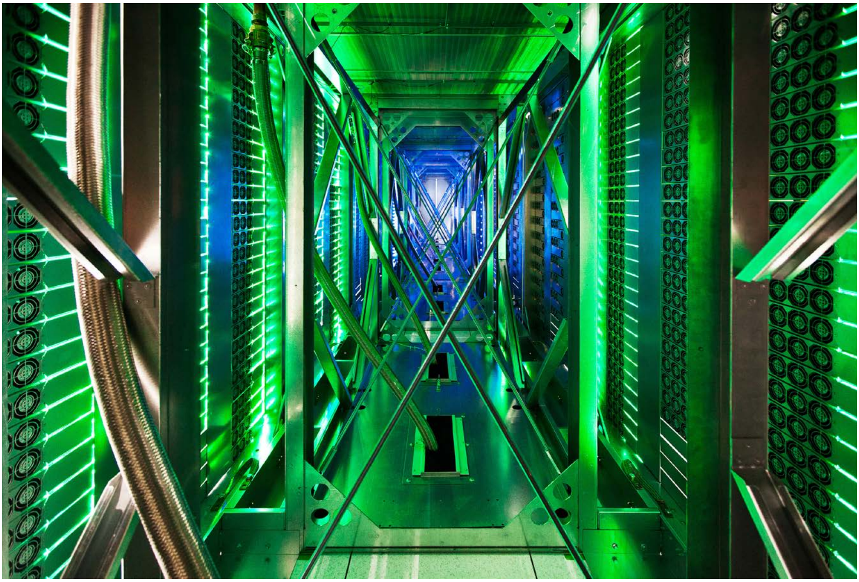

Fig. 2: White Space, Google Data Center Server Room, Mayes County, Oklahoma, USA.
Source: https://www.google.com/intl/de/about/datacenters/gallery/#mayes-county-server-aisle, protected by copyright

The supporting infrastructure is located in the data centre's *grey space* (fig. 3) and is responsible for maintaining uptime—the systems' online availability. Downtime is the amount of time a system is unavailable—an estimated one hour of downtime on Amazon's servers during their 2018 Prime Day sale caused a loss somewhere between seventy-two and ninety-nine million dollars.[10] In the event of a power cut, backup diesel generators and batteries are used to maintain constant uptime. Environmental controls are provided by air conditioning units, heating systems, ventilation systems, and exhaust systems. Security typically consists of biometric scanners, guards, and video surveillance. Operations staff monitor and maintain the equipment from a centralised location using software such as data centre infrastructure management (DCIM). Grey space, the more mundane, rarely features in PR imagery.

10 Sean Wolfe, "Amazon's One Hour of Downtime on Prime Day may have cost it up to $100 Million in Lost Sales," Businessinsider, July 18, 2018. Accessed August 31, 2020. https://www.businessinsider.com/amazon-prime-day-website-issues-cost-it-millions-in-lost-sales-2018-7.

Fig. 3: Grey Space, Google Data Center, Cooling Plant, Hamina, Finland. Source:https://www.google.com/intl/de/about/datacenters/gallery/#hamina-cooling-plant, protected by copyright

For the architect and theorist Rem Koolhaas, data centres are part of the new rural architectural sublime.[11] At the Supernap data centre facility in Nevada, Koolhaas finds an architecture for "which no one is prepared… abstract and codified—uninflected by human need, distant from us and nevertheless produced by us and needed by us."[12] In his writing, Koolhaas uses descriptions such as "distant" and "beyond our imagination." In doing so, he reinforces the utopian fantasy that the processes that underpin Cloud computing are somehow ethereal and difficult to fathom. The PR imagery would have us believe a data centre operates as a perfect, quiet, remote, self-regulating autonomous machine. This is misdirection. Instead, we must understand them as a complex entanglement of matter and energy; data centres have "nothing to do with Clouds" but "everything to do with being

11 Rem Koolhaas, in Countryside: A Report (Köln: Taschen, 2020).

12 Rem Koolhaas, "The Cut: Where to from Here, When All the Horizon is in the Cloud," Flaunt.com, 2016. Accessed August 31, 2020. http://www.flaunt.com/content/art/rem-koolhaas.

cold."[13] Koolhaas asks, but fails to answer, the right questions: "How or what do you call life in this building? Do you call it life or process? What, as a profession, are we doing with these types of environments? Does it lead to techno-mysticism?"[14]

Formax

Contemporary technologies conceal the source of their power. The technological sophistication of the equipment that enables Cloud computing makes opaque the material and energetic forces at play in its operation. Dublin, Ireland, is currently home to the largest assemblage of data centre capacity in Europe. It is forecast that by 2027 the Irish data centre industry alone will consume thirty-one per cent of all available electricity on the national grid.[15] For the philosopher of technology, Gilbert Simondon, technical objects have a technical essence that places them in a genealogy alongside other technical objects.[16]

Identifying this genealogy allows one to connect contemporary technologies to their primitive ancestors. The data centre is an urban scale container technology that maintains, renders safe, a constant supply of electricity to its servers, and mediates the exhaustion of large quantities of waste heat produced by the servers. Electricity is a kind of "repressed fire,"[17] meaning the hearth, the furnace, and the data centre are kinds of container technologies, each tasked with rendering safe, and making useful, extreme temperatures. Philosopher of elemental media, John Durham Peters, describes container technologies as "the ground that brings out the figure but disappears in doing so."[18] The

13 Blum, Tubes, chap. 7, Kindle.

14 Koolhaas, "The Cut."

15 Donal Lally, "The Sacred Fire of a Data Centre," Strelka Magazine, October 2, 2019. Accessed August 31, 2021. https://strelkamag.com/en/article/the-sacred-fire-of-a-data-center.

16 See chapter two of Gilbert Simondon, Cécile Malaspina and John Rogove, On the mode of existence of technical objects (Minneapolis/MN: University of Minnesota Press, 2017).

17 John Durham Peters, The Marvellous Clouds: Toward a Philosophy of Elemental Media (Chicago/IL: University of Chicago Press, 2015), chap. 3, Kindle.

18 Ibid.

hearth and furnace bring forth the figure of fire, the data centre brings forth the figure of the Cloud. One may imagine a container technology to be impermeable or sealed—but to seal something is to assume the seal will eventually be broken (eggs, tombs, time capsules, etc.). A container requires the existence of a hole, it presupposes a vacancy: "containers are supposed not to leak, but to pour."[19] From the hearth, we generate heat and light for our homes; from the furnace comes the steel and bricks used to build our cities; from the data centre comes our digital existence.

The Cloud is maintained with electricity. Globally, coal and gas are still the primary fuels used to produce electricity.[20] Humanity's reliance on burning carbon, is of course, nothing new. From the campfires of Peking Man to the furnaces of the Industrial Revolution, the carbon burning process has been found at the centre of the cultural and technological progress of the homo genus for at least the past 500,000 years.[21] Still, since the invention and the widespread adoption of electricity, fire has receded from view, it has become estranged, and with that estrangement came a deepening of the global ecological crisis.

The data centre could be considered *the* architectural icon of the fourth Industrial Revolution, the digital revolution. The architectural icon of the first Industrial Revolution is arguably the ironworks. To better understand the data centre as a technical object, it is helpful to look at the ironworks as both buildings share the technical essence of being an industrial fire container. This article is an attempt to make visible the industrial processes of data processing. When the first factories began proliferating across the British landscape, artists of the early romantic period were driven by a similar desire to understand and foreground the cultural and ecological consequences of these buildings.

19 Ibid.

20 Hannah Ritchie, "Electricity Mix," 2020. Accessed January 22, 2021. https://ourworldindata.org/electricity-mix.

21 For a detailed study on true labour cost of producing primitive fire see William Nordhaus, "Do Real-Output and Real-Wage Measures Capture Reality? The History of Lighting Suggests Not," Cowles Foundation Discussion Papers, no. 1078 (1994). Accessed August 31, 2021. https://cowles.yale.edu/sites/default/files/files/pub/d10/d1078.pdf.

Fig. 4: "Coalbrookdale at Night" by Philip de Loutherbourg, 1801. Source: https://en.wikipedia.org/wiki/Coalbrookdale_by_Night#/media/File:Philipp_Jakob_Loutherbourg_d._J._002.jpg

The following is a description of the action in Philip de Loutherbourg's 1801 painting "Coalbrookdale at Night" (fig. 4). Flames surge forth; smoke billows; men toil "over smelted iron—half heroes, half demons," beheld by spectators from the "threatened rural idyll."[22] The painting is a romantic depiction of the Bedlam furnace at the Madeley Wood Ironworks, located in Coalbrookdale, Shropshire, England. The Bedlam furnace is perhaps the world's first coke-fired blast furnace. Constructed from observations made while travelling from Shropshire to Wales between 1786 and 1800, the painting represents the new industrial processes that began to proliferate across the English countryside during this period. Agriculturist Arthur Young described the countryside surrounding Madeley Wood as "too beautiful to be much in union with the variety of horrors spread at the bottom; the noises of forges, mill, with their vast machinery, the flames

22 "Coalbrookdale by Night," Science Museum Group. Accessed August 31, 2021. https://collection.sciencemuseumgroup.org.uk/objects/co65204/coalbrookdale-by-night-oil-painting.

bursting from the furnaces with the burning of coal and the smoke of the lime kilns."[23] Coalbrookdale's flames are symbolic of the economic and productive power of the ironworks and a critique of the environmental damage caused by these new technologies. The scientific discoveries of the Enlightenment invigorated artists to capture the "truth to nature" of their subjects. They aspired to create objective images', free from human interference.[24] De Loutherbourg's impulses were less conventional, his work being a "paradoxical mix of the mechanical and empirical with the aesthetic and spiritual." His practice confused his critics; was he an "artist or mechanic?" De Loutherbourg had a reputation as a mystagogue and as a deeply read occultist philosopher, and for a time, briefly acted as a mesmeric healer. His early landscape works garnered attention for their "extreme effects and their dramatic, climactic subjects." This eye to represent a heightened sense of drama was consistent across his painting, set design, and theatre designs: "Never were such romantic and picturesque paintings exhibited in that theatre before. They gave you an idea of the mountains and waterfalls, most beautifully executed, exhibiting terrific appearance," noted his friend, Henry Angelo.[25]

De Loutherbourg's masterpiece was the Eidophusikon, a fusion of art and technology by an artist who was both painter and mechanic. Described as a "new species of painting" and a forerunner of cinema and virtual reality, the Eidophusikon was designed as an immersive and time-based installation combining moving image, sound effects, and lighting.[26] Artist William Henry Pyne describes Loutherbourg's evocation of the Palace of Pandemonium from Milton's *Paradise Lost*: "Here, …stretching an immeasurable length between mountains, ignited from their

23 Mike McKiernan, "Philip Jacques de Loutherbourg: Coalbrookdale at Night (1801): Oil on canvas, 68 × 106.5 cm. Science Museum, London," Occupational Medicine 58, no. 5 (August 2008): 316–317.

24 Lorraine Daston and Peter Galison, "The Image of Objectivity," Representations 40 (1992): 81.

25 Ann Bermingham, "Technologies of Illusion: De Loutherbourg's Eidophusikon in Eighteenth-Century London," Art History 39 (2016): 377–380.

26 Ibid., 380.

bases to their lofty summits with many coloured flames, a chaotic mass rose in dark majesty, which gradually assumed form until it stood, the interior of a vast temple of gorgeous architecture, bright as molten brass, seemingly composed of unconsuming and unquenchable flame."[27]

Almost two decades later with "Coalbrookdale at Night," de Loutherbourg "brought the purifying furnaces of alchemy into mystical association with new chemical technologies and the furnaces of the Industrial Revolution."[28] In 1952, the British Science Museum purchased the painting, to "fire the imagination of the spectator." The purchase caused heated internal debate. To the Museum's Curator of Metallurgy, Fred Lebeter, the painting was the inaccurate result of the overbearing Romantic imagination, but despite the initial controversy, "Coalbrookdale" still plays an important role in the Science Museum's depiction of the first Industrial Revolution.[29] Coalbrookdale at Night's power comes not from a coolly scientific mechanical objectivity, but instead through the vibrant co-construction of science, experience, myth, and metaphor. In a similar vein, Andrew Blum deploys the metaphor of "mighty rivers," to describe a data centre's energetic force, and its connectedness: "What thrilled me about this room was how legible it made that idea. We are always somewhere on the planet, but we rarely feel that location in a profound way. That's why we climb mountains or walk across bridges: for the temporary surety of being at a specific place on the map. But this place happened to be hidden. You could hardly capture it in a photograph, unless you like pictures of closets. Yet among the landscapes of the Internet, it was the confluence of mighty rivers, the entrance to a grand harbor. But there was no lighthouse or marker. It was all underground, still and dark—although made of light."[30]

27 Christopher Braugh, "Philippe De Loutherbourg: Technology-Driven Entertainment and Spectacle in the Late Eighteenth Century," Huntington Library Quarterly 70, no. 2 (2016): 261.

28 Ibid., 259.

29 Boris Jardine, "Made real: artifice and accuracy in nineteenth-century scientific illustration," Science Museum Group Journal, no. 2 (2014). Accessed August 31, 2021. http://journal.sciencemuseum.ac.uk/pdf/article/2598/made-real.

30 Blum, Tubes, chap. 3, Kindle.

The data furnace

The data centre is an architectural space that actively produces new kinds of thermal ecologies, some of which are dedicated to the comfort of the human, and some of which are dedicated to the comfort of the machine. In 2010, Google's first data centre in St. Ghislain, Belgium, commenced operations. This "green" data centre was designed without the industry-standard (and energy-intensive) chillers which support the cooling systems responsible for server hall refrigeration. Instead, the St. Ghislain server halls are designed to occasionally run hot—the servers are designed to sustain temperatures of up to 45°C. Typically, a server hall has both hot and cold (chilled) aisles, allowing a technician to move between the two to maintain physical comfort. In St. Ghislain, the data centre utilises fresh air to keep server room temperatures within a safe range. On a hot day, the temperature inside the server hall is free to heat up—Google refers to these periods as "excursion hours"—whereby the temperature inside the data centre can rise above 35°C. During excursion hours, humans must vacate the server area. In sweltering conditions, if a worker's blood temperature rises above 39°C, they risk heat stroke or collapse. Above 41°C, delirium or confusion can occur. This temperature level can prove fatal, and even if a worker does recover, they may suffer irreparable organ damage.[31] During "excursion hours, the server hall becomes a human exclusion zone, "too warm for people, but the machines do just fine."[32] The data furnace is not an exclusively industrial process; we are now witnessing its transformation into public utility. In the Dublin suburb of Tallaght, Amazon Web Services is constructing a data centre that, via a district heating system, will recycle its exhaust heat into the local urban network. This includes a hospital

31 "Heat–The case for a maximum temperature at work," TUC. Accessed August 6, 2020. https://www.tuc.org.uk/sites/default/files/Temperature.pdf.

32 Rich Miller, "Too Hot for Humans, But Google Servers Keep Humming," Datacenter Knowledge, March 23, 2012. Accessed August 6, 2020. https://www.datacenterknowledge.com/archives/2012/03/23/too-hot-for-humans-but-google-servers-keep-humming.

campus, a university campus, a cultural centre, and an apartment complex. What appears on the surface as a settled urban matrix is now being reoriented, and plugged into the exhaust pipes of the Cloud. If we shift briefly into a speculative mode; consider an American tech engineer living in a new apartment in Berlin. It is a white Christmas. The engineer returns home from work; the central heating is on. The engineer's mind is tired, and they feel a slight pang of holiday homesickness. Seeking a more profound comfort, they switch on Netflix and select the *Fireplace for Your Home*. They stare peacefully into the recorded flickering flames, and slowly lose themselves in reverie. As one of Amazon Web Services largest clients, it might be fair to speculate that Netflix host their content, at certain times, on the servers at the Tallaght data centre, meaning this engineer, lost in reverie, has set off a series of systemic events that result in a tiny puff of heat radiating from a processor. This exhausted heat is captured, and converted into hot water, reheated again, and delivered to the intensive care unit of a local hospital.

Exosomatic artefacts

For architect Luis Fernández-Galiano, "Architecture can be understood as a material organisation that regulates and brings order to *energy* flows: and, as an *energetic organisation* that stabilises and maintains *material* forms."[33] The data centre is undoubtedly one of the most apparent manifestations of this idea, yet rarely do the spatial phenomenon of the energy flows feature in data centres imaginaries. This paper seeks to redress that imbalance and critically rebuild the data centre as an inseparable entanglement of matter and energy. Moreover, a data centre is a material organization that stabilizes, and disguises, the energy which flows through it. Both the data centre and its energetic flows are exosomatic artefacts—they are of us, but exists outside of us.

33 Luis Fernández-Galiano, Fire and Memory: On Architecture and Energy, trans. Gina Cariño (Cambridge/MA: The MIT Press, 2000), 5-8.

Endosomatic energy feeds the internal metabolism of an organism, i.e. the energy that feeds the human body. Endosomatic energy has a limited threshold of variation; that is, the energy produced and consumed by the human body is predicable within a range, usually between 1500 and 2500 kcal. Humans harness exosomatic energy to maintain our living standards, including heating, transport, food preparation, air conditioning, the building and maintenance of dwellings, and information dissemination. The range variation of exosomatic energy is virtually limitless. Endosomatic energy is biological, exosomatic energy is cultural—the first being a necessity, the second a choice.
The Cloud is a PR construct that easily vanishes into abstraction due to its vast scale. To dissipate the PR illusion, we must make tangible the Cloud's systems of maintenance and supply. The Cloud is not "uninflected by human need" or "distant from us." It is an assemblage of exosomatic artefacts, constructed with vast quantities of rare earth minerals, fuelled in the main by burning carbon, always working for us. The Cloud is beautiful, the Cloud is immense, the Cloud is hungry, the Cloud is thirsty, the Cloud is heavy, and the Cloud is dirty.

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The critical concern of the book “Utopia Computer” is the euphoria, expectation and hope inspired by the introduction of computers within architecture in the early digital age. With the advent of the personal computer and the launch of the Internet in the 1990s, utopian ideals found in architectural discourse from the 1960s were revisited and adjusted to the specific characteristics of digital media. Taking the 1990s discourse on computation as a starting point, the contributions of this book grapple with the utopian promises associated with topics such as participation, self-organization, and non-standard architecture. By placing these topics in a historical framework, the book offers perspectives for the future role computation might play within architecture and society.

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