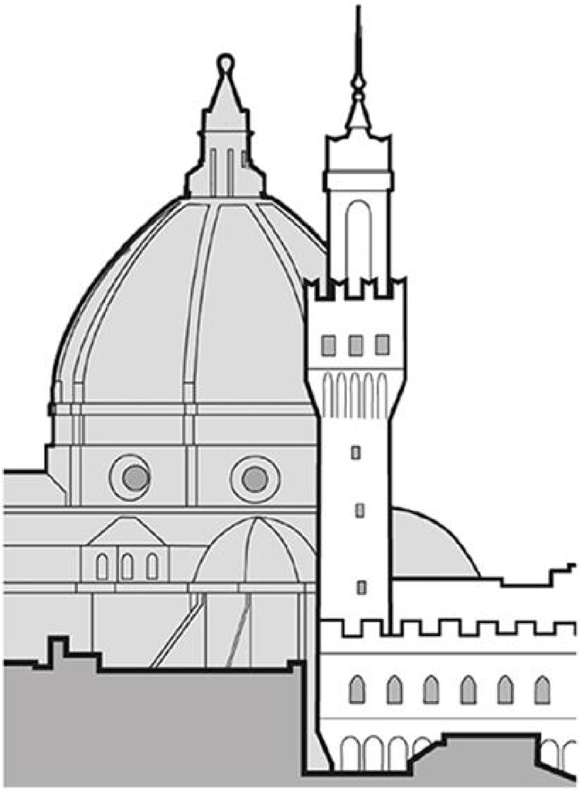
Electronic Imaging & the Visual Arts

EVA 2019 Florence

PROCEEDINGS

Editor: **Vito Cappellini**



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8-9 May 2019

edited by

Vito Cappellini

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PROGRAM

For CELEBRATIONS of LEONARDO DA VINCI

Electronic Imaging & the Visual Arts

'The Foremost European Electronic Imaging Events in the Visual Arts'

The key aim of this Event is to provide a Forum for the user, supplier and scientific research communities to meet and exchange experiences, ideas and plans in the wide area of Culture & Technology. Participants receive up to date news on new EC and international arts computing & telecommunications Initiatives as well as on Projects in the Visual Arts field, in archaeology, history and other Culture Activities. Working Groups and new Projects are promoted. Scientific and technical demonstrations are presented. Technology and Art Exhibitions are promoted.

Main Topics

- European Commission Projects and Plans regarding Cultural Heritage
- Mediterranean Initiatives in Technology for Cultural Heritage: Synergy with European & International Programmes
- 2D – 3D Digital Image Acquisition
- Leading Edge Applications: Galleries, Libraries, Archaeological Sites, Museums & Historical Tours
- Integrated Digital Archives for Cultural Heritage and Contemporary Art
- Management of Museums by using ICT Technology: Documentation, Access, Guides & Other Services
- The Impact of New Mobile Communications on Cultural Heritage and Modern Arts Area
- Cloud Networks
- Semantic Webs
- Ontology Systems
- Human - Computer Interaction for Cultural Heritage Applications
- Copyright Protection
- Secure Electronic Commerce (Anticounterfeiting)
- Cybersecurity
- Culture and *e-government*
- Activities and Programmes for *e-learning*
- Digital TV and films
- 3D Developments and Applications in the Cultural Heritage Area
- Virtual Galleries and Exhibitions
- Digital Art
- Music - Digital Music
- Theatre - Digital Theatre
- Cultural Tourism & Travel Applications
- Impact of Culture in the Smart City
- Art and Medicine

WHO SHOULD ATTEND

THE CULTURAL SECTOR: The Visual Arts Community including Museums, Libraries, Archaeological Sites, Educational Institutions, Commercial Galleries and Dealers, Auction Houses, Artists & Collectors

THE HI-TECH INDUSTRY SECTOR: Multimedia Systems, Image Acquisition & Analysis, Databases, Display & Printing, ICT Industry, Telematics & Systems Manufacturing, On-line Information Services

MEDIA & RELATED SECTORS: Publishing, Press, Film, Television, Photography, Printing, Advertising, Graphics Design, Consumer Media

IMAGING SYSTEMS RESEARCHERS: Imaging Systems, 3-D Acquisition, Reconstruction & Representation Systems, Information Sciences

TOURISM & TRAVEL SECTOR: Tourism Agencies & Operators, Travel Agencies

THE GOVERNMENT SECTOR: Ministries of Culture and other Institutions involved in Cultural Heritage, Ministries of Industry, Education, Research and Science, Regional Governments

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Co-Chairmen: Vito Cappellini, Enrico del Re – Florence University
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SeSa s.p.a

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Venue: **Hotel Pierre**
Via De' Lamberti, 5 - 50123 Firenze
Tel. +39 055 216218 Fax +39 055 2396573
E-mail: pierre@remarhotel.com
http://www.hotel-pierre-florence.com/

Special reservations for rooms are provided (please use code EVA19)

WORKSHOP

ROOM A

WORKSHOP INNOVATION AND ENTERPRISE – INNOVAZIONE E IMPRESA
(Italian Language)

9,30 – 13,00
Chairman: *Enrico Bocci, Vice-Presidente Confindustria Firenze, Firenze*

Technological requirements in the Cultural Heritage field are outlined and opportunities for Italian Enterprises and SME's working in the field, using new technologies, are presented.
Regional and National Applied Research Programs in Italy are described.
Activities by National Organizations and Firms working in the area of Telecommunications, Informatics, Environment and Infomobility are presented.
Funding by European Commission is considered, with particular reference to multimedia and telematics for Cultural Heritage. Special consideration is given to the EC Plan HORIZON 2020 and the following ones.
Initiatives regarding the "know-how" transfer from Research Organizations to the Industrial Sector are described, in particular to create Start-Ups and new Enterprises.

Invited Speakers:
- Andrea Arnone, Pro-Rettore al Trasferimento Tecnologico e Presidente di CsaVRI, Università degli Studi di Firenze, Firenze
- Laura Castellani, Responsabile del Settore Infrastrutture e Tecnologie per lo Sviluppo della Società dell'Informazione, Regione Toscana
- Paola Castellacci, VAR GROUP

Speakers include:
- Stefano Cinquini and Luigi Carfagnini, TELECOM ITALIA
- Renzo Zampini, INFOCAMERE
- Andrea Calistri, SAPAF Srl, Firenze
- Claudio Tasselli, Qu.In. Srl, Calenzano, Firenze
- Riccardo Bruschi and Luca Bencini, T.T. TECNOSISTEM Spa, Prato
- Carlo Lastrucci and Luca Lastrucci, Powersoft Spa, Firenze
- Gianluca Vannuccini, Servizio Sviluppo Infrastrutture Tecnologiche, Comune di Firenze, Firenze
- Giacomo Bucci, Università degli Studi di Firenze, Firenze
- Francesco Mati, Piante MATI, Pistoia
- Giuliano Benelli, Università degli Studi di Siena, Siena
- Franco Guidi, NEUMUS Srl, Firenze and Roberto Piermarini, ICT Consulting Expert
- Paola Imposimato, Studio Creazioni di Design e Arti Grafiche e Pittoriche, Firenze

Closing:
- Cecilia Del Re, Assessore Sviluppo Economico e Turismo, Comune di Firenze, Firenze

13,00 Lunch Break

ROOM A

CONFERENCE

Wednesday, 8 May

Chairmen: *Vito Cappellini, University of Florence*
Enrico Del Re, University of Florence

14,15 *Opening:*

Eugenio Giani,
President of Consiglio Regionale della Toscana
Enrico Vicario,
Director of Dipartimento di Ingegneria dell'Informazione
Università di Firenze
Gabriele Gori,
General Director of FONDAZIONE CR FIRENZE
Paolo Castellacci,
President of GRUPPO SESA

15,30 Coffee Break

ROOM A

15,45 **SESSION 1 – STRATEGIC ISSUES**
Chairman: *Paolo Blasi, University of Florence, Florence, Italy*

"The DAFNE Project: Human and Machine Involvement"

V. Cantoni[1], L. Lombardi[1], G. Mastrotisi[2], A. Setti[1]
[1]Dept. Electrical, Computer and Biomedical Engineering, University of Pavia, Pavia, Italy
[2]Novaria Restauri Srl, Novara, Italy

"Restored Paintings and Visual Perception: A Proposed Protocol to Study Emotional and Cognitive Involvement in Art"

V.A. Sironi[1], A. Banzi[2], R. Folgieri[2,3]
[1]Centre on the History of Biomedical Thought, University of Milano Bicocca, and Cespeb Neuroaestetic Laboratory, Milano, Italy
[2]Cespeb Neuroaestetic Laboratory, Milano, Italy
[3]Department of Philosophy "Piero Martinetti", Università degli Studi di Milano, Milano, Italy

"Technology and the Art Market: Access, Protection, and Transparency"	Frances Oglesby Artive Inc., Atlanta, GA, U.S.A.
"Evolutionary Dynamics and Computational Aesthetics: Experiments in Minimalist Blends"	Stefano Kalonaris RIKEN Center for Advanced Intelligence Project (AIP), Tokyo, Japan
"Electrical Networks as Media: Post - Humanist Media Archaeological Analysis of the Digitalization of Electric Networks"	Mika Laakkonen, Ville Kivivirta Faculty of Social Science, University of Lapland, Rovaniemi, Finland

ROOM A

17,25 **SESSION 2 – NEW SCIENCE AND CULTURE DEVELOPMENTS & APPLICATIONS**

Chairman: Edoardo Calia, FONDAZIONE LINKS, Turin, Italy

"It's Time to Give Back" (03 LAB)"	Massimiliano Zanoni[1], Jean Paul Carradori[2], Qing Li[3] [1]O3 Lab, Milan, Italy [2]Shanghai International Interior Design Festival O3 Lab [3]Art Projects O3 Lab, Beijing, China
"A Blockchain-Based Support to Safeguarding the Cultural Heritage"	Mariano Basile[1], Gianluca Dini[1], Andrea Marchetti[2], Clara Bacciu[2], Angelica Lo Duca[2] [1]Dept.of Ingegneria dell'Informazione, University of Pisa, Pisa, Italy [2]Institute of Informatics and Telematics, National Research Council, Pisa, Italy
"Educate to Wellness by the Emotion of Light"	G. Alfarano[1], A. Spennato[2] [1]Department of Architecture - Design Campus, Laboratory Design Model and Laboratory Smart Lighting Design, University of Florence, Florence, Italy [2]Department of Architecture - Design Campus, Laboratory Design Model, University of Florence, Florence, Italy

“Robot Surgery for Total Knee Arthroplasty”

Michele D’Arienzo[1]
Lawrence Camarda[1],
Antonio D’Arienzo[2],
[1]Department of Orthopaedic Surgery,
University of Palermo,
Palermo, Italy
[2]Department of Orthopaedic Surgery,
University of Pisa,
Pisa, Italy

Thursday, 9 May

ROOM A

9,30 **INTERNATIONAL FORUM ON “CULTURE & TECHNOLOGY**
Chairman: Vito Cappellini, University of Florence, Florence, Italy

The structure of the FORUM is presented.
Actual developments and perspectives are outlined, regarding *Culture* and *Technology.*

- Cooperation Groups
- Proposed Projects
- Funding Opportunities
- European Commission Plans

Opening: *- Eugenio Giani, President of Consiglio Regionale della Toscana*

Speakers Include:

- Cristina Acidini, President Accademia delle Arti del Disegno, Florence, Italy
- Edoardo Calia, Deputy Director, FONDAZIONE LINKS, Turin, Italy
- Alberto Del Bimbo, Centro per la Comunicazione e l’Integrazione dei Media, University of Florence, Florence, Italy
- Luigi Rucher, Technical Director THALES ITALIA, Italy
- David Feldman, Vice President THE MONA LISA FOUNDATION, Zurich, Switzerland
- Monica Carfagni, Full Professor of Industrial Engineering, University of Florence, Florence, Italy
- Carlo Francini, Florence Municipality, Florence, Italy
- Paolo Zampini, Director of Conservatorio di Musica Luigi Cherubini, Florence, Italy
- Francesco Bellini, University of Rome “La Sapienza” and Research Director of EUROKLEIS, Rome, Italy
- Giovanni Gasbarrone, Innovation Advisor, Rome, Italy

11,45 Coffee Break

12,00 **SESSION 3 – NEW TECHNICAL DEVELOPMENTS & APPLICATIONS**

Chairman: Andrea De Polo Saibanti, Fratelli Alinari IDEA Spa, Florence, Italy

"NEMOSINE: Innovative packaging solutions for storage and conservation of 20th century Cultural Heritage of artefacts based on cellulose derivate**"**	Andrea De Polo Saibanti Fratelli Alinari IDEA Spa, Florence, Italy
"Living in the Present: Using 3D Mixed Reality Technology to Enhance Guest Experiences with Museum Objects and Collections"	D. Marshall[1], R. Hite[2], J. Hoffman[1] [1]Museum of Texas Tech University, Texas Tech University, Lubbock, Texas, U.S.A. [2]Department of Curriculum & Instruction, Texas Tech University, Lubbock, Texas, U.S.A.
"Combining RTI & SFM A Multi-Faceted Approach to Inscription Analysis"	Moshe Caine[1], Michael Maggen[2], Doron Altaratz[1], [1]Hadassah Academic College, Jerusalem, Israel [2]Israel Museum, Jerusalem, Israel
"Chateau de Chambord, a Perfect Order"	Jeanette Zwingenberger[1], Bertrand Triboulot[2] [1]Université Paris 1 Panthéon-Sorbonne, Paris, France [2] Direction régionale des affaires culturelles d'Île-de-France, Service régional de l'archéologie, Paris, France

13,15 Lunch Break

ROOM A

14,50 **SESSION 4 – CULTURAL ACTIVITIES – REAL AND VIRTUAL GALLERIES AND RELATED INITIATIVES**

Chairman: Jeanette Zwingenberger, Université Paris 1 Panthéon-Sorbonne, Paris, France

"Architectonic design for mediating Cultural Heritage "	Dominik Lengyel[1], Catherine Toulouse[2] [1]BTU University of Technology Cottbus-Senftenberg, Cottbus, Germany [2]Lengyel Toulouse Architects, Berlin, Germany
"Innovative methodologies and technologies. Civil liability and "genetic code" of a work of art"	Sara Penco Restorer and creator of Smarticon Project, Rome, Italy

"Information Technology in Conservation and Restoration of Art Works: Perspectives of Ukrainian Universities Project"

Roman Mykolaichuk[1], Tetiana Tymchenko[2], Alisa Mykolaichuk[3], Iryna Somyk-Ponomarenko[2], Vira Mykolaichuk[3], Antonina Mykolaichuk[2]
[1]Taras Shevchenko National University of Kyiv, Kyiv, Ukraine
[2]The National Academy of Fine Arts and Architecture, Kyiv, Ukraine
[3]State University of Telecommunications, Kyiv, Ukraine

"Museum Collections Using Information and Digital 3D Technologies"

Tinatin Mshvidobadze, Sopio Mshvidobadze
Gori State University, Georgia

16,05 Coffee Break

ROOM A

16,20 **SESSION 5 – ACCESS TO THE CULTURE INFORMATION**
Chairman: James Hemsley, EVA Conferences International, U.K .

"Contemporary Methods of Functional Harmony Teaching in a High School Context"

Anna Shvets
Institute of Cultural Studies,
Maria Curie-Sklodowska University in Lublin, Lublin, Poland

"The Aesthetics of Volumetric Photography for Virtual Reality"

Daniel Buzzo
University of the West of England, Bristol, UK

"Optimising 3D cultural environments with large amount of texts for 3D Web. The Santo Stefano Lapidarium to the dead soldiers of the Great War, a case study"

Beatrice Chiavarini, Daniele De Luca, Antonella Guidazzoli, Maria Chiara Liguori, Silvano Imboden, Luigi Verri
VisitLab Cineca, Bologna, Italy

"A techno social collaborative platform to optimize Cultural Heritage funding: final results from the validation phase"

F. Spadoni[1], F. Tariffi[2], R. Rossi[1], S. Lusso[2],
[1]Rigel Engineering Srl, Livorno, Italy
[2]Space Spa, Prato, Italy

SPECIAL EVENT

Wednesday, 8 May: 19,00 - 21,30

Visit to ACCADEMIA DELLE ARTI DEL DISEGNO
President Cristina Acidini

with Concert by Paolo Zampini, Director
of CONSERVATORIO DI MUSICA "LUIGI CHERUBINI"
of Florence

in Cooperation with ANTICA COMPAGNIA DEL PAIOLO
President Anna Bini

and

"Wellcome Drink"

EXHIBITION

ROOM B

Wednesday 8 May: 10,00 - 13,00

TECHNICAL EXHIBITION

Coordinator: Marco Cappellini, CENTRICA Srl

Advanced Technologies will be presented, with Technical Demonstrations, regarding in particular:

- Augmented Virtual Reality Immersive Systems
- 3D Digital Models Protection
- Uffizi Touch® Cloud Edu for Schools

by some Enterprises, Leaders in the above Areas.

Thursday 9 May: 10,30 – 13,00

ART EXHIBITION

Coordinator: Vito Cappellini, EVA 2019 FLORENCE Organizer

Digital Presentations of Museums, Art Institutions, Virtual Galleries and Art-Works will be performed.
In particular Digital Art-Works of LEONARDO DA VINCI will be presented.

in Cooperation with ANTICA COMPAGNIA DEL PAIOLO,
President Anna Bini

Events Organization: INN-3D Srl, Empoli (FI)

Official Television TVL Spa Pistoia

NEXT EVA EVENT

8-11 July 2019 **EVA 2019 London**

Website: http://www.eva-london.org/eva-london-2019/

PROCEEDINGS

STRATEGIC ISSUES

V. Cappellini (a cura di), *Electronic Imaging & the Visual Arts. Eva 2019*, ISBN (online PDF) 978-88-6453-707-8,

THE DAFNE PROJECT: HUMAN AND MACHINE INVOLVEMENT

V. Cantoni*, L. Lombardi*, G. Mastrotisi, A. Setti***

*Dept. Electrical, Computer and Biomedical Engineering, University of Pavia, Italy

**Novaria Restauri s.r.l, Novara, Italy

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Abstract – The DAFNE challenge originated with the aim of involving autistic subjects in the post-seismic re-composition of destroyed frescoes, trying to develop their social involvement while favoring their inclusion in productive activities, enhancing their peculiarities and abilities, and promoting their potential. Our goal became to produce also a software tool that applies the most advanced computer techniques, such as Machine Learning and Deep Learning. As different tracks are proposed, this initiative can bring to different applications. It widened then in a research of up-to-date artificial intelligence solutions suitable to the restoration of collapsed buildings, promoting their re-use, enhancing cultural heritage conservation.

INTRODUCTION

We focus on the digital anastylosis of frescoes. The reconstruction of an artwork destroyed by natural events, such as earthquakes, or wars, is a very complex task. Several attempts to restore collected fragments, based on traditional methods, have been done in the last 60 years, but without great success. Since 1998 [1] many efforts have been devoted to the restoration of the inestimable frescoes by Andrea Mantegna – located in the Ovetari Chapel of the Eremitani Church, in Padua (Italy), and destroyed in a bombing during the Second World War – by using mathematical methods and computer techniques based on comparison with an old gray level image of the fresco prior to the damage. Unfortunately, with this technique only a partial reconstruction of the fresco was possible: from the 78.561 pieces, mostly with an area of 5-6 cm^2, less than 8% of the artwork was covered.

A variety of different approaches have been proposed in the last decade. A first broad taxonomy of these techniques [2] is based on the main matching factors: color information [3], geometric outline characteristics [4] or both together (shape as well as sample colors along the border of the pieces) [5, 6, 7].

A number of proposed methods has been explicitly based on the optimization of specific remapping problems. An important one has been defined ‘colorization’; as an example, in the quoted case of the Ovetari Chapel, the simple 8% of coverage of the frescoes was certainly instrumental to a high fidelity to the fresco re-colorization, which is a crucial issue in art restoration [8, 9]. A second example refers to image ‘completion’, focusing on the cases of occlusion areas that produce regions to be completed [10, 11]. A peculiar case is the one of non overlapping images, in which images are extrapolated to cover the gap between them through alignment and inpainting [12]. A related problem is image ‘melting’, in cases of transition regions in which chromatic and structural properties change gradually so that a patch transform allow the implementation of image interpolation and morphing by combining inconsistent images [13, 14].

It is worth to mention another approach, based on the analysis of fracture patterns in order to model the cracking process so that it will be possible to predict the patterns and help future computer assisted anastylosis [15].

In the very last years, two very promising innovative solutions have been proposed, both computation intensive, but now supported by the high performances of the new technology. The first one exploiting a genetic algorithm approach [16] and a second one, becoming more and more popular, exploiting machine learning and deep learning [17]. In this connection, we are proposing this challenge and we foreseen too far, may mature in the next couple of years, a ‘blind’ anastylosis in which no data on frescoes content and semantics are known [18]!

THE DIGITAL ANASTYLOSIS OF FRESCOES CHALLENGE (DAFNE)

The challenge’s goal is to collect the best solutions to virtually recomposing destroyed frescoes, starting from the digitalization of their broken collected elements. This is not meant to replace the restorer’s or archaeologist’s skills and knowledge, but to be an additional tool in the restoration task. In this context, it can be interpreted as a very challenging ‘puzzle’ and finding the global position and rotation for each piece, so that all fragments jointly reconstruct the original surface, is the final objective. Critical issues are due to: i) the number of randomly mixed fragments is usually huge; ii) fragments are mostly corrupted, and with general irregular shapes; iii) mismatch of the boundaries of the collected eroded pieces; iv) some pieces have gone irretrievably lost; v) due to extreme fragmentation, presence of spurious/distractors elements, as pieces from different frescoes could be involved in the building collapse.

The challenge entitles participants to use, at their discretion, a number of different cases of destroyed well-known frescoes that have been simulated in order to populate a dataset containing fragmented pieces, useful for the development and testing phases of the challenge. Five different parameters have been used for the generation of elements, in order to respond to the critical issues previously listed: A, the number of fragments; B, the type of random distribution; C, the percentage of missing parts; D, the percentage of spurious fragments; and E, the ratio between the fragment area after the erosion and the original area in the fresco plane tessellation.

Participants are invited to develop solutions that re-assemble a given set of pieces, discarding spurious ones, and are required to submit the reconstructed image generated by their application − showing the fragments properly placed − which will be evaluated in accordance with quality requirements and metrics.

Methods developed for DAFNE can be tested on cases for which ground truth fragments alignments are available for verification. ANASTYLOSIS DB1 collects for each fresco image more sets of digital fragments, mixed with spurious elements (distractors), that participants have to re-assemble. Two phases will be considered: 1) a development phase, during which registered participants will be provided access to DB1, with fragments and solution (an image file with each fragment provided in the right position and a corresponding table with location and rotation for each fragment); 2) a successive testing phase, during which registered participants will be provided with a dataset DB2 of fragments from the image of five frescoes – with distractors from other frescoes – and the original image of the corresponding fresco, but no ground truth solution will be provided.

FRAGMENT GENERATION: THE CRACKING PROCESS

Studies have been done on the topic of “natural” fragmentation, to model a method for generating surface crack patterns, and different solutions have been proposed. For example, the Berkeley Surface Cracking Toolkit [19] model a hierarchical fracture process that appears in materials such as mud, ceramic glaze, and glass, that the user can control using a set of simple parameters for the characteristics and appearance of the cracks; others [16] run their experiments with data from Princeton Synthetic Fresco, a plaster wall painting created and fractured by Greek archaeologists for the purpose of testing reconstruction algorithms. Some authors [2] used data from artifact/fresco broken based on a fragmentation of dry mud; other [20] evaluated their approach using scanned frescoes from archaeological excavations (but with a dataset limited to 1200 fragments), as well as a modern-day “synthetic” fresco data set, created and then broken into pieces to have fragments similar to the ones found at archaeological sites. In addition, other authors [20] present a system for acquiring images, geometry, normals, and associated metadata, for small objects such as fragments of wall paintings.

Starting from examples of real fragments of destroyed frescoes we based our simulated fragments generation on some generic considerations: the fragments must be in different sizes, they do not have sharp edges, they may be convex or concave, we have to discard the too small fragments (so a threshold has to be fixed in order to eliminate the fragments that result too small after the fragmentation), size and shape of the fragments have not to be dependent from their position inside the image.

An application tool has been developed to generate some examples of plausible fragmentation, to populate the challenge dataset. Figure 1 shows the fragmentation obtained with two different types of distribution: concentrated and uniform. Figure 2 and Figure 3 show two examples of plane tessellations and corresponding ground truth cases.

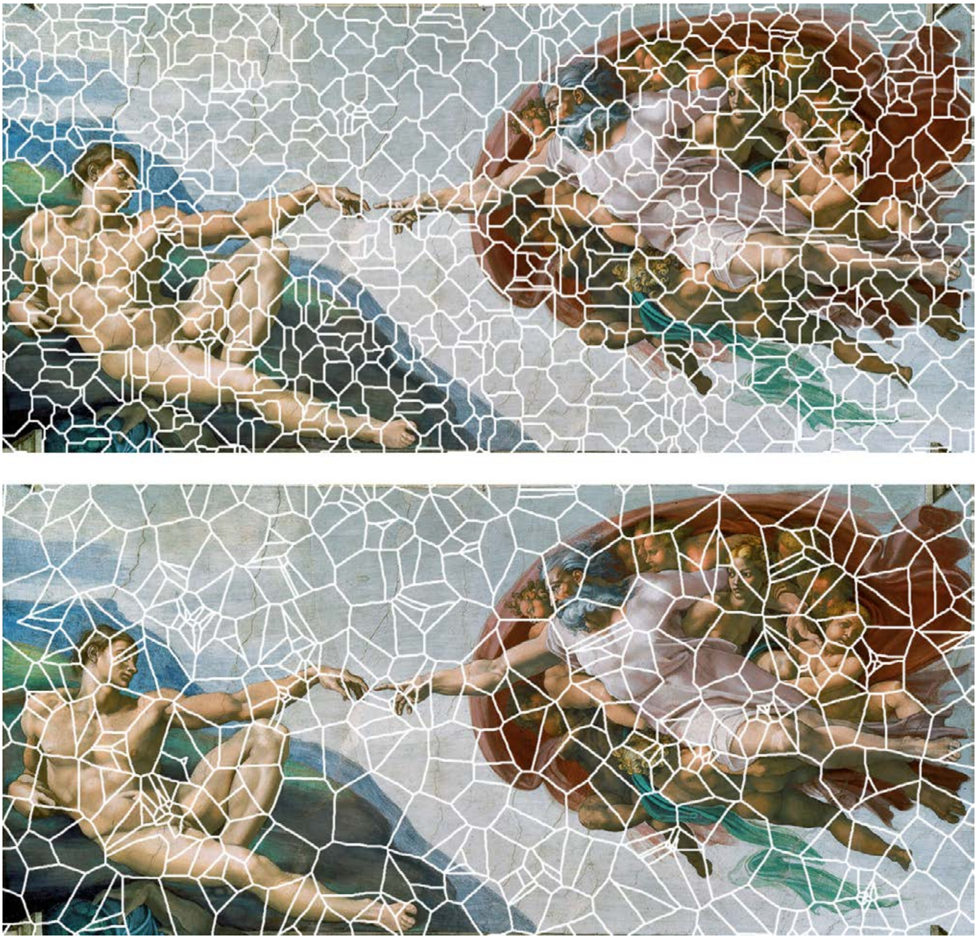

Figure 1. Above: Plane tessellation with a uniform distribution adopting the Manhattan distance (detail of the fresco “The Last Judgment” by Michelangelo Buonarroti, Sistine Chapel, Vatican City, 1536–1541). Below: Plane tessellation with a concentrated distribution adopting the Euclidean distance.

Figure 2. Above: Plane tessellation with parameters: A=750; B=random distribution generated adopting the Manhattan distance; C=7.5%; D=7.5%; E=0.10. Below: Ground Truth, with original image in background and overlapping fragments (image of the fresco “The Plague of Milan” by Cesare Nebbia, Collegio Borromeo, Pavia – 1604).

Figure 3. Above: Above: Plane tessellation with parameters: A=253; B=random distribution concentrated distribution adopting the Euclidean distance (annular measures ρ_1=3px, ρ_2=10px, τ=0.5); C=7.5%; D=7.5%; E=0.10. Below: Ground Truth, with original gray image in background and overlapping color fragments (detail of the fresco "The Last Judgment" by Michelangelo Buonarroti, Sistine Chapel, Vatican City,1536–1541).

A graphical interface (Fig. 4) has been designed for handling the fragments to be reassembled. This has been studied and will soon be tested by people belonging to the autism spectrum. This tool allows them to move and rotate each single piece in the position that they suppose it is right. Automatically a table identifying each moved fragment with its final location and rotation will be listed for restorers' usage during the physical phase of artwork reassembling.

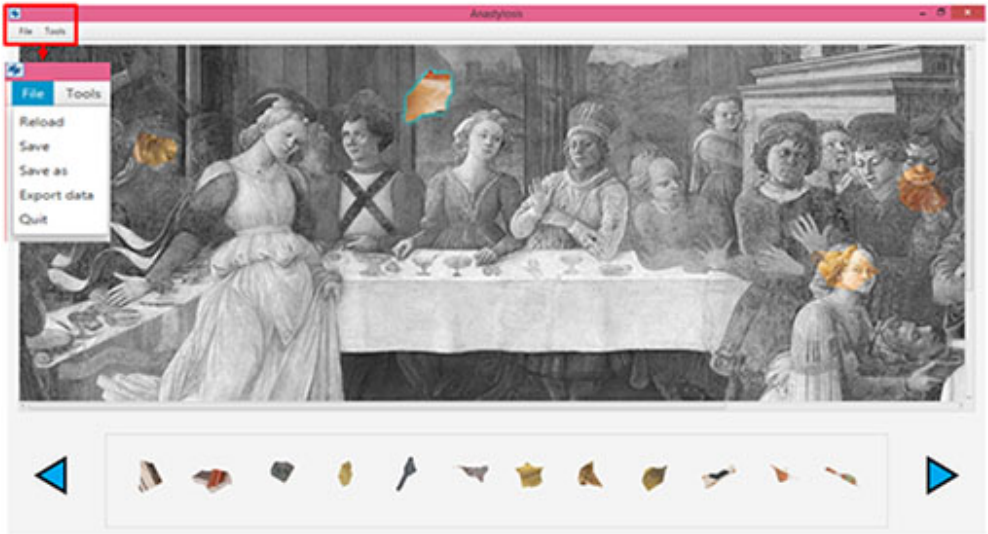

Figure 4. The multi-platform application which provides a set of tools to reconstruct images from pieces, like a puzzle. The interface has been designed to let the user move and rotate the fragments, store them on the provided panel and save the progress, in order to retrieve their position for further usage. The lower part of the screen shows a list of fragments to be reassembled, while the majority of the display is occupied by the image that has to be reconstructed (in figure, a detail of the fresco "Herod's Banquet" by Fra Filippo Lippi, located in Prato Cathedral, Italy). Both mouse and keyboard bindings are provided in order to assure a comfortable usage and allow fast and accurate operations. The fragment with blue borders is the active one.

CONCLUSIONS

This initiative can foster different strategies. The topic is of interest for the Pattern Recognition community and advanced computer techniques such as Machine Learning and Deep Learning can be applied to improve methods and applications.

Restoration of damaged frescoes is a crucial task in cultural heritage preservation and these kind of solutions can result in a precious additional tool for restorers. Furthermore, the involvement of autistic subjects in the post-seismic recomposition of destroyed frescoes, can be both an inclusion opportunity as well as an enhancement of their peculiarities and abilities.

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RESTORED PAINTINGS AND VISUAL PERCEPTION: A PROPOSED PROTOCOL TO STUDY EMOTIONAL AND COGNITIVE INVOLVEMENT IN ART

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Abstract – In this ongoing study we are interesting in investigating visual skills, cognitive understanding of an artworks and the observers' brain response to the aestetic perception of the artwork. The study will involve a wide number of participants to the experiment, making our investigation a unique occasion to confirm data and outcomes from previous works described in literature.

INTRODUCTION: AIMS AND MOTIVATION

For some year neurosciences have begun to take an interest in art to try to understand the neurobiological bases of artistic production and to know which neurophysiological networks allow us to grasp how "beautiful" and/or "pleasant" or "unpleasant" and/or "ugly" a painting, a sculpture or an architectural work is.

Every time an aesthetic judgment is formulated, different areas of our brain are activated. The techniques of recording cerebral electrical activity (EEG, Electroencephalography) and the modern neuroimaging techniques (as Functional Cerebral Magnetic Resonance) allow to investigate what happens in the brain of people who observe an artistic work. If a "pleasing" work enters our field of vision, for which we formulate a positive aesthetic judgment, the medial orbital-frontal area is activated, together with the occipital cerebral areas designated for vision [10, 9]. If, on the other hand, our aesthetic judgment is negative, the left motor cortex is activated [8]. Finally, if we remain indifferent, the lower part of the cingulum and the parietal cortex enter into action [16]. Different areas are also affected when the subject of the artistic work changes: landscapes, portraits and faces, still lives or objects activate different areas, as if each type of representation corresponded to a different cerebral "micro-conscience"[15].

In this field, the neurology of art or neuroaesthetic, as named by Semir Zeki [20, 12], represents an approach that considers the artistic-aesthetic analysis as a function of the neurological impact and the neurophysiological study of the work of art. Many information has now been acquired in this area, but often these studies investigate only some functional and neurophysiological parameters and are conducted on a limited number of people.

In this context, our study, developed by CESPEB (Centro studi sulla Storia del Pensiero Biomedico) of the Università di Milano-Bicocca with the involvement of his Neuroaestetic Laboratory, born from interdisciplinary collaboration between Department of Phylosophy of the Università degli Studi di Milano and Department of Medicine and Surgery of the Università degli Studi di Milano-Bicocca, has a double aim: as first, to confirm the outcomes from previous researches through a significantly wider data sample; then, we also aim to add a series of investigations usually not used in research. Indeed, the project includes a first phase during which the already known data reported in the literature as related to the vision of pictorial works using non-invasive easy-to-use tools will be taken back to obtain more reliable quali-quantitative indicators.

Sometimes visitors cannot look at and understand a restored artistic exhibit displayed in a museum. Looking is a learned skill [17, 18, 19, 2, 21] that is neither innate nor spontaneous. In this paper, as previously mentioned, we introduce a promising approach consisting of analysing subjects' brain signals collected by an EEG-based device. The approach is currently in use in our *in fieri* project concerning museums and art exhibition in Lombardy Region.

In next paragraphs we will introduce the protocol in use and a discussion about our choices, in the light of the outcomes we expect from the study.

BACKGROUND

In our study we are interesting in investigationg visual skills, cognitive understanding of an artworks and the observers' brain response to the aestetic perception of the artwork.

To collect data useful to analyse these aspects we chose to use some devices and methods, better described in next paragraph about the adopted experimental protocol. Specifically, we chose to use Brain Computer Interfaces (BCIs) and an eye tracker to analyze brain data and visual skills related to the emotional and aestetic impact of an artwork on observers and the priming methodology to investigate their cognitive response. We also aim at using data coming from the measurement of the skin conductance, collected while individuals are looking at an artwork.

As visual literacy experts state [3, 4, 13, 14], visual skills are not to be confused with vision, colour vision, disease, and various anomalies. *Visual perceptual motor skills* and *ocular motor skills* are the main visual skills categories. These skills are developed after birth. Visual perceptual motor skills process visual information and affect eye/ body movements. They encompass abilities such as visual memory, visual-spatial skills (e.g., mapping locations), visual analysis (e.g., discrimination), visual-motor coordination, visual-auditory integration (e.g., matching sound and image), and visualization. Ocular motor skills involve eye movement control and focus control.

A work of art is composed of different layers of meanings including also the restored version of the object. How can we understand these meanings?

According to Angela Lawler and Susan Wood [11] there are five steps which teach people how to look at art. We have adapted this methodology to the observation of restored artworks.

The first step is to *observe* artworks in silence, secondly time it is taken to *describe* the artwork objectively. The third step *analyses* contents, such as colour, balance, space, line, value, and technique. The fourth step tries to *interpret* the works of art exploiting what museum-goers know and have seen. Finally, museum-goers try to make a critical judgement of the artwork. Judging art requires fair and logical consideration. Angela Lawler and Susan Wood recommend taking time, because *reading* art is a slow, thoughtful, and exciting process of discovery.

There is a final step we would like to add in order to foster visual skills: comparing the artwork before and after the restoration, asking the visitors to list the diversities between both pictures (the restored one and a picture of the artwork before the restoration).

THE PROTOCOL

The ability to analyse the formal qualities of a restored artwork is an important step of the art-making process understanding, depending on several factors and involving visual skills, the brain response to stimuli [5, 6, 7] and the body related reaction to such perceptions. Here is a streamlined example of a tentative method of collecting artwork-related visual skills data through the collection of different brain and body response.

The approach

We decided to adopt an ecological approach, that is we decided not to isolated the individuals from the environment. Specifically, we chose to collect data while individuals submitted to the experiment are visiting a Art exhibition so that we could collect real response to stimuli from artworks in a real environment, also influenced by distracting factors, noises, fatigue due to the tour. Indeed, we intend to analyze a real scenario, that is the condition in which individuals usually look at artworks.

The data will be collected on a selected number of paintings, specifically ten, and in conditions of spontaneous and "guided" vision, allowing us to elaborate fundamental information to understand the neurobiological mechanisms involved in the neuroaesthetic perception.

Participants to the experiments

A population of several hundred people will be studied, namely, a large number of visitors to temporary exhibitions and permanent art museums in Lombardy Region. The sample will be composed by individuals of different nationality, sex, age and education level, so that we could have a large set of data to perform our analysis and comparisons.

Materials

During the vision of the paintings the skin resistance will be recorded to know the neurovegetative involvement of the subject, the eye movements with an eye-tracker, which highlights the parts of the work most observed by the visitor, and the brain electric activity with an EEG-based Brain Computer Interface (BCI) headset [1] to observe the changes of the electric activity in brain areas solicited and activated by the vision of the masterpiece.

Because of the ecological approach we chose to use easy-to-wear devices, such as:

- the Pupil headset for the eyetracking (https://pupil-labs.com/store/);
- the Mindplay (http://mindplay.com/) EEG-based BCI;
- tools developed using the bitalino (https://bitalino.com/en/) to measure the skin conductance and possible other biofeedbacks.

All these devices are used during the performed experiment to assess and collect data on the museum-goers' visual skills and emotional/cognitive reactions to the artworks. The listed devices have been chosen because they are low-cost and portable. Also, they can be connected via bluethoot or WI-FI to a computer, so the visitors will be free in movement and not under the effect of anxiety often induces by more complex devices. Moreover, they are perfectly comparable to the performance of medical devices. Indeed, for this latter reaons, they are widely used in research.

Thanks to devices listed above, the participants will visit the museum without any restrictions.

Individuals will be informed about the experiment and provided by a written consent to take part in the experiment.

Also, a questionnaire will be prepared, with the aim to verify what they experienced and what they remember after the visit.

Procedure

At the onset, participants wear the BCI devices and read the instructions which they will then paraphrase back to the experimenter. Participants are asked whether they have any doubts as to what they have to do.

The museum-goers freely observe the restored artwork for 1 minute. Subsequently the experimenter asks each participant separately to describe the artwork without any specific instruction. After that he guides the analyses of the visual features of the restored artwork following a preset list of visual contents such as colour, balance, space, line, value, and technique.

The next step is very delicate since it requires an interpretation of the artwork made by the participant. After collecting the participant's interpretation, the experimenter explains the discoveries made during the restoration in order to give a correct point of view on the basis of scientific results. The museum-goer is invited to try to express a critical judgement of the artwork.

To facilitate the complete understanding of the artwork, the participant is encouraged to look at a copy of the artwork before the restoration and to list the differences between the two pictures (the restored one and a high-resolution picture of the artwork before the restoration).

After the museum exhibition tour, participants, still wearing *Mindwave* in order to collect more EEG signals, complete a questionnaire about the visual features of the corresponding restored artworks. Indeed, at the end of their tour, the participants will be asked to answer some questions about the masterpieces chosen for the experiment in order to check what they remember. This latter step will allow us to analyse also the effect of the priming approach on the visitors' cognitive process.

DISCUSSION AND CONCLUSION

The novelty of the study consists in many points. First of all, a population of several hundred people will be studied, making the project one of the larger experiment ever performed in the field. Also, the ecological approach is very interesting, allowing us to collect data on a selected number of paintings in conditions of spontaneous and "guided" vision, to elaborate fundamental information to understand the neurobiological mechanisms involved in neuroaesthetic perception in a real enviroment. This approach will allow us to obtain important information giving us practical and useful guidelines for exhibitions and museums. Another aspect is related to the new cognitive technologies adopted (EEG-Based BCI headset) and Artificial Intelligence approaches (eye tracking, facial expression recognition) combined with physiological measurements (skin conductance, possible ECG, EMG) allowing freedom of movement to the individuals participating to the experimental sessions.

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TECHNOLOGY AND THE ART MARKET: ACCESS, PROTECTION, AND TRANSPARENCY

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ABSTRACT – The increasing development of digital networks and technologies is changing the way that data is collected, digitized, managed, and searched. These strides not only provide platforms for tangible materials to be digitally recorded and exchanged, but also raise the standard of accessibility, methods of protection, and ease of research. Can the current climate of technological advancements assist in making provenance research a priority for institutions, companies and individuals involved in the art market?

This paper will examine what potential impact future technological opportunities and interpretations of 'Big Data' could have on cultural property protection, provenance research, and due diligence processes.

INTRODUCTION

The longstanding identity of an art world rooted in tradition and noted for resistance to change is being challenged by the increasing availability of digital technologies within business and research practices. Today's media teems with buzzwords such as 'blockchain', 'Artificial Intelligence', and 'Big Data' thus pressuring industries across the board to consider how they will progress in this time of technological renaissance. How are these trends targeting or inspiring thought-leaders in the art world? As our globe becomes more connected through endless channels of communication and networks for exchanging information, does this create a demand for quicker, easier, and cheaper modes of research and transactions? And if so, how might these impact the standard of business practices in the art trade?

To answer these questions, throughout this paper we will explore where we are seeing technologies applied to art practices, analyze what this means for the future standard of art business, and point out the areas of hope and resistance present throughout the industry in reaction to the promises made by forthcoming technologies.

1. Technology and the Art Market

To begin, let us establish a basic understanding of the current state of technological advancements and what has informed their development. Less than thirty years ago the public introduction of the world-wide web greatly stimulated the concept of digitally recording, storing, and exchanging information. It was a nuanced idea that tangible materials could be held, accessed, and traded without geographical limitations. From there, more complex conversations about data collection began and continues to be explored, informing a significant increase of electronic research tools and data collection platforms. This brings us to the buzzwords mentioned above.

Defined in their most basic form, 'blockchain'; digital ledgers, 'Artificial Intelligence'; machines mimicking cognitive functions, and 'Big Data'; extensively large amounts of data, are all tools intended to set high standards for how data should be handled and to build trust among users. These technologies of the future are for "those hoping for a utopian future of information sharing and the end of big business dominating the use of personal data". While some research may suggest that aspects of these technologies are "more a narrative than any specific technology" it is plain to see that they have "sparked the imaginations of people across sectors to consider how digital technologies" could alter the landscape of business and research methods in a very positive way [1]. As these technologies are developed and implemented into business practices, the endless possibilities of collecting and sharing information leads to a demand for data democratization. Can democratization of this nature find a place in the notoriously private, opaque world of art?

This question brings us to the second establishment that needs to be made: let's define the fundamental qualities of the art market. Plainly stated, the art sector is discreet and highly consolidated. Art sales continue to be largely private in nature, with physical transactions dominating the market and the "lion's share of profits" going to "a fairly small number of top galleries and auction houses" [1]. While sectors such as banking, insurance, and real estate are highly regulated markets governed by well-established protocols to protect their participants, the art market remains opaque and vulnerable to tampering. We see this in the way that the art market is "rife with illicit business. All too often owners of art works, even, or especially, at the higher end, use assets to launder money, or at least as a value store that is beyond the scope of regulatory bodies." Additionally, such works are often traded completely discreetly and without tax. Art is frequently stored by its owners "in offshore locations, or jurisdictions which are beyond the reach of regulators". For such individuals, the lack of transparency in the art market is of critical importance. Accordingly, the companies which service this high-end clientele also greatly value the discreet and opaque nature of the market. Therefore, there are more vested interests to keep the art market opaque and stop it from adopting" technologies that would bring transparency, shedding light onto such discrepancies [1].

So, it is evidenced that the opaque nature of the market is directly connected to its problematic qualities. This is why perhaps even more necessary than other industries, trust is absolutely essential for the preservation and success of the art world [1]. Fearful of the illicit activities mentioned above, artists, buyers, and sellers seek access to information regarding the pieces they are trading as well as who they are trading with. Advancements in technologies and the promises they are making of transparency and increased ease of access to information is instilling great hope for the industry.

2. Digital Advancements, Research, and Accessibility

Over the past decade we have seen an undoubtedly dramatized flair cast upon the topics of looted, stolen, missing, and forged artworks. Increased media attention through films such as *The Monuments Men* (2014) and *Woman in Gold* (2015) have gathered a wide audience of intrigued viewers, entranced by the mystery and suspense of illicit art activities. While these stories, based in truth, focus on the catastrophes of World War II looted art that have ongoing repercussions, the same threats continue to retain relevance in the contemporary marketplace. As plainly stated in a 2018 report by the University of Oxford and Alan Turing Institute, “art is currently plagued by fraud, illicit business, and tax evasion” [1]. It is therefore easy to imagine how promises of transparency and accessibility brought forth by digital advancements would seem attractive to buyers who want to purchase art in good conscience. Buyers want to trust that “they are able to transact at a fair market price, that the piece is genuine, and that the seller has a legal claim to be selling it” [1]. The same is true for the reverse. Responsible sellers want the “ability to prove their ownership, [and] prove that the piece is genuine” [1]. Whether tainted by proximal association to WWII looted art, sourced from unknown or at-risk territories, or lacking sufficient records of provenance, authenticity, etcetera, there are innumerable scenarios necessitating responsible due diligence in art. The desire for trusted transactions from both buyers and sellers offers space for technologies to intervene and provide solutions.

2.1 Due Diligence

From issues of provenance and titleship to miscreant players in the industry, it is essential that buyers and sellers seek proper due diligence prior to any transaction. How does ‘proper due diligence’ look? At its core, due diligence is a risk management tool intended to protect all parties involved in a sale or transaction from engaging with illicit factors. These whether factors could be due to the object itself, the players involved, or the circumstances of a transaction. For example, in used car sales it is customary to research the car’s history and be able to answer questions such as: How many times has the vehicle been sold? Has the vehicle ever been involved in an accident or crash? What repairs have been made to the vehicle? Etcetera. Seeking answers to such questions is a form of protection for all parties involved in order to set a standard for the transaction. Furthermore, failing to know this information prior to purchasing a vehicle is seen as irresponsible. The same is necessary for art and cultural objects. Where was the object sourced from? Is there a clear record of ownership? Are there any red flags or grey areas associated with the geographical locations the object has been, or the hands through which it has passed? Committing oneself to seeking answers to these questions even though there is no governing body enforcing such actions is simply being responsible. This need for responsible market practices points back to the reoccurring question: what is needed to build trust in the market?

Thankfully we are in a time where conversations around the possibilities of technology’s impact on the art market are forcing market participants to be increasingly mindful and aware of their actions. And this mindfulness is not limited individual potential buyers in the market. We can observe the way in which pan-national governing bodies as well value the creation and implementation of digital resources as well. On the 17th of January of this year the European Parliament passed a resolution calling for a “pan-European meta-database of looted-art, [and] funding for provenance research” as well as a proposal for “art market professionals to maintain a transaction register and provenance research programmes” [2].

2.2 Provenance Research and Databases

Historically, provenance research has been limited to museums, libraries, and archives confining the practice to an academic setting. The increased media attention over the last decade on the nature of fraudulent risks is helping to break the trend that due diligence research is kept to academia and is instead beginning to be implemented across the market. As observed in a report from the Smithsonian Institute, "digital technology is profoundly changing museums, libraries, and archives and the way they reach and interact with people…While it is true that the traditional role of our cultural institutions is still valued by the public and is needed, they must find ways to accommodate digital technology or risk becoming marginalized" [3]. Finding ways to implement digital efforts into art business and research practices is therefore imperative for its relevancy. And with the case of provenance research, digitization efforts and other technological schemes are breaking the mold of traditional archival research making it efficient and accessible to a growing audience. Individuals involved with digitization efforts of art historical resources have voiced a desire to see "better data capture methods, including mass digitization of archival and image materials to bring more of these "hidden resources" online" [4]. This desire has informed the creation of many growing databases.

With over 1.5 million digital records of various art histories and information stored, The Getty Research Institute is encouraging the use of online databases and providing opportunities to do so via platforms such as their Provenance Index Databases. Similarly, law enforcement specific resources like the FBI Stolen Art File and the collaborative project "PSYCHE" between Interpol and the Italian Carabinieri Command for the Protection of Cultural Heritage offer searchable, digitized data of stolen art further adding to the landscape of digital resources easily used for due diligence research. Other growing databases such as the Artive Database, Art.sy, and the Archives for American Art just to name a few, are allowing information to be widely available, therefore encouraging collaborative rather than duplicative digitization efforts across the field [4]. It is our belief that through collaboration and an increasing presence of digitally accessible resources, provenance research and due diligence practices will become more and more promoted, hopefully one day becoming the norm for all art and cultural property transactions.

2.3 Access to Pricing

In addition to ownership history, some of these platforms are able to build trust within the market by sharing historical information on pricing. Pricing is an element that greatly attributes to the exclusivity and elitist quality of the art world, which various programs are beginning to challenge. What validates the price of an artwork? How are buyers able to trust that their money is being spent fairly? Applications and services such as ArtTactic, Magnus, and Pi-eX are committed to providing "financial clarity in the art world by mapping transactions…to give clients a better expectation of sales prices on artworks of the same artist by registering the sale prices of artworks" negating the exclusivity of often ambiguous asking prices [5]. These developments are important to our conversation because they further exemplify how technology is able to fulfill a demand and desire for art market participants – artist to dealer, buyer to seller – yearning to find their place within the landscape of the art market. Perhaps the main reason the art market continues to be opaque and highly consolidated is because the majority of players within it have been unable to find clarity within its practices. To alleviate this cloud of uncertainty, data and access to information is becoming progressively valuable and desirable. As observed by Pi-eX CEO Christine Bourrone, "art may not be an investment, but if you invest in it, you should be aware of the data" [5].

2.4 The Challenges of Digital Research

With such a wealth of information becoming accessible through these databases and various applications herein lies a challenge; how does a user determine which resources to use? While digitized records and searchable databases allow research to be efficient with a massively increased ease of access, the information on these various resources can be scattered and disconnected. A researcher could spend just as much time if not more navigating the extensive amounts of digital records as they might have spent visiting on-site research institutions. In a perfect world, a comprehensive, running list of databases with how-to instructions for each resource would exist allowing the process to be as unintimidating and inviting as possible. But through various studies, art historical researchers have expressed frustrations around "being unable to easily determine if tools might be relevant for their own work" and often claiming "they just don't know what is out there" [4]. Additionally, it can be challenging to keep up with the advances and changes in digital resources, and with limited opportunities to formally learn best practices for digital research methodologies, researchers may unfortunately give up due to frustration without ever gaining an understanding that would benefit their research.

2.5 The Technological Solution

The magnitude of present and potential technological advancements, however, does provide a source of hope that could alleviate these challenges. The solution lies in a hypothetical but highly conceivable connectivity between digital resources. As digital assets are added to cloud-based technologies, they "can be linked to just about any other set of digital assets, offering a powerful tool for users to search for connections among not only museums, libraries, and archives, but also universities and information sources" [3]. In other words, through cloud-based technology and 'digital-ledgers' such as blockchain, large datasets can be linked, and sources fastened, allowing digital collections to be shared across platforms connected in the cloud. As evidenced by these challenges, the adoption of digital technologies in the art and cultural property sector has proven to be difficult and will continue to be so due to cost, and technical infrastructure. But through collaboration and a unified commitment among cultural institutions, art companies, independent researchers, and other market participants to embrace and explore the possibilities that technological advancements propose, successful integration is possible. Perfectly concluded in an exploration of the digital age in the cultural sector, the Smithsonian stated that "while digital technology poses great challenges, it also offers great possibilities" [3]. It is our responsibility to continue this conversation by exploring and applying technological advancements to instill greater transparency and wider participation in art business practices, research methods, and overall engagement of the fine art and cultural sector.

3. The Big Picture

What is the big picture? Digital technologies are changing the landscape of the art market. Digitization efforts are altering the methods in which research is conducted, and by whom. As our world becomes increasingly connected and information more accessible to a wider audience, the ability to pursue research outside the realm of academia is made possible. This presents an increase in the frequency of due diligence research opportunities, hopefully bringing due diligence to the forefront of art and cultural property transactions. While technology's impact on the art world is still fresh and there is a lot of work to be done before it has grounded itself in the market, the possibilities it presents are inspiring thought-leaders and participants. Through continued conversations and collaborative efforts, change is possible.

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EVOLUTIONARY DYNAMICS AND COMPUTATIONAL AESTHETICS: EXPERIMENTS IN MINIMALIST BLENDS

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This paper describes an auditory and visual display of a population-based game, the Demographic Prisoner's Dilemma. Agents' parameters (such as life expectancy or strategy mutation) are gradually introduced to explore the population's dynamics. As the implementation of the game undergoes such changes and variations, aesthetic considerations rise to the fore, prompting a re-evaluation of the system's cross-space mapping and of computational aesthetics as a field of investigation.

INTRODUCTION

Evolutionary programming and algorithms have been used extensively for the production of works and generative systems in the domains of music, art and design. On the contrary, population dynamics based on a game-theoretical perspective have rarely been employed, to this end. Evolutionary game theory differs from other flavours of this area of applied mathematics in that it considers systems in which agents are not overly rational. Instead of analytical solutions to Nash equilibrium [11], evolutionary game theory is concerned with behaviours that are adopted or abandoned in the context of a population of such agents. Through repeated simulation of a Demographic Prisoner's Dilemma [5], hereinafter DPD, the emergence of cooperation is observed, and consequently used for a conceptual blend [6] which maps cooperation to homogenous and harmonious audio-visual (AV) content. The blend between DPD and a population of AV agents is explored via modifying the cross-space mapping to obtain aesthetically pleasing results. Thus, questions concerning computational aesthetics or universal notions of beauty arise and are discussed. Arguing for a dialogical approach to aesthetics and a relational, dynamic negotiation of one's artistic aspirational levels, future directions are considered.

DEFINITION AND BLEND

A DPD is an iterated Prisoners' Dilemma [12], hereinafter PD, played pairwise amongst a population of agents who inherit a fixed (immutable) strategy and who are identical and undistinguishable from each other. A DPD differs from the classic PD in that it is a memoryless game, and agents do not get to change their strategy according to the recollection of previous actions or game outcomes. There are only two pure actions, namely cooperate (*c*) or defect (*d*). The game matrix for a PD is shown in Table 1, were the payoffs (rewards) for a given combination of actions are given in the corresponding tuple, with $T>R>P>S$. While in a *one-shot* PD game the Nash Equilibrium is the pure strategy *dd*, it has been shown [5] that in a DPD cooperation can emerge and endure. This is an exciting result which contradicts some intuitions and axioms of rational decision-making, and can inspire speculative explorations at a societal and artistic level.

	c	*d*
c	(R,R)	(S,T)
d	(T,S)	(P,P)

Table 1: Prisoner's Dilemma matrix.

A typical game is such that a random number of agents is placed on a discrete grid, each with a fixed strategy. Each agent looks around its vision perimeter, choses a random neighbour within it, with whom it plays a PD game. Payoffs are added or subtracted to the agent's wealth accordingly and, if such wealth exceeds a given threshold, the agent can reproduce within its vision perimeter. The child will inherit the parent's strategy as well as a random portion of the parent's wealth (which is detracted from the parent's). Conversely, if an agent's wealth falls below zero, the agent dies.

Conceptual Blend

To exploit this game at an AV level the notion of conceptual blend can be useful. This comprises two input spaces (which ones wishes to integrate), a generic space (which contains all the elements in common), a cross-space mapping (which contains connections of identity, transformation or representation), and a blended space (which contains all the generic structures as well as some that might be impossible in the input spaces). The projection onto the *blendoid* is a selective, non-unique process. A simple diagram for conceptual integration is shown in Figure 1.

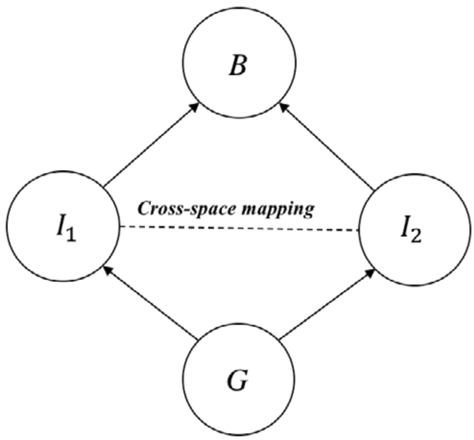

Figure 1: Conceptual blend. I1, I2: input spaces, G: generic space, B: blended space.

The chosen cross-space mapping is now described. Each agent is represented as a coloured square in a discrete grid. The colour indicates the agent's strategy: green for *cooperate*, red for *defect*, whereas the edge roundness is proportional to the wealth. Each agent is also endowed with a frequency modulation [3] process, where the carrier frequency is proportional to a fundamental frequency and the agent's position on the grid. Each agent is thus a sound source and it is spatialised using binaural panning. The fundamental frequency is different depending on the agent's strategy. Defectors have a granular, noisy sound texture, whereas co-operators are partials of a harmonic texture which is richer as their number grows. This basic mapping was the first step of an ongoing exploratory process and, despite its simplicity, was able to render the population dynamics of the DPD.

POPULATION DYNAMICS

There can be many variations of the game and therefore of the population dynamics. These can be achieved by introducing changes to the properties of the agents. For example, agents might have (in addition to wealth and vision) the following parameters: maximum age and strategy mutation. The simplest version is such that each agent can live on indefinitely and its (eventual) offspring inherits its pure strategy with zero probability of mutation. In the simulations of this version, cooperation started to emerge around the 50th iteration. In the subsequent version of the game, a maximum age is set for all players. Above this threshold, an agent dies regardless of its wealth. Age is mapped to transparency, so that the older the agents becomes, the more transparent is shown. In this version, convergence towards cooperation seemed to emerge much sooner, around the 30th iteration. In addition to the maximum age, a third version introduces a probability that during reproduction the offspring of an agent might mutate strategy. This is the version of DPD where one can observe more variance in the population's behaviour. In the epochs shown in Figure 2, the mutation probability was set to a value of 0.5, however, this probability value can be explored heuristically, to one's liking.

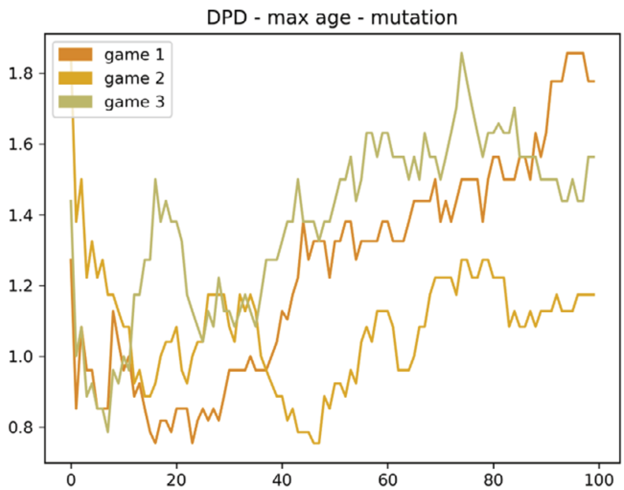

Figure 2: A plot of the co-operators/defectors ratio in three games of a maximum age, strategy mutation DPD.

Beyond the effectiveness of the AV display as an aid to understanding the population dynamics of the DPD, the cross-space mapping needs to be considered further, since it is a crucial factor for obtaining aesthetically pleasing results.

AESTHETIC CONSIDERATIONS

While the AV DPD described so far is sufficient to visualise and sonify the game's evolutionary process, it is evident that the aesthetic result at a visual level falls short to being palatable (see Figure 3). To this end, it is useful to investigate further the notion of aesthetics, and in particular of computational aesthetics.

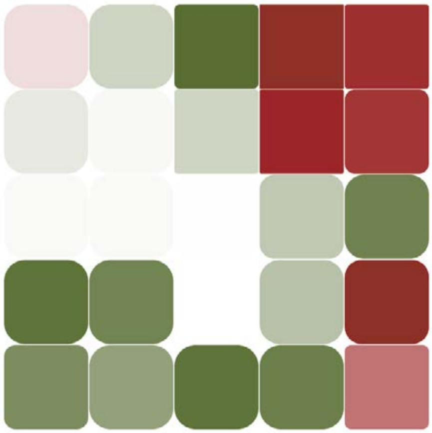

Figure 3: A snapshot of a maximum age, no mutation DPD iteration.

Computational Aesthetics

Computational aesthetics is thought of as he theory, practice and applications of aesthetics in computing, however it has different connotations depending on the objectives and beliefs of who is considering it. For example, it "has been appropriated by engineers to mean the automated evaluation of image quality, by critics to mean the distinctive material genres of computer arts, and by technologists to mean specific programming technologies" [2]. Computational aesthetics often involve assumptions on universal notions of beauty, thus becoming liable of critical enquiry. This is because the broader field of aesthetics has developed beyond the theory of taste and beauty [9, 10], or of the philosophy of fine art [8], to include philosophy of criticism [1], art as experience [4] and pragmatist aesthetics [13]. It is unfortunate that the notion of aesthetics in computer science seems to have developed independently from that in philosophy of the arts.

There are two main perspectives on computational aesthetics. While one investigates the value that computational processes or products have with respect to a human-centered notion of beauty, the other examines what it means for a computational system to be able to evaluate its own process and output. Thus, the latter is linked to some sort of machine meta-aesthetics. To this end, several aesthetics measures have been proposed and implemented in the computational domain, for example automated fitness functions or evaluation metrics based on loss functions. More in detail, these aesthetic measures can be broadly categorised into information and complexity based, geometric and fractal, psychological, biologically inspired and neuroscience based. Given the scope of this paper, the reader is referred to [7] for a comprehensive survey of these measures and the methods used to implement them. We now turn to the perspective more akin to an aesthetics of digital arts, and how the AV DPD meets or violates the author's goals and desires.

AESTHETIC DYNAMICS

To negotiate with the author's aesthetic aspirational levels, a process of variation in the cross-space mapping was initiated. Given the exploratory nature of this endeavour, what is described below is only an initial step towards artistic speculations of the AV DPD. In line with the minimalist and meditative result at the sonic level (a continuously morphing harmonic texture where different partials are enhanced or suppressed based on the population's behaviour), the colour gamma was dramatically reduced. Co-operators, defectors and background (empty nodes in the grid) were thus associated with very similar colours. Furthermore, the active cells of the grid were rendered with a varying stroke weight and spacing, proportionally to the wealth of the agents. The result can be seen in Figure 4.

The main motivation behind these choices in the cross-space mapping was to arrive at smoother and more homogeneous results. While these changes were minimal, the results attained represented a step forward in meeting the author's aesthetic expectations, and the system's output can be considered sufficiently satisfactory.

Figure 4: A visual variation on the DPD theme.

DISCUSSION AND FUTURE DIRECTIONS

In implementing suitable conceptual blends between evolutionary games and AV works the role of cross-space mapping is paramount. This is also the crux of other processes related to visual or auditory display, e.g., sonification of data. While it is unreasonable to seek aesthetic universals, it is important to set individual aspiration levels and to maintain a dialogical process of continuous negotiation between the system's designer and the computational process and output.

Future work in this direction will likely involve further exploration of the cross-space mapping, and of the evolutionary scope. Agents' properties, for example, could include more rules of behaviours, akin to cellular automata (e.g., The Game of Life) or a more varied visual (e.g., tints of colour) or sonic (e.g., oscillator type, audio parameters) character. Thanks to some of these variations, the AV process and result could become arbitrarily complex, in order to meet the designer's criteria and objectives.

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ELECTRICAL NETWORKS AS MEDIA: POST-HUMANIST MEDIA ARCHAEOLOGICAL ANALYSIS OF THE DIGITALIZATION OF ELECTRIC NETWORKS

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Abstract

In this paper we conduct post-humanist media archaeological analysis of electrical network as media and investigate the digitalization of electrical network in one city. We present the cultural and historical contexts of the digitalization of electric networks, and argue that understanding the cultural and historical context of the digitalization of electrical networks is important especially when media archaeological theory seeks to understand the role of new ICT technologies used in our basic infrastructure.

INTRODUCTION

Media and administration both store, process and calculate information. In order to function, cities and administration also need hidden infrastructure, something that is now sometimes called the "grey media" or "logistical media". In this paper we analyse electrical networks as media and provide an overview of the historical and cultural context of their digitalization. Electrical networks, sometimes also called as power grids, electric grids or electricity distribution networks are basic infrastructure of our society. Our approach to their analysis is post-humanist media archaeology. It was Foucault who shifted the emphasis from archives as dusty places where historians do research into more abstract conditions of knowledge. The technological dimension gained momentum informatics and in the so-called German media theory that has since then became successful German intellectual export. Media archeologist approaches the media technological assemblages both as an ethnographer who observes the interaction between humans and media and as an amateur engineer who experiments to learn how media technologies function as *Kulturtechniken* of information society.

We mobilize media archaeology into an analysis of the media technologies of socio-cultural memory, analysis of the technical media infrastructures and associated the discourse networks comprising both human and non-human elements. Thus, our post-humanist media archeology is not limited to the archive or simple analysis of the traditional storage media. Instead, we focus on technologies of our media culture, its basic infrastructure and ultimately how media organises information in time. Our case is media archaeological overview of the electrical network of one Finnish city called Rovaniemi located in the Finnish Lapland, where publicly owned private entity called NEVE Ltd. provides and maintains services related to infrastructure, digitalisation and circular economy. We start our media archaeological overview by presenting cultural and historical contexts of power networks as media and the digitalization of electric networks. Our analysis is based on media archaeological theory, historical documents, and ethnographic field research conducted in 2018.

We focus on digitalization of electric networks because we want to see media history through ruptures. As a concept, digitalisation has been utilized to refer to the process where many areas of life are integrated into digital ICT-infrastructures. In theoretical debates digitalisation is often related to the questions regarding the role of information. In this case digitalisation changed the nature of electric networks from media archaeological perspective. Our main research question is: How digitalization has changed the electric networks from the perspective of media archaeological theory?

Electrical networks as media

This paper deals electrical networks through an engagement with media archaeological theory. We draw from media archaeological theory to better understand the digitalization process of electrical networks. The value of contemporary media archaeological theory is that it pays increased attention to the hidden technological infrastructure not commonly viewed as media. This allows to analyze technological infrastructures, devices and techniques surrounding us in their media cultural context.

For us the most profound media theory in this paper emerged especially in Canada and West Germany after the Second World War. It was Harrold Innis [6] who understood the importance of infrastructure for media research and insisted that technical infrastructure should be at the heart of media theory. Another Canadian Marshal McLuhan [15] then popularised media studies that focuses on analysing how communication technologies are key agents in social and historical change. These media theoretical insights together with ideas from information theory and genealogical philosophical understanding were then picked up in West Germany. This led to the emergence of the so-called German media theory that soon became intellectual export. These classical media theories emerged as part of generation of other thinkers and reflection of political, technological, economical and media in that period.

Kittler [8] wrote that the focus in media archaeology is on the “networks of technologies and institutions that allow a given culture to select, store, and process relevant data.” For Kittler, culture was already a procedure of data processing [1], and media were cultural techniques that allowed to select, store, and produce data and signals [14]. The production sites of data discourse networks emerge with technological media. They contain technological and institutional elements and can be analyzed by practicing technological media analysis that focuses on the operations of media structures in data processing – what Krämer [14] calls “the material ‘carriers’ of information”. In the context of mobile phones, which used to be very important field of industry in Finland, we could ask, what have been the forms of material carriers of information in mobile phones in the historical and cultural perspective and what could we learn from it in relation to media archaeology theories.

Kittler [9] seen networks of information in our basic infrastructure. Because cities have been "traversed and connected by a network of innumerable networks", that regardless of conveying primarily information or energy, are all information, "if only because every modern stream of energy needs a parallel control network" (ibid., 718). When taking this logic to the end, cities are media because they calculate, store, and transmit information, and this was the basic definition of media for Kittler [9]. It is maybe evident that networks process, transmit and store information, but according to Kittler [9] this suffices to calculate all that is calculable. In other words, commands, addresses, and data make media abstract Turing machines, where the neural network based artificial intellectual deep learning algorithms hiddenly operates.

In *Literature, Media, Information Systems* Kittler [10] points out that data processing is the process by which temporal order becomes moveable and reversible in the experience of space. This means that data processing for Kittler, storing is connected to spatial order, materializing a temporal process in a spatial structure [14]. It is the spatialization that enables media to capture temporal events [13]. In addition to Kittler it has been Wolfgang Ernst who has continued the analysis of timing mechanisms and time-giving technologies of technical media in German media theory. Ernst [3] argues that the essence of technical media is revealed in the processuality of temporal operations, resulting in timing (machine) agencies.

Ernst's discussion also moors the analysis of *Kulturtechniken* alongside media archaeology. According to Huhtamo & Parikka [5], media archaeology more like "a bundle of closely related approaches", with a joint interest in the archaeological dimension of media technologies and media culture. For Ernst [2] the archive is a medium: "an economic place for symbol circulation, where a given present derived from numerous channels ("tradition," "the past") comes to light, to create a product called memory". Media-memory archaeology then analyses what can be stored and transmitted in the apparatus that overplays the subject, writing about them transitively [16]. Ernst [2] concludes that now when all information may be stored, cyberspace is not only space but much more a topological configuration, where the storage procedures for multimedial space and the "anarchival signature " is on display for media archaeologist.

Ernst [3] summons that the concept of smart grid makes the electrical distribution network reactive in time-critical domain, allowing controllable logistical distribution is space and time. The basis of the time responses is now, like Ernst reminds us, the "immediate knowledge of the network itself". In practise, in case of electrical network interference digital time with 0 and 1 standstill there is no information flow, and not possibility for time manipulation, only immediate knowledge of the network exists. When the bits start to move and transfer data the time-space manipulation become possible. In 2007 electrical network in the whole city of Rovaniemi stopped for a few hours. The electrical network was not able to calculate, store, and transmit information. This practical case shows how central role electrical networks have as a media via communicating and transmitting information. Media now is broadly theorised as "assemblages or constellations of certain technologies, fields of knowledge, and social institutions" [4].

In this paper we conceptualise the electrical networks as media; the main means of electrical networks as media communicate with the information society enlarge. The electrical networks and its infrastructure have fundamental communicative, informative and mobility role in modern digitalized world. Electrical networks are the platforms for organising information in our society. From the perspective of cultural history electrical networks, where the energy of charged elementary particles are formed, has been perceptualized as solid objects that could be seen and touched. However, digitalization has transformed electrical networks to invisible forms and fields of information, where electrical networks as media, as presented earlier, direct, transform, and in particularly illustrated dynamic change movements of our society. This makes media such as basic infrastructure an assemblage of associated technologies, fields of information and social institutions that maintain it.

Digitalisation of electrical networks in cultural and historical context

The historical and cultural overview of context of the electrical networks as media and their digitalization are investigated by illustrating from 100 years period of history electric network in the city of Rovaniemi located in the Finnish Lapland. The Imperial Senate ordered on October 21st in 1901 that the municipality of Rovaniemi should create new land use and building decrees for densely populated areas. This formed the legal basis of building electric networks in the city area by providing autonomy that was the beginning point of electrical networks in the city of Rovaniemi. Electricity distribution in city of Rovaniemi began 1914. First there was 1000 pieces of lamps connected to electrical network by individual citizens and on May 25th, 1914 there was 38 street lamps installed to the city. At the end of the year 1914 flux consumption was 1300,88 kilowatt-hour. In 1925 there was already 7259 lamps in the compact city of Rovaniemi. In 1940 the demand for electricity per year was already 4 million kilowatt-hour. [7]

In 1944, near the end of the Second World War, almost complete destruction of the city Rovaniemi in the phase 4 of the operation *Birke* ("Birke zerkleinern") demolished the electrical infrastructure of the city. The decades after the war were the decades of rebuilding, development and rising the standards of living. In 1950 electricity volume increased fivefold and demand for electricity in 1960 was three times higher than 1950. In both the 70s and 80s, the volume of electricity distribution doubled. In the 90s the electricity consumption has been increasing somewhat slower. The digitalization history in electrical networks also modify concepts in theoretical and practical level. In 2000 the electrical networks in Rovaniemi commenced to be described as smart grids, where data transition, digital processing of applications and information management via user interfaces occurred. The interfaces within the tens of applications in NEVE Ltd. were built to be able to control data flow, network security ja information. In digitalization process electronical networks, the role of information management and organization in time has become core. Operational manager at NEVE Ltd. describes digitalisation process in practical level:

> Until the year 1986, all the machineries in electronical network were manual. First phase to digitalisation process was so called Procol-measurements equipment, which functioned via telephone networks and were used to boundary point measurements. Second phase was in year 1995, when the electrical meters were measured via computer data networks. However, only the biggest electrical consumers were measured via network. In 2012 all the kWh electrical meters were read remotely via radio/telephone network. In this phase, in addition to kWh consumption also, the data from malfunctions of low voltage interference alerts was transferred remotely and could be analysed from graphical user interface. (…) Also, the security of electronical networks increased in 2000 and the science of cryptology become more and more important. In electrical networks, the machines can be programmed the proper security level. Regarding to maintenance, the sensors in electrical network transfer data for malfunctions. Electrical network is quite stable, there is only 50 malfunctions cased per year. (Interview of the operational manager)

Operational manager highlights the role of measuring electricity consumption remotely and the role of ICT in risk management. However, some of the people encountered during in the field during our ethnographic research also reflected the broader role of the electric networks. The chief of the digital business services in NEVE Ltd describes the implications of digitalization for the electric network:

> In practice, in second millennium electronic networks were started to see as part of media, information and communication technology. NEVE Ltd. [Rovaniemi energy corporation] own local area networks via ethernet cables that were provided for citizen in Rovaniemi first time in 2018. The electronic networks were seen as a new form of media inside and outside the energy corporation, where in LAN-networks different applications, massive data flows, security and information and communication technology were organizing information in time. The new era of digitalization has become. [...] The most important thing is to control complex information flows in local area networks. (Interview of the chief of the digital business services)

Much of the work that has been going on in electric network digitalization, also substation and distribution automation, is now included in the general concept of the smart grid. In the following picture engineer is operating the electrical substation before digitalization (see picture 1.). In the digitalized system the same information can be seen in digital user interface (figure 1.). This illustrates the cultural and historical shift caused by the digitalisation.

Picture 1. Pekka Kauppinen, Chief Operating Officer of the electrical substation operating VII sa in physical form in the 70's. (located in Viirinkangas)

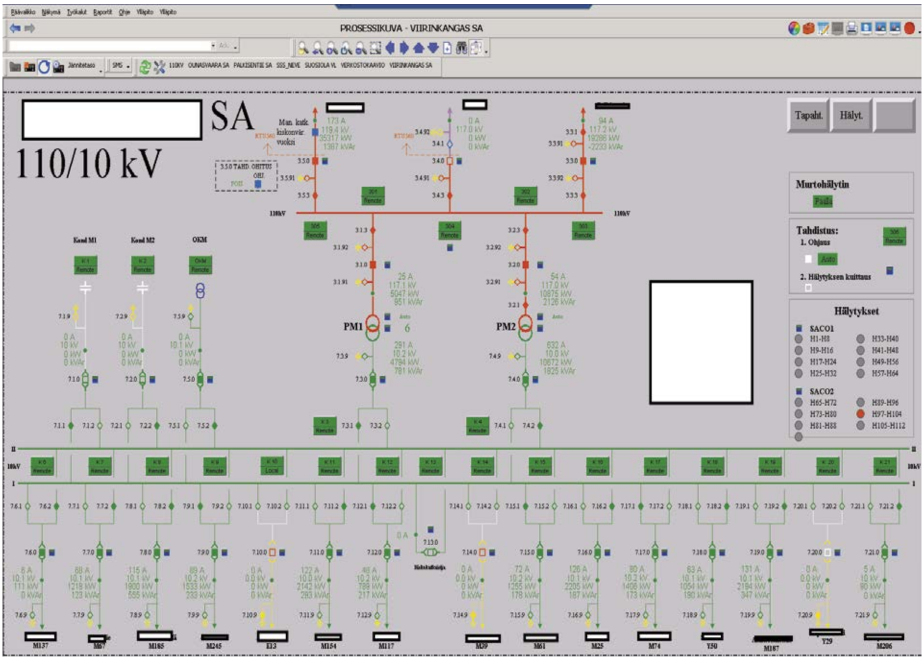

Figure 1. Electrical substation in digital user interface 2018 (located in NEVE Ltd's main building)

Rovaniemi energy corporation own local area networks via ethernet cables were provided for citizen in Rovaniemi first time in 2018. This illustrates that the digital transformation of the basic infrastructure like the electrical network can be arduous and slow. Based on our analysis, in our study the electrical networks is seen as *medius,* within its intermediate functions in IoT network. The electrical networks as media shall more and more organize the information in time in our society, in which we have become reliant.

CONCLUSION

Electrical networks have slowly been digitalized. They serve as our basic infrastructure and as media communicate with the information society enlarge. There have been ideological debates concerning the role private sector in the maintenance of basic infrastructure in monopolistic situation that guarantees steady dividend payments for the investors. Nevertheless, we often notice and pay attention to the communicative nature of our basic infrastructure when the technology breaks. When there is no electricity the urban mobility soon becomes very complicated and logistic systems of contemporary economy halts. Especially in the urban settings digitalization not only allows possibilities for diagnostics that helps in maintenance, but also communicates with the human agency and other technical systems that consume electricity.

The benefits of analyzing the digitalization of electrical networks as media is that media theoretical approach reveals the role of hidden infrastructure and highlights its communicative function. Like Durham Peters (2015, 4) observes, “[d]igital devices invite us to think of media as environmental, as part of the habitat, and not just as semiotic inputs into people’s heads.“ This environmental view of the media is in the heart of the smart city thinking, “where data is no longer produced through statistical apparatus” but instead with networks dedicated to capturing data often using space technology “that are an advanced and geostationary stage of exosomatization, more or less specialized, functioning as relays for networks of all kinds” [18]. Building and digitalising basic infrastructure is resource-intensive and can take time, and in our post-humanistic media archaeological study we have not only analyzed the electrical networks as material remains of human life and activities, but described the cultural historical of digital transformation of electrical networks as media. This environmental view of the media is vital when media archaeological theory seeks to understand the role of new ICT technologies used in our basic infrastructure.

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NEW SCIENCE AND CULTURE DEVELOPMENTS & APPLICATIONS

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"IT'S TIME TO GIVE BACK" (O3 LAB)

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Abstract – In order to still be able to induce emotions and to increases people's awareness, artistic production evolves. In our complex and liquid world, multidisciplinary and technology innovations are part of this transformation. From the experience of the multidisciplinary artistic group O3LAB, we created "It's time to give back", an installation that addresses the problem of ecology using media and video art and interaction design.

INTRODUCTION

In last decades technological and economical innovations led to some important consequences in the way we behave. We live in complex and *liquid world* (Bauman, 2000). In this complexity we are discovering that solutions to problems require to have a broad knowledge to address all the facets and to evaluate all the consequence. However, on the other side, we are going towards a professional hyper specialization. This brings the need of a continuous interaction between disciplines: at all levels more and more organizations discover the importance to adopt multidisciplinary working teams (Agile Paradigm).

Technology is one of the fundamental actors of the human evolution since nowadays it has a great role in our daily life: among the other effects, it deeply transformed the way we communicate, and we build relations.

In this scenario, how has the artistic production changed, or is changing? How can art still induce emotions and increases people's awareness? How can art still be the "lie that reveals the truth"? To find the answers to these questions is a hard task, but we highly believe that interdisciplinary (Ian Heywood, 2012) and the adoption of technology not at support to the creative process, but into the creative process (Alexenberg, 2011) are two of the key elements in the transformation process for the present and the future in artistic production.

In support to this vision, we founded O3LAB, which is an artistic group composed by technologists and artists in different disciplines. O3LAB created "It's time to give back", an installation that addresses the problem of ecology. The installation is divided into two distinct sections: a video (in loop) and an interactive installation. The video is an accusation of our lack of interest to the environment, we have little time to change (maybe we do not have any more time) and therefore "it's time to give back" what we took from nature. Following we show some frames of the video.





The interactive installation attempts to push the attenders to think at the need to move to action through and embodiment paradigm thanks to interaction design techniques.

“GIVE IT BACK” AN INTERACTIVE INSTALLATION

Ecology is one of the most on-the-spot and controversial problems that involves the entire world at different levels. It is controversial for several reasons. Among them we believe that two specific aspects have an important role:

- **do not exists a unique single solution** – do not exists a unique solution to the problem, more likely the solution will be the consequence of our personal positive or negative actions

- **slow changes** - the effect of our personal positive or negative actions have only a small impact on the entire system, but the contribute of a mass of people can be highly be visible after some time of constant contribute

“Give it back” is an artistic installation through which attenders can interact with the artistic subject. The interaction paradigm allows people to make a personal and immersive experience that, through the embodiment paradigm, drive them to go in deep into the ecological problem and to increase the awareness of the need of a personal contribute.

The main subject of the installation is a virtual tree that evolves as long as the visitors interact with it. At the beginning the tree is presented as bare and dry. Through and interaction process the attenders have the change to contribute to reflourish it. Figure 1 shows the virtual tree in three stages of its evolution: the bare and dry tree at the beginning, a semi-reflourished tree and the reflourished tree.

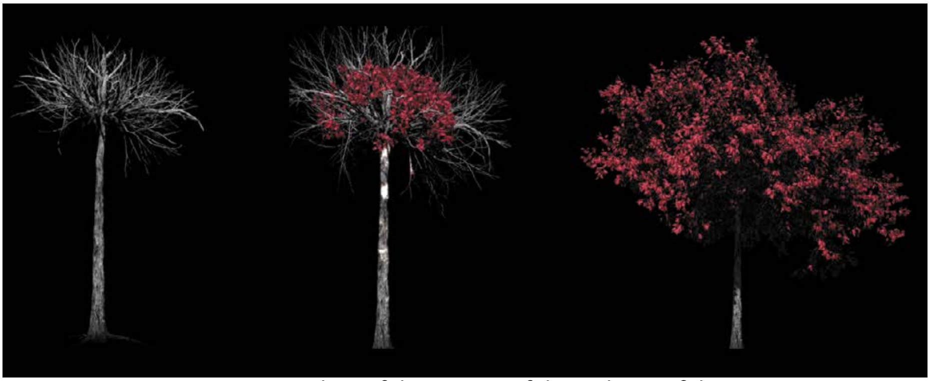

Figure 1 – Snapshots of three stages of the evolution of the tree

The visitors, one at the time, through specific gestures are able to generate an animated virtual drop of water that will appear on the same projection plane of the tree (Figure 2).

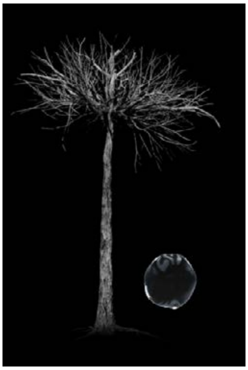

Figure 2 – Virtual drop of water

Once the drop is generated, its movements will be synchronized with the visitor’s hand movements and the visitor will be able to move it through the screen. A vertical movement of the hand in the space corresponds to a proportional vertical movement of the drop and a horizontal movement of the hand in the space corresponds to a proportional horizontal movement of the drop on the screen. With a forward movement of the hand, the user will be allowed to feed the tree bringing it the drop of water. Once the action is complete some few leaves will grow on the tree.

The interaction is design in order to embody the two aforementioned elements (*do not exists a unique single solution* and *slow changes*):

- Each one is allowed to concretely feed the tree. This is to underline that each one can contribute through a concrete action.
- The attenders need to understand how to give their contributes through the systems, indeed no instructions are given so that each one can discover how to interact with the tree. This is to underline that each one needs to find their way to provide a contribute to solve the problem.
- The attenders are free to choose if they want or not to give the contribute, they are allowed to just play with the drop without feed the tree. This is a metaphoric way to express that each one is free to choose if he/she wants to provide his/her own contribute or not.
- The attenders are free to choose the number of contributes, this is to underline that we are free to choose how much we would like to be involved in the problem.
- Each contribute has a visible but small effect on the re-flourishing process. Just few leaves will appear at each contribute, this is to underline the slow changes issue.

We realized "Give it back" for the first time at the **5°Creativity and Design Week in Chengdu** (China) in a dedicate booth shared with External Reference Architects[1] and Sporph. In Figure 3 we show an overall picture of the interactive installation: it is well visible the projection of the tree and the drop and the sensor used for the hand tracking. Figure 4 shows an overall view of the installation into the dedicated booth. The projection of the tree occupies the entire bottom wall of the booth.

Figure 3 - View of the interaction paradigm

Figure 4 - Overall view of the interactive installation in the booth

[1] http://externalreference.com

TECHNICAL SETUP

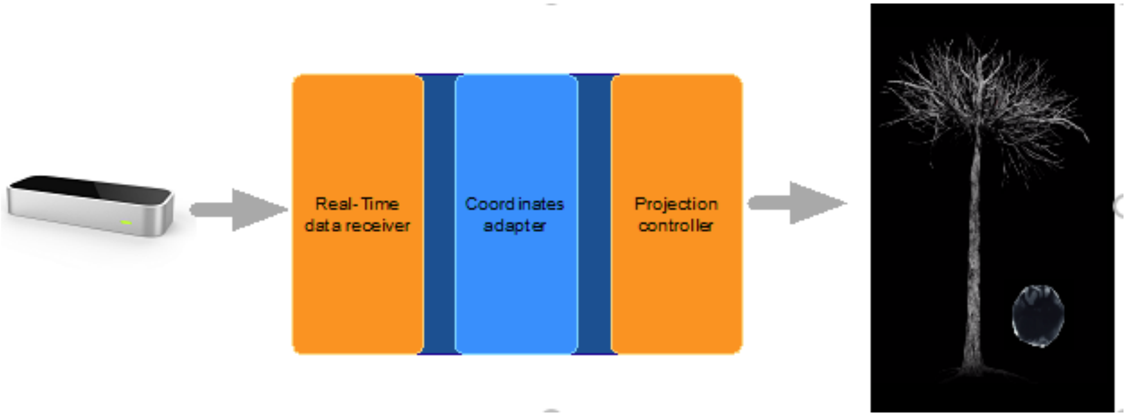

Figure 5 –Overall schema of the system

Figure 5 shows the overall schema of the system. Two are the main components: the projection and the tracking system used for the interaction.

As far as projection is concerned it consists of two layers projection. The first layer concerns the tree and the second concerns the drop. It is interesting to mention that the tree has been modeled by using the 3d modeling software SpeedTree[2] mainly used in movies and games industries.

The interaction system is based on the tracking of the hand of the attenders. It is realized through a Leap Motion hand tracking system[3] placed in front to the projection as shown in Figure 3.

Leap Motion controller, through two cameras and three infrared LEDs, is able to provide a 3D reconstruction of the skeleton of the human hands (Figure 6). The system allows to track various joints and output the positions and the rotation for each one of them. The controller is able to acquire data at 60 fps as the frequency rate.

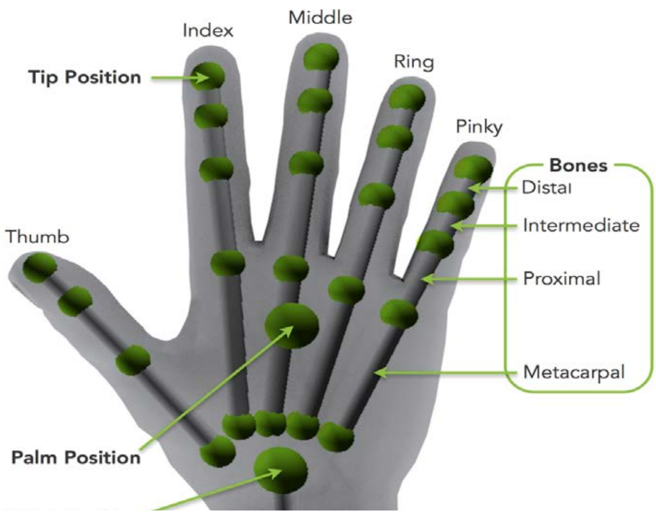

Figure 6 – Skeleton of the hand reconstructed by the Leap Motion controller

The high data acquisition sample rate and high data transmission rate guarantee the real-time experience to the users that do not perceive any temporal lags from the movement of their hand and the movement of the drop on the screen. This is also guaranteed by the optimized.

Each time it receives now data from the Leap motion controller related to each joint, the *coordinates adapter* software infers the average position of the hand and transposes it from the spacial coordinate system adopted by the controller to the coordinate system adopted for the screen projection.

The software has been implemented using OpenFramework, a C++ framework for media art and interaction design. The C++ language is suitable for applications were low computational time is required. Our software has been also optimized to guarantee the real-time interaction.

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A BLOCKCHAIN-BASED SUPPORT TO SAFEGUARDING THE CULTURAL HERITAGE

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Abstract – Public administrations need digital archives that are typically maintained as centralized repositories or databases. This solution constitutes a security and trust single-point-of-failure. We have faced with these issues in the case of digitalization of the General Catalogue for Cultural Heritage which gives support to promotion and safeguard of the Italian national heritage. In this work we propose a *blockchain-based architecture* for that digital archive that guarantees security and availability in a decentralized, efficient and cost-effective way. Furthermore, the architecture gives the chance to restore the catalogue contents in a tamper-proof way.

I. INTRODUCTION

Public authorities collect and use a large amount of information in the form of *digital archives* which are mostly implemented as *centralized* systems. In case of a collection of structured, interrelated data, a digital archive is maintained as a *database*.

Centralization raises several security issues. First of all, it implies that customers trust organizations to effectively keep data secure. At the same time, it makes public authorities prone to attacks because it is the authority itself that controls the archive. Furthermore, a centralized database system represents a single-point-of-failure. This was particularly common in Web 1.0, where entities setting up their own servers. Things did not get much better in Web 2.0. Cloud providers offer cheap, sometimes even free, scalable database services (DBaaS), but scalability and fault-tolerance come at the cost of providers' owning the content, profiling users and collecting huge amount of data about user activity.

We faced with the above issues when we considered the "*Catalogo Generale dei Beni Culturali*" (General Catalogue for Cultural Heritage), hereafter the "catalogue", under the control of the *Ministry of Cultural Heritage and Activities and Tourism* [8]. This database plays a significant role in the spreading of knowledge and in the promotion of the Italian national heritage. Furthermore, it contributes to manage crimes and natural disasters that may affect the national heritage.

In this work we propose a *blockchain-based architecture* for the catalogue. For performance and cost reasons, we also adopted an *off-chain data storage* strategy.

There are several reasons for overall solution. First, it is architecturally and politically *decentralized*, so overcoming the security and trust issues previously mentioned. In addition, it is *secure* as it ensures *integrity*, *long-term data availability* and *authenticity*. In order to guarantee some degree of *privacy*, data is also encrypted, whenever required, at the application level. The properties we have just presented are of paramount importance for the catalogue. It is important to outline that the proposed solution gives also the chance to *restore* the catalogue contents, as needed, with the guarantee that data has not been tampered with. Finally, the solution is also *efficient*, both from an economic and performance viewpoint.

The remainder of the paper is organized as follows: in Section II we discuss related work. In

Section III we introduce the catalogue and explain the way we created a (reduced-size) clone. In Section IV we describe the proposed solution. In Section V we present an early prototype. In Section VI we evaluate the cost of our solution. Finally, Section VII concludes the paper.

II. RELATED WORK

The problem of managing records through a blockchain has been largely investigated during the last few years. In her paper, Lemieux proposes a classification of blockchain applications [1], based on which information is stored in the blockchain: a) *mirror type*, b) *digital record type*, c) *tokenized type*.

In the mirror type, the blockchain serves as a mirror, which stores only records fingerprints. The complete information of a record is stored into an external repository and the blockchain is used only to verify records integrity. In [2] the authors describe a first implementation of a decentralized metadata database, based on the combination of the blockchain and IPFS technologies. In their paper Liang et. al. describe ProvChain [3], a system which guarantees data provenance in cloud environments. Vishwa et. al. [4] illustrate a blockchain-based framework, which guarantees copyright compliance of multimedia objects by means of smart contracts.

In the digital record type, the blockchain is used to store all the records in the form of smart contracts. In [5] the authors illustrate a distributed and tamper-proof framework for media. Each media is represented by a watermark, which is firstly compressed and then stored into a blockchain. Approved modifications to media are stored in the blockchain thus preventing tampering. In [6] the authors describe Archain, a blockchain-based archive system, which stores small-sized records. Multiple roles are defined in the system, thus allowing records creation, approval and removal.

In the tokenized type, records are stored in the blockchain and they are linked to a cryptocurrency. This constitutes an innovative case, where the literature is not consolidated yet. Adding, updating or removing a record has a cost. An example of this type of blockchain is represented by the Ubitquity Project [7], which records land transactions on behalf of companies and government agencies.

III. THE SAFEGUARDING OF THE CULTURAL HERITAGE

The General Catalogue for Cultural Heritage [8] is a centralized database system which collects data about Italian cultural assets. It responds to protection and promotion purposes of the national heritage by providing users with the knowledge of Italian cultural works**.**

The catalogue is aimed at identifying and describing all cultural objects for which a specific artistic, historical, archeological or anthropological interest has been recognized.

In particular, the catalogue allows to consult information related to thirty different typologies of cultural assets. Each typology is properly described by means of a specific standard, called "*scheda di catalogo*" (catalogue record), whose definition is led by the "*Central Institute for Cataloguing and Documentation*" (ICCD). In more general terms we can state that a catalogue record is basically a set of attributes which takes into account peculiarities and intrinsic key features of each typology of cultural object.

Around May 2016, the ICCD has launched a project, called *Openiccd* [9], which aims at sharing, among other things, raw data about cultural assets being catalogued. Open-data are available for each Italian region and refers to the following two *typologies*: "archeological exhibits" and "artworks".

Initially, for the sake of simplicity, we have limited ourself to the ICCD open-data related to exhibits and artworks of Tuscany which however amounts to 75.662 records with 51.977

images in the form of URLs and 46 attributes for each record.
In order to store these data, we chose a *NoSQL* database system. In particular, we selected the *Elasticsearch* "*document* store"-type database [10]. In Elasticsearch, any information item is stored into an *index* which is a collection of documents that have similar characteristics. Therefore, for the storage of Tuscany ICCD open-data we defined two indices, one for artworks and the other for exhibits. Before being stored into Elasticsearch, open-data have been parsed exactly as defined in related catalogue records.

IV. A *BLOCKCHAIN-BASED* ARCHITECTURE FOR THE SAFEGUARDING OF THE CULTURAL HERITAGE

With reference to Figure 1, the solution we propose assumes a frontend that allows principals to insert, edit, delete or search cultural assets. We assume these principals do not behave maliciously and thus are trustworthy. The designed architectural solution assumes also the following components: *Elasticsearch*, the *Ethereum blockchain* and the *InterPlanetary File System* (IPFS).
When the frontend issues a *search* operation, the execution of this operation only involves retrieving data stored in a specific Elasticsearch index. In contrast, in case of a *modifying operation*, i.e., an *insert*, *update* or *delete* operation, things are slightly more complicated. The operation is reflected on the local database, i.e., Elasticsearch which simply acts as a collector where information about cultural objects is stored and retrieved by. After that, the Ethereum blockchain [11] comes into play.
We have considered Ethereum because it is a public and Turing-complete blockchain. Furthermore, by means of an Ethereum smart contract, we let the catalogue operate programmatically without the need for ownership or control by a particular entity. In this sense, an ad-hoc designed Ethereum smart contract has been provided. The smart contract exposes a method which fulfils a twofold task: a) to check whether or not the operation has been issued by an *authorized trustworthy* principal; b) to store the *operation* and an *identifier* for the Elasticsearch index involved in the operation itself into the blockchain. As to point a), when a modifying operation is issued at the frontend, a principal is always required to sign an Ethereum transaction. When the transaction is signed, the smart contract method is invoked. At that time, authentication is performed. If the principal is indeed authorized, the operation and the identifier for the Elasticsearch index are stored into the blockchain. However, because Ethereum on-chain accounting has different limitations, namely, storage of data is really expensive and withdrawing data is relatively slow, the operation has actually been accounted *off-chain.*
Specifically, a *JSON object* encoding the operation and the related arguments, i.e. information about the item, is created. The JSON data-interchange format has been chosen because a document, the basic unit of information that can be indexed in Elasticsearch, is expressed in JSON. Off-chain means the JSON object being stored into the content addressed, versioned, peer-to-peer, distributed file system IPFS [12]. At that time, an *IPFS link* under the form of cryptographically secure digital digest is obtained and stored on-chain together with the identifier of the Elasticsearch index that gets modified.
The execution of a modifying operation takes place in six steps.

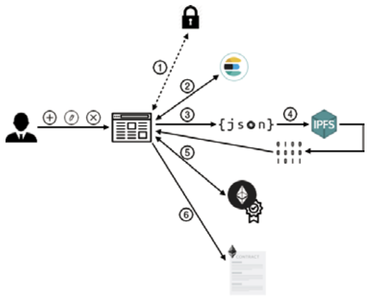

Figure 1 - Tasks carried out by the frontend in case of insert, update or delete operation; a dashed arrow indicates a conditional task.

1. If the modifying operation is either an insert or an update operation, the frontend may encrypt some of the information about the item as needed;

2. The frontend executes the operation on Elasticsearch. Moreover, the frontend keeps track of the specific Elasticsearch index involved in the operation.

3. The frontend creates a JSON object encoding the operation and the related arguments. In the case of an insert or update operation, the encoding complies with the rules defined in the item related catalogue record.

4. The frontend stores the JSON object into IPFS. IPFS returns an IPFS link to the frontend.

5. The frontend prompts the principal to sign an Ethereum transaction.

6. As soon as the transaction gets signed, the frontend invokes the Ethereum smart contract method. The method checks if the signer belongs to the authorized ones. If this is not indeed the case, the transaction is rejected. Otherwise the transaction continues and the following two pieces of data are stored into the Ethereum blockchain: a) the permanent and immutable IPFS link; b) the identifier specifying the Elasticsearch index involved in the operation (tracked at point 2).

Let's make some comments about our proposal. First, the proposed solution actually overcomes all the problems described in Section I. In particular, Ethereum guarantees the integrity of IPFS links and Elasticsearch identifiers while IPFS guarantees the integrity of JSON objects.

In addition to integrity, the solution provides also availability for two reasons. First, the IPFS infrastructure guarantees availability of JSON objects, provided the infrastructure is properly designed, that is its contents are replicated over many nodes. Second, Ethereum guarantees the availability of IPFS links.

Finally, it guarantees the authenticity of the catalogue. This is because the smart-contract has been conceived to allow *only authorized trustworthy* principals to issue modifying operations and thus generate and store IPFS links.

Actually, in designing a cost-efficient solution, we have gone far beyond the off-chain storage approach. When talking about costs, we implicitly refer to *gas*, that is the key mechanism underlying the security of Ethereum. In this respect, it is worth focusing on the smart contract implementation. As mentioned, the smart contract consists of just one method.

The method takes the IPFS link and the identifier as parameters in order to store them. To actually accomplish this task, we have enforced the body of the method to cause the Ethereum Virtual Machine (EVM) to *emit an event*. The specific event has also been provided within the smart-contract implementation. The arguments for the event call are indeed the IPFS link and the Elasticsearch index themselves.
In general, when an event is emitted, a *log* is generated. A log is a data structure which is available in the *receipt* associated to any transaction. We came up with the idea of storing IPFS links and identifiers into Ethereum logs, being a log the cheapest kind of storage. Furthermore, since generating it requires to pay (among other things) also 8 gas for each byte of data, we designed two complementary strategies. Data is actually intended as the arguments passed to the event. As previously mentioned, the arguments passed to the event are the IPFS link and the identifier. The first strategy enforces an IPFS link to always be converted from the default 46 *characters* base58 multihash encoding to a 32-bytes base16 encoding. This allows us to use a *bytes32* data type instead of a *string* datatype for the IPFS link. This requires less gas; hence it costs less.
As to the second strategy, instead, we let the data type for the identifier be an *uint8*, i.e. just 1-byte. The reason for using specifically an *uint8* is the following. In the most general case, we have just as many Elasticsearch indices as the number of possible typologies of cultural objects (30). A possible solution consists in defining a lookup table where typologies are the table keys while values are the identifiers codified by unsigned starting from 0. Using an *uint8* type for the identifier, which was more than the required, resulted also in saving gas.
To conclude, it is worth noting that the proposed solution gives also the chance to *restore* the catalogue contents wherever necessary. This may be actually required because forgeries, thefts, natural disasters or even because some nodes in the Elasticsearch cluster are faulty. In all such scenarios, there is a strong interest in finding out the last consistent state of all the cultural assets affected. In this respect, it is not appropriate or even not possible to exploit information about the items stored in Elasticsearch. This is because nodes may be compromised or crashed respectively. In the former case in particular there is no guarantee that information about the item has not been tampered.
The solution we propose overcomes this limitation. Moreover, having stored in an Ethereum log also the identifier for the specific Elasticsearch index involved in a modifying operation, we are actually able to restore only specific Elasticsearch indices, that is just specific typologies of cultural objects.
With reference to Figure 2, restoring an Elasticsearch index consists of the following steps:

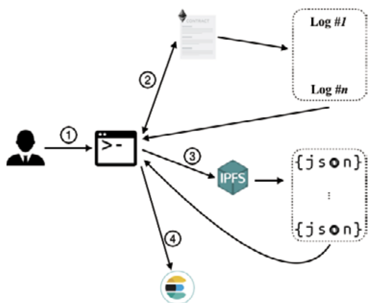

Figure 2 - Restore an Elasticsearch index. Overview.

1. The user specifies at the frontend which Elasticsearch index(indices) to restore, that is which typology(ies) of cultural object(s). The frontend exploits the lookup table in order to get the correspondent 1-byte identifier(s);

2. The frontend gathers Ethereum logs from the blockchain and filters them based on the value(s) of the identifier(s). To this aim, we have declared the identifier, in the smart contract event signature, with the reserved keyword "*indexed*";

3. For each gathered log, the frontend turns the 32-bytes IPFS link (stored inside the log itself) back into the base58 encoding. At that point, the frontend uses IPFS links in order to retrieve from IPFS the correspondent JSON objects;

4. Finally, the frontend executes operations encoded in retrieved JSON objects *exactly in the same order* they have been initially performed.

V. AN EARLY PROTOTYPE

We implemented an early prototype which comes in the form of an *Ethereum decentralized application*. Differently from the conceptual description in Section IV, the actual implementation of the backend code actually consists of *three* (3) smart contracts written in Solidity. They are three instead of one, because each one provides exactly one of the functionalities described in Section IV. This is a typical approach so as to provide modularity.

A smart contract named "*AccessRestriction*" allows only *an authorized* principal, i.e. the creator of the smart-contract itself, to store IPFS links and identifiers. We have adopted this behavior, instead of a whitelist of authorized principals, just for the sake of the prototype itself. To this aim, the contract implements a "*restriction access*" pattern by means of an "*onlyOwner*" Solidity function modifier.

The "*CulturalGood*" smart contract actually encodes the business logic of the application.

Finally, another contract called "*Mortal*", which inherits from *AccessRestriction*, accounts for the specific need of removing the code and storage from the blockchain. This may be required for whatever reason, at a point in time. Actually, the *CulturalGood* contract inherits from *Mortal*, which in turn inherits from *AccessRestriction*, hence it actually provides both the two functionalities previously described.

The backend code has been deployed and run on a *private* and *local* Ethereum blockchain named "*ganache-cli*". With respect to the client side, instead, we implemented the frontend as a Web application running on Google Chrome. The Web application is written in HTML5, CSS3 and JavaScript. The jQuery library has also been used.

The next component is "*Metamask*". It allows us to connect, from within the Google Chrome browser, to the custom RPC endpoint exposed by ganache-cli. In this way, it is possible to import ganache-cli defined accounts and sign transactions. The last two components are the IPFS service and the Elasticsearch service.

The prototype we just presented has been deployed within a *containerized* dev-environment with *Docker* [13]. Specifically, a *multi-container* Docker application has been built.

VI. COST EVALUATION

To evaluate the cost of our solution we need to consider two costs: a) the cost for the deployment of the *CulturalGood* smart contract, and, b) the cost related to insert, update or delete operations.

With respect to the first cost, the *contract creation transaction* accounts for 289154 gas. The latter is due to the cost of several EVM operations that the transaction affects.

The cost for the contract deployment has been evaluated on 16 October 2018. Specifically,

considering a gas price equals to 10 Gwei (< 2 minutes confirmation time) and the exchange at that specific time (1 ETH = 183 EUR), the actual cost for the contract deployment was approximately EUR 0,53.
As to the operations cost, instead, when a new cultural object is inserted, or when an existing one is altered or deleted, as we already mentioned, the user gets prompted with a (Metamask) notification in order to sign the transaction. When the transaction gets signed, it is then broadcasted. Broadcasting the transaction causes the *CulturalGood* smart contract method to be invoked. The function call once compiled into transaction data, calldata, accounts for 68 bytes overall. The first 4 bytes represent the method's signature followed by parameters in chunks of 32 bytes. In our case, the parameters are such that the first 32 bytes encode the IPFS link whereas the subsequent encode the identifier. Whatever the operation performed, calldata is such that the method's signature is always the same, what can vary are only the parameters. In the *worst case*, in terms of gas consumption, we end up with only 31 bytes out of 68 being zero. These corresponds to the 31 most significant bytes of the identifier.
So, we can compute the upper bound of the amount of gas to pay. It turned out that, in the *worst case*, the transaction accounts for 25642 gas. Following the same reasoning as above, the cost for storing *within a log* an IPFS link (32 bytes) and an identifier (1 byte), in the *worst-case* amounted to EUR 0,047.
It is worth noting that costs we have just presented refer *to the prototype implementation*. In practice, in order to allow a whitelist of authorized principals the costs will be higher.
Finally, the actual *overall* cost will depend on the number of insert, update and delete operations that will be performed over time. In this regard, we try to give an *estimate* based on both the information available in last ICCD public survey [14] (2011) and the total number of cultural assets actually stored (~ 2,7 Million). According to the just mentioned, every eight years roughly 1,35 Million cultural assets get indexed. If we suppose the same for the next eight years (2019-2026), i.e. *considering only insert operations* (plus considering the same exchange rate as before), the cost to pay will be EUR 63.450.
The ICCD survey also presents the total expenditure for cataloguing from 2002 to 2009. This amounted to EUR 12.495.757. The *estimate* of EUR 63.450 actually accounts only for 0.5% of that cost. If we consider the additional value provided by the solution, it may be worthwhile for the ICCD bearing this cost.

VII. CONCLUSIONS & FUTURE WORKS

In this work, we have described a blockchain-based architecture for the safeguarding of the cultural heritage. The proposed solution is decentralised, secure and efficient, both from an economic and performance viewpoint. The solution also allows to restore the catalogue contents in a tamper-proof manner where necessary.
Finally, it is right to note that in our prototype JSON objects are supplied to one single IPFS node only. Even if data cannot get garbage collected, since automatically pinned after being added to IPFS, we still have data on one single IPFS node. In order to improve the data redundancy, for the reasons outlined in Section IV, one possible enhancement may be keeping several IPFS nodes online pinning the data. The more the IPFS nodes pinning content, the better the redundancy.
In this respect, there are some tools being developed which can help in sharing the costs of bandwidth and disk-storage. Among all possible implementations *IPFS Cluster* seems to be the most promising. One possible future work may involve designing a solution of this kind. Another possible future work may involve designing a solution in which a whitelist of authorized trustworthy principals is allowed to store IPFS links and identifiers.

ACKNOWLEDGEMENTS

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EDUCATE TO WELLNESS BY THE EMOTION OF LIGHT

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The light in addition to being the factor that most influences the human perception, makes a leading wellbeing role in everyday life. Learning about relationships, influenced by the light, amongst emotions and behaviors, is a relevant investigation to stimulate applications and projects that can help us to improve the health and emotional status. Through mental processes related to our individual experiences, we attribute to light the ability to make more familiar the environment that hosts us. Feeling at ease in a place, it depends much of our relationship with light. The perception of the visible that enables us to understand and interact comfortably with everything that surrounds us, taking, even unconsciously, the well-being from the pleasure to be a part of *that* place and to appreciate its characteristics without efforts: the niceness of enjoying and be enjoyed.

Light, besides being the factor that most influences human perception, contributes in a pre-eminent way to the psychophysical well-being of the individual in everyday life.
Knowing relationships, influenced by light, between emotions and behaviors, is a relevant investigation to stimulate applications and projects that improve health and emotional state in an environment.
In perceiving one's relationship with space, each of us needs to make sense of the surrounding environment.
Through mental processes related to individual experience we recognize the ability to make us appropriately familiar with the environment that hosts us. Feeling comfortable in one place depends a lot on our relationship with light. Our perception of the visible allows us to understand and interact easily with what surrounds us by taking, even unknowingly, well-being through the pleasure of being part of that place and to appreciate its features without effort: the pleasure of pleasing and be welcome.
If the objects had the possibility to speak and the rooms had the possibility to be walked, this would be certainly due to light. If this is accepted spontaneously, less spontaneously we accept that objects and environments have their own independent experience with respect to those who use them. Yet phenomena occur in them which do not depend on the will of the user, but rather, express conditions that suggest moods, purely emotional perceptions.
The logic that the isometry of the form is to determine the functions or destinations of use is often a logic of perceptual suggestions, of relational relationships between light and shadow.
Light not only illuminates, but characterizes shapes and spaces.
Not only it allows perception, but it is precisely through it that emotional relationships are born. The objects, the spaces through the modulation of light, chromatic declination, tonal intensity, offer varied fruition dimensions.

Namely that if the physical space always remains the same in time, the luminous space can change and transform the perceptive conditions (by) changing the psychological relationship of things' fruition in a cognitive or even suggestive way.

Designing by light

Designing light today also means refurbishing methodologies of approach to the discipline by adopting training paths that are able to interact in close partnership both to the design of physical parameters and to the project of intangible contents.
To all this we add education to perception as a cultural structure. As Arnheim (1974) has already amply advocated, perception requires time, and in this it is necessary to educate oneself to be aware of it.
According to Arnheim our perception, in a general sense, does not differ from what is necessary. That means that the concepts remain as generic as it is allowed by their application in understanding what one is observing.
To perceive an object as immutable means to abstract it at the highest possible level of generality. In the physical world, modifications do exist. The control and design of this variability condition contributes greatly to the well-being of fruition to be more corresponding to what we actually see; otherwise everything would be immobile enough to make us argue that the variations either do not exist or do not matter, renouncing the emotional sensoriality.
On this heightened awareness, accelerated by the evolution of technological possibilities, today new aspects of the project of light are developing. By now skilled in scientific mastery, the ligthing designer needs to tap into the sweet sensuality of light as a research tool for visual well-being and subsequently as a method of rationalizing perceptual cognition.

Emotional Intelligence

How the perceptual cognition of light has changed and how the need arose to relate it to emotional sensoriality can be highlighted by the development that the studies had on the influence that emotions exert on our perceptive abilities.
According to the most recent studies, emotions contain information capable of enabling some sensorial capacities in order to read phenomena and influence our perceptions of well-being in a qualifying way. It is now clear that emotions characterize a very discriminating part of what it means to think, to make decisions and to solve problems.
Yet until not long ago, emotions were still understood as an element of disturbance and fragility in cognitive processes. Only as from the end of the eighties in psychology there is a strong interest in emotions.
The first signs of the interest of neuroscience to emotional phenomena were already triggered in the twenties by Edward Lee Thorndike, who proposed the concept of "Social Intelligence".
To arrive at this codification, he paid attention to define the concept of halo effect.
Indeed, he argues that a single positive or negative aspect of an individual can generate a positive or negative halo on other individuals.
At the same time the studies of Robert Sternberg and Howard Gardner were in turn orientating themselves on other perspectives. Overcoming the classic "IQ", they began some researches based on models of Multiple Intelligences, which included the concept of "Personal Intelligence"
In 1990, J. J. Mayer and P. Salovey finally brought order to the complex constellation of studies on the subject by definitively launching a real new branch of research.
The contribution of Emotional Intelligence, however, did not have a big echo in the public right from the start and much less was influential on the culture of the project, which was still strongly linked to functionalist principles, despite the gain of the Post Modern.
Instead, who contributed to its popularization and popularization was Daniel Goleman, who studied the works of Mayer and Salovey and attended their seminars: in 1995 he published the

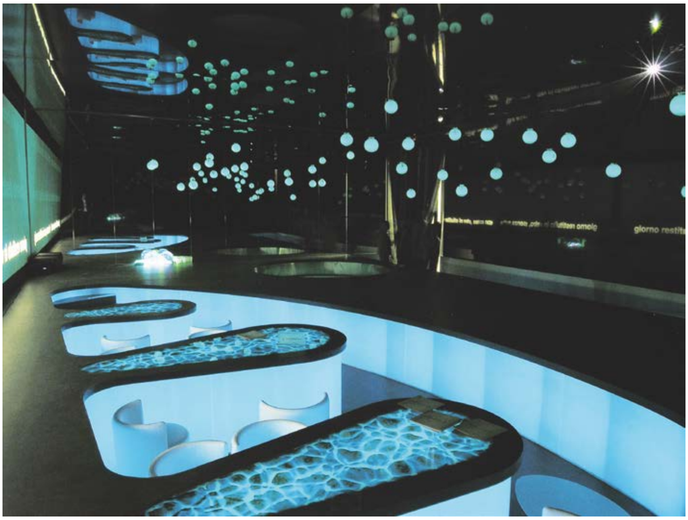
famous best-selling book "*Emotional Intelligence: what it is and why it counts more of the IQ*".
Goleman, moreover, has led the research beyond the theorization of Mayer and Salovey, by adding many other connotations within his definition of emotional intelligence and often going beyond the scientific evidence of research on the topic.
If, on one side, the volume of Goleman has had the merit of making Emotional Intelligence known to millions of people, on the other side it has generated lots of confusion in this field of studies. In fact, today there is no single definition of Emotional Intelligence.
However, the studies on neurosciences conducted so far bring to our attention the evidence that the emotional centers of our brain are not hierarchically in a secondary position compared to the centers of what we could define reasoned cognition. But, on the contrary, these two dimensions communicate in a complex, harmonic & systemic manner which are strictly interconnected.
From now on, the culture of the project cannot separate itself from this consideration and start from the emotional reactions in order to shape the spaces and define the shapes by using the new technological possibilities of lighting.

The bright climate

To design light, we are now in an advanced phase where we can easily understand that the choice of lighting instruments and their positioning is no longer enough, even if determined by the characteristics of the type of light. We are able to pay attention and reason on which bright climate we want and we can get. The thing we want is nourished by the regeneration of the culture of vision in reference to the new cultural skills of perceiving space. The way to get it is based on the capillary and experimental knowledge of the new technical skills to produce light.
The Bright Climate is a component that those who practice the design of the environments consider taken for granted: One of the obvious events in which the project stumbles. In fact what is taken for granted is also inefficient.
Having tools to understand what mood and state of mind can be suggested or take care of is not easy, considering the innumerable incident variables. Meanwhile, the subjectivity of the user changes anthropologically from one person to another, just like the induced variables of the time factor. Our knowledge of light is based on variability. Natural light is never equal to itself and independent from our will. This is our reference experience in perception. In the light that we design everything is instead fixed, determined, but above all voluntary. It depends on a choice of who designed it or who uses it. This may seem to be an advantage and until now in the culture of the project it has been like this; an excellent and ample benefit to shed light on request. But the potential offered by new technologies opens up completely different scenarios and conditions. More knowledge of both technical culture and perception culture is needed to focus on new choices and new formulations of lighting requirements.
The bright climate today has many possibilities to be built, but needs to understand what kind of space to define based not only on the needs, but also the way to live it, to interpret it in a variable and transformable way.
The simple act of "highlighting" is a design fact, based on choices, on responsibility and however spontaneous, rarely completely conscious. The act of shedding light today more than in the past needs information, knowledge, skills to give not only light, but the possibility to perceive our actions with agreeableness and acceptability.

Photoluminescence

The tools that the culture of light design has already refined converge largely towards the acquisition of the founding principle that “light can be declined as an emotional value”. The light passes from a necessary condition to see to a perceptive element that arouses moods.



"Kulana Nalu" by Pierandrei Associati
Experimental set up realized for Lucedentro srl

The light used as an expressive language can be translated into symbolic value. The cultural direction of perception greatly orients the suggestible capacities of communication. The hotter is the light the more it works as an attractor. It becomes "fire" to collect people around.
Emotionally it generates a symbolic perception, an imaginary that supplies security and comfort.
The fact that light is a symbolic emotion tells us that it is not possible to find the same path in the attribution of symbolic value both for "warm" and "cold" light.
If the warm light associates an emotional imagery that welcomes and warms, for the cold light we are in a cultural evolutionary stage in which it becomes commonplace to associate the colors that go towards the blue at low temperatures.
Today the symbolic value of this graduality of light is associated with new technologies. It combines with the most advanced performance of innovative materials.
In this new perceptive perspective, photoluminescence is included.
The signs of change can be appreciated, with various perceptive fluctuations, precisely in the ability of the new generations of photoluminescent pigments to be a vector of cultural orientation.
To appreciate the considerable shift in the cognitive parameter we are subjecting to, we must first reaffirm a basic theoretical concept that has accelerated this ongoing process. There is no light but there is light in all its forms. It seems an axiomatic, purely conceptual postulate, but it has been the most significant stimulus that in recent decades has given awareness to the use of light as an emotional component.
Says Vittorio Storaro: "We must continue to learn the art of seeing. The eye must seize ... the whispers of the visible".
The availability that today gives us the photoluminescence is to educate us to an emotional perception of the whisper of light. Doing little with the very imagination we need. The photoluminescence reinterprets the shadow light dichotomy, on/off, overcoming it by proposing a faint light, but useful to illuminate small spaces.
In front of it the eye is purified from the overload to which artificial light has accustomed it and, as in a moonless night of stars, slowly rediscovers the complexity of the world and new

magical dimensions. Luminescence thus becomes a friendly, comfortable form useful for regenerating psychological and environmental energies.

The chromatic pleasantness of light

The common experience leads to understand that the objects are presented mostly with a very specific color. This leads us to believe that color is an exclusive and constant property of objects and surfaces of environments. Less spontaneous is the evaluation of what really happens to the color. It depends fundamentally on enlightenment and it is known through knowledge acquired by culture and certainly not by direct perception.

Rather than understanding what color objects, surfaces, volumes & spaces are, we are urged to learn the information that color leads to acquiring.

The new lighting technologies, the new lighting possibilities, considerably shift the interest from visual perception to visual comfort.

It is a passage that is increasingly needed for awareness.

The passage is almost epochal: the shift From the interest in the color of objects to the project of the color of light can be explained as a cognitive paradigm that is fundamental for the well-being of perception beyond perception itself.

The growing awareness of how and how much certain aggregations of colors influence the mood and cognitive perception of a space can not sustain itself on the spontaneous notions of differentiation between warm colors and cold colors.

Giving consequently the artificially cultural and simplistic meaning of excitement, aggressiveness, positivity to the so-called warm colors and instead calmness, privacy, relaxation, tranquility, negativity to the so-called cold colors the project methodologies are categorized rather than favoring their application in terms of benefits the potential that innovations allow.

"*I tried to express the terrible human passions through red and green*". Vincent Van Gogh was already aware of this categorization.

If we want to understand the perception of color today, we must ask ourselves not only how it works, but also what are the ideas that men have made of it and how we intend to use it today.

Surely among the most motivated applications there are processes that imply it to be effective in giving wellbeing.

And it is the wellbeing that is subjected to a new exploration because not only is it not easy to define it, but it is amply demonstrated that its effectiveness depends strictly on the variants of its perception.

The well-being as a guarantee of continuity of a certain state of health, of comfort, gives way to the increasingly variegated progress of the perception of the pleasantness of the phenomenon. Character completely subjective and closely linked to the social and cultural environment in which the observer lives and moves. Rather than being interested in wellness, perhaps it is necessary to consider the motive that leads us to perceive it: pleasure.

It is through the pleasure we perceive well-being.

Pleasure comes from emotions, it arouses emotions and variable effects.

It allows to participate in a personal way to the mutability of things, of life. It allows us to escape from the compactness of certainties and the fixity of the perception of the world. It benefits the variety, the variability, the vastness of interpretation of what we see, perceive and which by nature is elusive.

The pleasure of appreciating a color takes place before such a perception can manifest itself as well-being.

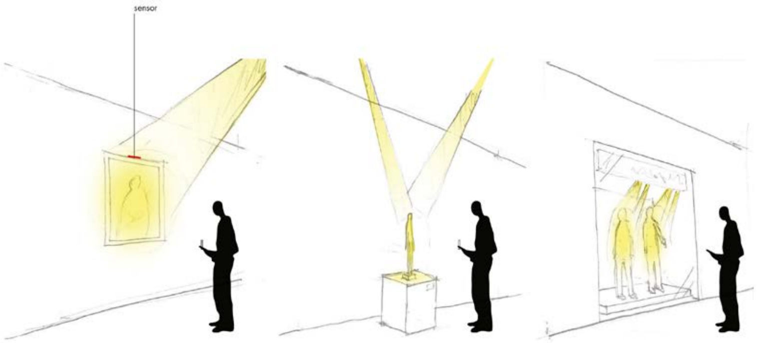
The pleasantness thus becomes an attitude that is still little explored and enormously interesting, especially if considered in relation to the growing sophistication of visual languages and cultural complexity we live today the awareness that light is not only a perceptive feature, but a category we think about light with.

To give importance to pleasure, as a discriminating element of our perceptions, we need to start from the consideration that in our contemporaneity enlightenment takes on the value of a complex code of communication.
To better understand it, we must distinguish our perception of color with respect to the source of illumination.
At the root of our concepts of perception there is a misunderstanding that must be debunked and exists in the true color of things.
But even his substitute must be debunked that is that to distinguish a true color you need to put it under the right light.
And here is the first of the conventions to be overcome. Considering the sunlight more reliable than that of a light bulb is a conventional guarantee certificate and commonly used for instrumental acceptance for productivity purposes.
We have already widely acquired by convention, not only in the practice of human narration, but especially in evaluations of industrial products, that the colors are estimated by placing them under the standard light of 6500 Kelvin degrees and it resemble the temperature of the sunlight of a generic noon.
The light, therefore, takes on the role of leading architect in giving ways to describe and furnish the space.
Today we are creating a global approach to color space. A perspective set to be considered together as a complex play of lights and reflecting surfaces that can be regulated by the infinite possibilities of light modulation.

The experience of the new immaterial dimension of light

We are now widely used to see environments that change color only with the temporary effect of artificial light. So, we are culturally predisposed to accept and perceive, as a value, intangible light effects that can change the visual perception of the place.
Since the 1960s, pop art has been able to accept advertising light as the most advanced expression of the lighting technology that modernity could have.
Las Vegas and Times Square have spread the culture of diffused light.
The sixties were the years of fluorescent neon inaugurating "the era of the naked bulb", or the luminaire in sight.
The jump happened because there was no need to hide the light source anymore. Everything is left to the eye. The lamp becomes no longer just a source, but a legitimate medium in itself that characterizes the colors of the spaces.
The result is the diffusion of a fluid, magical, undulating weightless perception.
F. Wright writes in the “Testament” - “Glass pipes superimposed like bricks of a wall make up the luminous surfaces” - we are in the age of “diaphanous” light: light that envelops, light as much as possible.
With the advent of digital control of artificial light, we can define a new immaterial dimension. To the conventional dimensions is added the emotion produced by the varied applications of lighting technologies. The point control of each lighting effect can be reactively managed with the environment, in direct correspondence to the needs of the moment and to vary according to the perceptive conditions of the users.
Light from an immaterial dimension becomes a participatory immaterial dimension: it produces sensations and stimulates immersive perception. A new dimension that needs more awareness in the organized scandery of the fruition of space. The immaterial interconnectivity of objects, which is now expanding, has the concreteness of existing if it finds in the lighting apparatus the dimension in which to express the usefulness of its own abilities.
The light is totally involved in creating both the technical functionality of the connectivity between the objects, and the LI-FI is already a physiological reality, both in creating the environmental conditions. By doing this, the new invisible prodigies of technology can be

perceived by humans.



Project by Viabizzuno srl

In this, now an advanced performance scenario, the lighting project overcomes, with ever more sophisticated implementation tools, the commitment of providing a correct contribution in lumens to the environments in order to quickly move to a new methodological application phase. Moving the ligthing design towards a strongly cultural trajectory: educating to wellbeing by educating to the perception of light.

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Robot Surgery for Total Knee Arthroplasty

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In order to reduce complications and to improve patient satisfaction after total knee arthroplasty (TKA), in recent years many technological advances have been introduced. Most of them aim to better place the femoral and tibial components, allowing a reduction of the risk of uncorrected prosthesis placement. In fact, improved alignment has been shown to increase implant survival and decrease revision surgery. In this scenario, robotic surgery has become an increasingly popular tool for orthopaedic surgeons. Robotic surgery has the potential to enhancing the surgeon's ability to generate reproducible techniques through an individualized surgical approach, optimising the soft-tissue balancing and restoring the normal joint kinematics. The most common robots commercially available work as a semi-active systems providing passive haptic restraints for surgical resection. In this condition, the surgeon can perform bone resection under the supervision of the robot, confining the cutting bone to only the planned level of resection. Different alerts trigger (vibration, beeping, colour change on the computer screen) provide feedback to the surgeon as the defined resection parameters are approached. Surgical steps include 1) creation of a patient-specific knee model 2) registration of the knee model and plan the bone resections 3) the use of the robotic to make bone cuts and carry out the preoperative patient's plan. During surgery, the position of the burr is evaluated by the robot and when it approaches the border of the planned resection the computer system will slow the speed of the burr or retract the burr into the hand piece, effectively decreasing the potential for over resection of the bone. During this phase, surgeon could make adjustments to the patient's plan in order to obtain the most accurate placement of the knee prosthesis. Surgical procedures are demonstrated such as clinical results of robotics surgery.

NEW TECHNICAL DEVELOPMENTS & APPLICATIONS

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NEMOSINE:

Innovative packaging solutions for storage and conservation of 20th century cultural heritage of artefacts based on cellulose derivate

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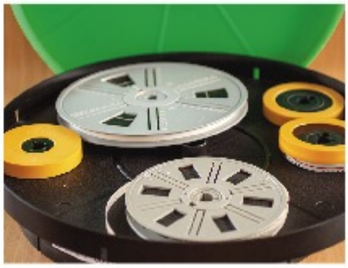
"We all die, but looking" is the title of the autobiography of Alberto García Alix, one of the most representative photographers of 2nd half of 20th Century in Europe. It is impossible summarize better, in a few words, the relevance of the natural capability of human being of catching everything that surrounds him. The human flair of converting images into memories contribute on building what we were, what we are and surely what we will be. Since last 1895 the memories of history of human being has being helped by the possibility of capturing and saving this part of our evolution into photographs and movies. These physical supports have saved main part of our global cultural, social and political history. But, looking into each individual, also gave the possibility of recording part of our family heritage. Photographs and movies have helped to preserve the cultural material that is faithful witness of socio-cultural European evolution in the recent era. It encompasses not only the possibility to understand the development of new arts such as cinema, photography or graphic arts but also the preservation of the socio-cultural memories of citizens in major museums, local museums (real testimony of the history of cities and their people) located in many towns worldwide & in a huge number of private collections. A huge percentage of the recent European cultural heritage (CH) can be found in movies, photographs, posters and slides produced between 1895 to nowadays were made using cellulose derivatives. More than 75 years of visual and audio memories are up to now in serious danger to be lost due to the natural instability cellulose acetate (CA) and cellulose nitrate (CN) materials. **The**

worldwide estimation of such holdings within professional film archives is around 18 Mio of film reels on cellulose acetate, whereof ca. 5% are in a critical stage or showing signs of vinegar syndrome (survey carried out by the OEAW-PhA in 2012, performed with 20 institutions, extrapolated to 125 members of FIAF (Fédération Internationale des Archives du Film). Figure 1.1.a shows an example of such film. There have had other technical approaches to solve this real problem that follow the line of replication and copy the original ones in modern digital supports (for example PIQLBox©- www.piql.com/). But, they do not give the possibility of a real preservation of the original ones. In the actual technology age, our duty, with the people that preceded us, pass through help on the preservation of these parts of original memories that built our past history and will help on understanding our future. Under the technical point of view, conservators consider two approaches when planning treatments to extend the useful lifetime of cultural materials: preventive or passive and active or interventive. However in the case of cellulose derivatives and other components of the movie or photography, once initiated, degradation cannot be prevented, reversed or stopped, but only inhibited or slowed. Inhibitive conservation of cellulose derivatives can either involve the removal or reduction of factors causing degradation including light, oxygen, acids, fungus and relative humidity, or of any breakdown products which accelerate degradation, as well as cost-sensitive processes such as freeze. The cellulose derivative degradations is autocatalytic increasing constantly the level of degradation with the time.

NEMOSINE aims to improve the traditional storage solutions, such as freeze storage (below 5ºC), by developing an **innovative smart package** with the main goal of **energy saving and extent conservation time of cultural objects based on cellulose derivatives**. Beyond the state of the art NEMOSINE plans to develop the following modular and integrated products: i)High O2 barrier and Active packaging using non-odour additives, ii)Active acid adsorbers based on functionalized Metal Organic Framework (MOFs) integrated in low density and porous structures, iii)Gas detection sensors based on nanotechnology to monitoring AA, water, O2 & NO, iv) Multi-scale modelling to correlate degradation & sensors signals for maintenance prediction and integrate all these technologies in v)Packaging with modular design to fulfil the technical & economical requirements of the different CH made by cellulose derivatives and vi) Curative packages containing controlled release of natural antifungal additives. The main targets of NEMOSINE project are ***cellulose derivatives, from photographic, movies and audio substrates***.

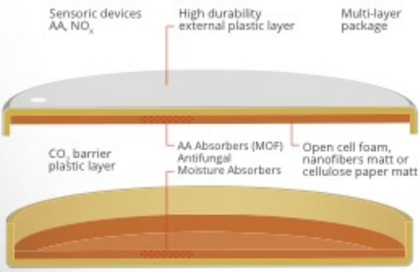
INNOVATIVE PACKAGING SOLUTIONS FOR STORAGE AND CONSERVATION OF 20TH CENTURY CULTURAL HERITAGE OF ARTEFACTS BASED ON CELLULOSE DERIVATIVE



A huge percentage of the recent European cultural heritage (CH) can be found in movies, photos and posters produced between 1895 to nowadays were made using cellulose derivatives. More than 75 years of visual and audio memories are up to now in serious danger to be lost due to the natural instability cellulose acetate (CA) and cellulose nitrate (CN) materials.

NEMOSINE aims to improve the traditional storage solutions, such as the usual freeze storage (below 5ºC) that involves high energy consumption and special facilities, by developing an innovative smart package with the main goal of energy saving and extent conservation time of cultural objects based on cellulose derivatives.

NEMOSINE smart package concept



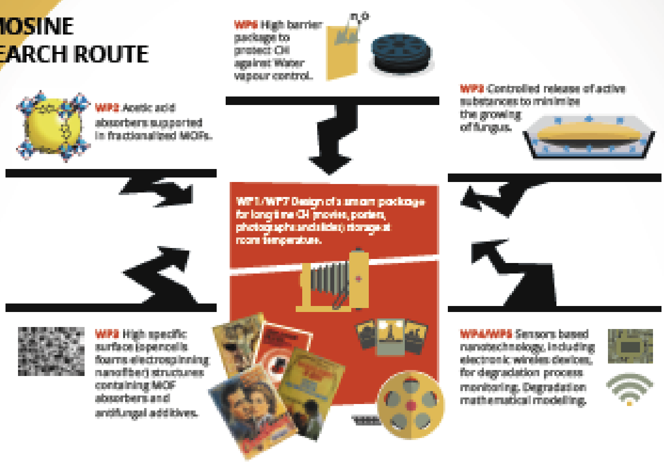
Beyond the state of the art NEMOSINE plans to develop the following modular and integrated products:

- **i)** Active packaging using non-odour additives.
- **ii)** Active acid adsorbers based on functionalized Metal Organic Framework (MOFs) integrated in low density and porous structures.
- **iii)** Gas detection sensors based on nanotechnology to monitoring AA, water, NO.
- **iv)** Multi-scale modelling to correlate degradation & sensors signals for maintenance prediction.
- **v)** And integrate all these technologies in on smart package with modular design to fulfil the technical & economical requirements of the different CH made by cellulose derivatives.
- **vi)** Curative packages containing controlled release of natural antifungal additives.

The main targets of NEMOSINE project are cellulose derivatives, from photographic, movies and audio substrates.

The actual trend within the archival community is related to digitisation and digital restoration of audio/film content, which is still very complex, costly and time consuming. As this is on one hand a disadvantage, because related activities are proceeding very slowly, this is on the other hand a big chance for new fully proven innovative packaging solutions. This is the chance to place a highest quality product in the market.

NEMOSINE RESEARCH ROUTE



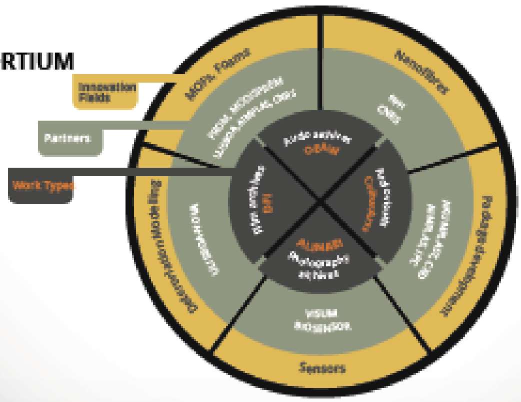
The main beneficiaries are the audio-visual collections can be grouped as follows:

1) (Partly) autonomous audio-visual research archives;memory institutions, such as libraries, big archives and museums; departments of research or cultural institutions, local museums, oral history societies, etc.

2) Materials privately owned by the researchers, collectors or audio-visual buff that created audio and video documents for their research purposes.

3) Private owners that keep own old family photographs (and/or their negatives), movies or audio.

CONSORTIUM



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LIVING IN THE PRESENT: USING 3D MIXED REALITY TECHNOLOGY TO ENHANCE GUEST EXPERIENCES WITH MUSEUM OBJECTS AND COLLECTIONS

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Abstract - Museums are experiencing a shift in their roles within society; a shift in revolutionizing the way museum guests access objects and participate in museums' collections. Contemporary museum guests desire more active immersion in, and interaction with, museum galleries, desiring direct contact with cultural and historical artifacts, and forums to discuss their experiences, aided by technology. To meet this need, *The Museum of Texas Tech University* is leveraging 3D Mixed Reality (MR) technology (zSpace®) to tap into these societal shifts; providing new ways for museum guests to conceptualize, communicate, and connect by replicating historical and cultural memories of Native American objects.

INTRODUCTION

Traditionally, museums have regarded themselves as *temples of knowledge;* physical spaces to house cultural and historic objects memorializing human culture across time and space. And thus, historically, these spaces were designed as formalized places of learning, with prescriptive architectural designs and specific language used for signage in exhibits. For decades, guest experiences at museums were defined by viewing objects under bright lights and thick glass; a 'look but do not touch' experience with the protection of collection objects. Yet, with dwindling museum attendance, especially among young adults [1], museums have begun to examine their approach towards exhibit design and purpose, reconceptualizing how visitors may have evocative and educative experiences with museum collections in new and interesting ways.

Fostering Interactive Exhibits: A Paradigm Shift

Museum professionals now seek to reimagine traditional perspectives of what constitutes the visitor experience, broadening *object* experiences (focus on the artifact) into *social, cognitive,* and *introspective* experiences; museums of are interested in how guests interact with each other, learn, and feel from their museum experiences, respectively [2]. Specifically, museums are now interested in exhibits that contain a combination of opportunities for guests to both acquire and share knowledge, and this hopefully results in the creation of emotion and reflection on the part of the visitor. To this end, research suggests that exhibit design should leverage aspects of *free choice learning* that motivate and empower visitors to learn about new historical and cultural narratives [3].

Theoretical Framework: Learning in Free Choice (Museum) Environments

As this paradigm shift progresses, museums are in need of devising plans to create educational and collaborative spaces for their public to participate in informal or free-choice learning activities [4]. To understand this body of informal education literature in which museums exist, we must first examine determined modes of learning, combining theoretical perceptions and modern understandings of the way today's societies access information. From decades of research, Lynn D. Dierking described *ten learning generalizations* that are influencing factors when understanding the context of the human learning process [5] in informal, free choice learning environments. These ten processes of learning generalizations describe that one's perception (1), motivation (9) and memory (2), informed by prior knowledge, beliefs, and experiences (7) and development (5) are central to one's learning. And, this learning occurs through nonlinear (6), active (3), cognitive and metacognitive processes (4), within physical and social contexts (8) that are unique to the individual (10). Quantifying the complex factors that influence the general processes of learning has the potential to expand our traditional methods of exhibitions methods of exhibit design, and to change our perspectives about ways to reach broader audiences. Therefore, in using these generalizations, museums can further their consideration of what constitutes methods of exhibit design and content, which can help to create a more educational and emotionally meaningful experience for museum guests.

Conceptual Framework: How Technology Can Enhance Learning (and Museum Goals) in Free Choice (Museum) Environments

Technological developments continue to shape and change the way we interact with everything we encounter, and this has been evident in the use of virtual, augmented, and (when presented together) mixed reality technologies. These include realistic and interactive 3-D images set within virtual environments, which stimulate, motivate, and enhance learners' understanding of events or phenomena, especially when traditional (hands-on) experiences are prohibited or difficult [6]. Such technologies have been found to aid museum guests' knowledge of artifacts as well as facilitating guest excitement and motivation [7]. Yet, most prior research has focused on replication of objects into various environments, by either placing the actual object in a sterilized setting (e.g. under glass) or creating a replica of the actual object and placing it into an approachable setting (e.g. in an exhibit where people may touch or see the object in a context). In either scenario, these actions still divorce the object from its cultural, social, and historical context. Yet, this should be important to museums, as traditionally the most important element within the presentation of these objects is the *authenticity* of these objects, namely their cultural affiliations and associated historical information. The general presentation under glass is waning; museum professionals are reexamining what it means to have an *authentic experience* and are applying new conceptions of the term *authenticity* to expand the methods of public exhibitions. In a 2010 publication titled *Fabricating Authenticity: Modeling a Whale at the American Museum of Natural History,* Rossi explained the qualifying features of authenticity when addressing using replicas within museums stating that, "Through these records, one finds that practices used by exhibitors to replicate whales were intimately tied up with questions of truthfulness, accuracy, authority, and moral and aesthetic worth—qualities that I will sum up under the rubric of *authenticity."* [8] (p. 340). These defining qualities of authenticity allow for those features to be applied to museum objects, regardless of their creation story and suggest that all objects that are modeled through accuracy, and that are morally and aesthetically truthful, could only then be considered *authentic*. Prior to this work, for decades—perhaps centuries—, an authentic experience was defined by visiting a museum and viewing objects under bright lights and thick glass. This 'look but do not touch' experience privileged the protection of the collection, with latter consideration to the guest. However more recently, museums have started to examine their approaches of conceptualizing exhibit design, conceptualizing how visitors can have meaningful experiences with the collection in new and interesting ways. Rossi clarified this shift in focus, stating that "although there was no decisive moment of this epistemic shift–old techniques for insuring an exhibit's moral, scientific, and aesthetic worth continued to find use alongside more novel tactics–exhibitors increasingly tended to view scientific authenticity governed not by objects, but by the experiences of viewers as participants." [8] (p.359). This suggests that the incorporation of emergent technologies (like virtual, augmented and mixed reality that seek to replicate the real world) within museum exhibits could now allow for museum professionals to redefine the notion of what constitutes an authentic experience within a museum setting. Museum professionals are now seeking to reimagine our traditional perspectives of what constitutes a visitor experience, making efforts towards curating new types of guest experiences within traditional exhibit spaces [9]. Meaning that exhibits could provide a combination of opportunities for gaining knowledge, combined with opportunities that induce important features of generalized learning, such as, evoking emotion, developing memories, and promoting self-reflection. When challenged with the idea of pairing an emotional response with a visitor's museum experience, museum professionals could provide a setting within which visitors are able to create their own understanding of authenticity, in turn allowing museum staff to redefine traditional notions of museum exhibits. One way that museums can be successful with shifting the idea of traditional exhibits is to focus on transforming the feel (italicize) of their exhibits; shifting from traditional, formalized "do not touch" exhibits, to exhibits that provide interactive elements, a museum can provide a visitor with a more personalized, collaborative, and emotional learning experience. Hence, it is paramount that exhibits encourage motivational and free choice learning for guests, so they may feel empowered in their learning about (new) historical and cultural narratives.

The Museum Collection: Southwest Indian Art Gallery

The Dierking generalizations [5] and ideas of robust virtual experiences [6, 7] fostered the framework of creating dynamic and educational visitor experiences, to be applied in a real-world museum setting at Museum of Texas Tech University; the idea for creating robust, virtual experiences was specifically applied to the William C. and Evelyn M. Davies Gallery of Southwest Indian Art Gallery, "Beyond Expressions in Clay" [10]. This exhibit includes objects (e.g. pottery, textiles, ceremonial and trade vessels) from 20 different Native American tribes in the Southwestern United States, spanning from the eleventh century to the twentieth century A.D. Many of these objects are far too fragile for display and are kept in the archives; those artifacts that are on display are under standard, museum protective glass. Many visitors to the museum and gallery are not Native American, and require museum-based scaffolding so they may be able to connect through their perception, motivation, and social interaction to name a few (related to Dierking's ten generalizations [5]), to foster robust learning and appreciation of the collection. Since museum guests hold little (if any) prior knowledge of, or experiences with, Native American culture and beliefs, it was important to try to create some kind of geographical and cultural context for the objects included in the project. By using original photographs from actual locations that are associated with selected objects, the goal is to foster a more meaningful, personal experience with objects in the collection. Mixed reality technologies were employed to replicate objects' authenticity, or the inherently situated nature of the social, historical and cultural relevance of the collection's artifacts.

Mixed Reality Technology: The zSpace® Platform

The zSpace® VR hardware is desktop-based that uses stereoscopic images to produce 3-D images. The technology uses elements of both augmented and virtual reality (within a modified desktop computer) to facilitate mixed reality, immersive and interactive experiences that promotes user-driven active learning. Figure 1 demonstrates the components of the zSpace® system.

Figure 1. The zSpace® 200 display.

The zSpace® unit consists of: a central processing unit (CPU); a 24-inch-high definition liquid crystal (1080p, 120Hz) 3-D stereoscopic display screen complete with built-in tracking sensors to track the viewing angle of the user; a 3-button stylus with integrated haptic technology and infrared LEDs for manipulating interactions within the virtual reality space; and a set of polarized eye-glasses with reflective sensors to track head and body movement in real-time. The system's monitor with specialized 3D glasses creates the perception of depth on the z-axis, making the objects on the screen stereoscopic, creating an immersive environment with apparent realism. The glasses synchronize with the zSpace® head tracking technology to sense how the user is moving their head and which direction they are focusing their view in real time to enhance the sense of user interaction. zSpace® also incorporates an attached specialized stylus pen that allows the user to interact with an object and manipulate it to get a 360-degree view. The additional zoom in/out capability allows for examination of the objects as they 'hover' in front of a user. This hardware, coupled with 3-D VR software applications, allows the viewer to see detailed, simulated images, that appear both within and out of the screen, and allows manipulation (e.g. rotated, zoomed, dissected, etc.) of these 3-D images with the stylus. zSpace® was chosen based on unique affordances among available mixed reality technologies. First, compared to other forms of augmented and virtual reality systems, this technology is relatively inexpensive to acquire. At $3000 to $5000 USD per unit, the zSpace® system allows for smaller museums to have much more affordable access to incorporate emergent technology within their institutions. Second, zSpace® allows for a dynamic and fluid informal learning environment. For example, one or two zSpace® systems could be incorporated as enhancements within traditionally styled museum exhibits, or, multiple zSpace® systems can also be used in a 'discovery lab,' creating a space for more guided interaction. Lesson plans can be continuously updated and customized based on specific learning objectives, audience, or age groups. Third, zSpace® is user friendly, which has been leveraged by prior research studies due to user familiarity of the computer style monitor, stylus pen, and glasses, hardware that is within the general public's lives and range of experiences [11]. Therefore, making the user interaction process less intimidating than similar emergent technologies. Fourth, the zSpace® employs a stereoscopic display that provides peer-to-peer interaction, unlike other forms of virtual reality hardware for single-users only, [12], and this foster rich conversation and interaction among museum guests while they are engaged with the technology. Last, the zSpace® lesson plan development process can be easily learned. A potential developer (with no formal training) could successfully scan and import artifacts to create custom lesson plans for objects within their own collection.

Integrating zSpace® into a Museum Collection

The goal of this ongoing project is to provide museum guests a better understanding of collection objects through the use of immersive and interactive 3D experiences via the zSpace® platform. Aside from the obvious entertainment value, the opportunities of enhancing the guests' educational and affective experiences with collection objects are immense. Informed by the Dierking theoretical framework of learning [5], objects from the Davies collection were scanned into fully-rendered 3D images (using an iPad with the 3D scanning application *itSeez3D*) and then imported into the zSpace® system software (*zStudio®*). Building upon the provenance and extant research of the objects, culturally representative music and appropriate scenery were added to the selected object's virtual environment (as seen in Figure 2).

Figure 2. The zSpace® 200 display of a Davies' Gallery Object.

This included 3-D models of the collection's objects, replete with Native American music, environments, pronunciations, as well as guided activities and questions to help guide the user experience (as seen in Figure 3).

Figure 3. A user interacting with an object in the zSpace® 200 mixed reality environment.

Now that objects from the Davies' collection have been scanned and loaded, and, lessons developed on their histories, a zSpace® system is now deployed in the Davies' collection as of fall 2018. In 2019, a full research study will explore guests' experiences within the exhibit.

Conclusion

Despite many museums' lack of funding for innovation, it is crucial to keep in mind that despite the evident academic and educational benefits for the public, museums are now in direct competition with other forms of leisure entertainment [13]. We must shape our museums by keeping this fact in mind with the understanding that if we want our institutions to remain relevant to the public, we must reinvent an authentic guest experience. The ultimate goal of the zSpace® intervention is not to act as a replacement for the traditional method of 'look, read, but do not touch' that is found within traditional museum exhibits, but rather as an enhancement to exhibits and objects. It is our purpose to provide our visitors with immersive and interactive virtual experiences with 3D, digital representations of collection objects, so that visitors are able to have novel, more *authentic* experiences with the artifacts, like never before. With our research, we anticipate zSpace® will help fulfil our Dierking-informed mission of learning [5] where guests may actively learn, discuss, explore and create, fostering memorable museum experiences and long-lasting learning.

ACKNOWLEDGEMENTS

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COMBINING RTI & SFM
A MULTI-FACETED APPROACH TO INSCRIPTION ANALYSIS

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This paper describes an approach of employing a dual heritage imaging process in an attempt to overcome the inherent challenges of inscription analysis and surface texture information in several different situations.
In the cases presented, we have employed a hybrid approach, cross-referencing traditional archaeological research with close-range 3D Structure from Motion (SFM) imaging and Reflectance Transformation Imaging (RTI).
As will be demonstrated, it is our opinion that in the circumstances such as these, there is not one dominant technology, but rather, a combination of complementing strengths, which can aid in unlocking the secrets of the engravings and inscriptions.

Jerusalem. Church. St Helena. Crosses. RTI. SFM. Milestones. Olmec. Seals. Tombstones. Museum

1. INTRODUCTION

In the fields of Heritage conservation, in restoration, analysis, measurement, research and presentation, a vast number of both invasive and (increasingly) non-invasive techniques are used to extend the range of our senses. Some peer and probe beneath the surface of the object, in search of visual clues, whether by multispectral methods, by radar, by LIDAR, or by magnetic resonance. Others, such as XRF and XRD looks at the elemental or chemical characteristics of substances. Microscopy extends the range of sizes accessible to our human visual system, while drone, aerial and satellite photography provide access to hitherto hidden vantage points and offer an overview of large surfaces.

Yet, much of the information we wish to view lies in plain sight is neither too big nor too small. Lurks not beneath the surface nor hovers above it. Does not extend beyond our visible spectrum and needs no chemical detection. Still, it remains hidden from our sight, due primarily to that one very source without which we would be lost: Light.

Light reflects off, refracts from, or is transmitted through surfaces and reaches our visual receptors. However, beyond the effects of intensity and wavelength, it is the angle from which it reflects which determines our ability to interpret information. We are talking here of surface texture. The texture is viewable by the way the light reacts with it, the quality of light and especially the angle of light hitting the surface. Inherent contrast or lack of it in the subject matter will affect our ability to discern detail. Yet it most cases the characteristic of texture recognition will be a factor of elevation and depression relative to the light source, while the angle of the light raking off it will determine the intensity of highlights and shadows, which give the surface its depth dimension.

However, in many cases, we are not the masters of the light source and are not in control of its interaction with the subject's surface. A rock carving may be illuminated by a dull overcast sky, yielding it virtually unreadable, while a highly reflective surface may be subject to direct harsh sunlight. Moreover, the nature, the intensity, and angle of light may be highly useful to one part of the subject, yet entirely unacceptable to another part of it. Curved surfaces reflect the light in different directions and thus by that very fact the optimal direction of light for viewing one part of the surface will be the wrong one for another.

This paper chooses to concentrate on two low cost and readily available imaging techniques designed to overcome these issues: Reflectance Transformation Imaging (RTI) and Structure from Motion (SFM). Both techniques have been around for some time and are reasonably well known and documented. However, their applications have traditionally been somewhat different and do not usually aim for the same purpose.
Here, I wish to argue and demonstrate that it is the combined virtues of the two techniques that, when used together may offer an effective and affordable solution to high-quality surface detection.

2. REFLECTANCE TRANSFORMATION IMAGING

2.1 Theory

Reflectance Transformation Imaging (RTI) is a unique digital photographic technique aimed at enhancing the surface detail of objects through an algorithmic rendering of multiple registered digital images of the object, shot with controlled, varying, yet known light positions. Termed initially Polynomial Texture Mapping (PTM), the method was invented by Tom Malzbender at the Hewlett Packard Labs. The seminal paper describing the method was published in 2001 [Malzbender, Gelb, Wolters, 2001]. Today the technology continues to be developed and promoted by a dedicated international team, supported by the Cultural Heritage Imaging Corporation (CHI).
The power and beauty of RTI lie in its ability to enhance the surface-detail of a wide variety of materials by changing the apparent direction of light falling upon it. This 'virtual torch' [MacDonald, 2011] is done after the photographic session has been completed, and at the leisure of the researcher in the comfort of the lab. During photography, the light sources are positioned at a constant radius from the subject and surround it at incremental angles, forming a dome or hemisphere of light positions. The user may also zoom in and out, change sharpness, contrast and other light and surface properties, through a series of real-time filters, thus often revealing surface details not visible to the naked eye under normal viewing conditions (See Fig. 1).

2.2 Practice

As the real-life cases here demonstrate, the RTI technology is very flexible, relatively easy to master and yields remarkable results. Yet, though relatively cheap and straightforward, it is nevertheless time-consuming and demands total accuracy in execution. These two demands, while acceptable in a controlled studio environment are in some cases challenging to achieve, due to environmental or time constraints. Furthermore, the fixed location of both camera and object limit the viewable area of the surface and the information it may yield.

3. STRUCTURE FROM MOTION

3.1 Theory

Structure from motion (SFM) is a photogrammetric range imaging technique for estimating three-dimensional structures from two-dimensional image sequences that may be coupled with local motion signals (see: Wikipedia). It is based on the principle that while a single photograph can only yield two-dimensional coordinates, height and width (X-Y), two overlapping images of the same scene,

taken slightly apart from each other (a stereo pair) can allow the third dimension (Z) to be calculated through the process of triangulation.
A photogrammetric model combines the elements of shape, texture, and lighting of the object and stores them as a combined vector and raster file, thereby providing the combined advantages of mathematical accuracy and flexibility, along with photographic exactitude of colour and texture. This process lends itself especially to 3D reproduction and representation of existing real objects and surfaces, rather than the creation process of new objects, based on copying or imagination
Recent years have seen a significant advancement in this field, due both to improvements in algorithms and software, as well as the proliferation of high-quality DSLR cameras and high-end phone cameras. Consequently, today, there is a growing argument that for many purposes, 3D digitisation by SFM can equal and often surpass laser and structured-light imaging [Skarlatos, Kiparissi, 2012]. Thus, photogrammetry-based 3D imaging has moved from the status of low cost / low quality to that which challenges the quality of mid to high-end scanners in specific fields [Cultural Heritage Imaging, 2015].

3.2 Practice

SFM is sometimes an unpredictable process. Some objects respond better, and some yield poor results. Much depends on the nature of the surface captured, the quality of the light sources and of course the quantity and quality of the photography. Sharpness and even lighting are of great importance, and though this may sound trivial, it is often challenging to achieve. In the cases presented here, environmental and temporal shooting conditions played an essential part in the level of success.
As opposed to RTI, where there is just one main software approach to processing the images (CHI RTI Builder), SFM offers many software solutions of varying complexity and price. In the cases presented here, all objects were processed in at least 3-4 software packages. These included:

- Agisoft Photoscan
- Autodesk Recap 360
- 3D SOM
- 3D Flow Zephyr Aerial
- Reality Capture

Each software package has its advantages and disadvantages regarding speed, accuracy, flexibility to overcome shooting faults, hardware demands and so forth. Subsequently, it transpired that the best results were achieved overall with Agisoft Photoscan and 3D Flow Zephyr Aerial.
Due to the subsequent file size of the photogrammetric models and the need for the researchers to access the models with ease and furthermore to annotate them with their findings, it was decided to upload the models to the Sketchfab web platform. This excellent site allows for post-processing, lighting, Meta tagging and annotating the models.

4. TEST CASES

For this practical research, we have concentrated on several test cases, which highlight the various complexities in surface information detection and the benefits of the combined RTI / SFM approach. These include:

- The Saint Helena Chapel Crosses in the Holy Sepulchre, Jerusalem
- Roman Milestones along the Incense Route
- Jewish Tombstones in Germany
- Cylinder Seals

4.1 The Saint Helena Crosses

This case describes an attempt to provide insight into the riddle surrounding the thousands of crosses, symbols, and texts, inscribed on the walls and behind the altars of the Chapel of Saint Helena, within the Church of the Holy Sepulchre in Jerusalem, ascribed to the Crusaders of the 12th and 13th centuries [Pringle, 1993].
Working with the *Israel Antiquities Authority* in collaboration with the custodians of the Church, both RTI and SFM were employed, in a concentrated attempt to document as much empirical data as possible during a short period of 48 hours when renovations to the chapel opened up a small window of opportunity for access.

Figure 1: *Detail of stone (6X10 cm). RTI with Specular Enhancement & SFM Radiance Scaling (left). 3D plot of a cross (right)*

RTI alone was not sufficient for this purpose. While the quality achieved on some stones was remarkable (See Fig.3), the sheer volume of tiles made this lengthy process impractical. Furthermore, the very short shooting distance between the back of the altars and the walls, the position of some tiles near the floor or high up, in niches or other inaccessible locations made it impractical to position tripods or move the light source in the required hemispherical direction. Lighting conditions and extremely thick stone dust (due to renovation work taking place) further hampered the process. SFM was in these cases a more convenient solution where the very close shooting distance available was an advantage. Nevertheless, those tiles which were accessible to the camera and lights yielded remarkable detail, both via RTI and SFM. Analysis of the chiselled incisions on the stone reveals regular V-profile grooves (See Fig. 1, left). The angles were determined by using a photometric stereo ('shape from shading') image processing technique to determine the surface normal vectors at each pixel position (See Fig. 1, right).

4.2 Roman Milestones

Last winter, a lost section of the ancient Incense Route (see: Wikipedia), stretching seven kilometres, was discovered in the barren heart of Israel's Negev desert. Along with this stretch, several Roman-era milestones were discovered. Two thousand years of harsh conditions had taken their toll and as a report in the local newspaper stated: *"One of the Roman milestones still bears all-but-indecipherable writing, which seems to be in Latin or Greek.*
Under the auspices of the *Israel Nature and Parks Reserve* along with experts from the *Israel Museum and the Tel Aviv University*, detailed imaging of the milestones was undertaken.

From the outset, it was clear that conventional photography was not going to assist much in recovering the faded letters. Thus, RTI was deemed the hopeful solution. Indeed, this was in some

cases so, enabling the confirmation or rejection of long-lost messages from the past, including the name of the Roman Emperor Septimius Severus (145-211 AD) (See Fig. 2, right).
However, Roman Milestones are cylindrical and therein lies an inherent limitation of RTI, which works primarily on two-dimensional surfaces. Texts which stretch along the cylindrical surface cannot be captured in full. This is where close range SFM came into its own, giving the researchers full access at any angle, level of zoom and light direction. Furthermore, readily available 3d viewing software such as Meshlab, offers both interactive relighting and filters, such as Phong shading or Radiance Scaling, which aided greatly in accentuating the texts on the surfaces (See Fig. 2, left).

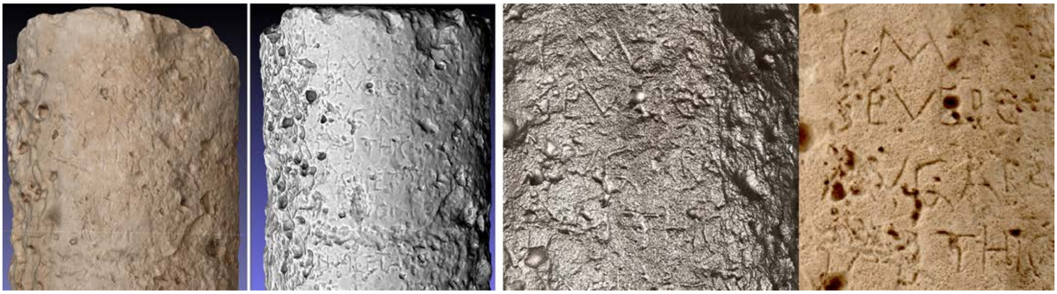

Figure 2: *Milestone: SFM and detail rendered in Lambertian Radiance Scaling (left). Detail bearing the name of the Emperor Septimius Severus. RTI unsharp & specular (right)*

4.3 Jewish Tombstones – Germany

As part of an ongoing conservation project, Jewish tombstones in several small German communities were documented (See: Unfolding Communities). These communities all perished during the Holocaust, and until recently, their cemeteries too fell into disarray or worse still suffered vandalism. The conservation effort involved teams of young students from the local German schools alongside students from Israel and small teams from the Institute for the Preservation of Cultural Heritage at Yale University and the Hadassah Academic College Jerusalem.
All the tombstones were photographed, and their data uploaded online. However, many of the stones have succumbed to the ravages of both man and climate, making their reading all but impossible. These stones were earmarked for special treatment, namely, RTI and in some cases SFM.
The RTI documentation proved invaluable in its ability to bring out the faded lettering on the stones and even to restore long lost names, through which the story of the deceased was retraced and documented (See Fig. 3, left) In other cases, however, the conservation report went beyond the lettering and related to the general state of the stone, its cracks and its subsidence. In cases such as these, SFM provided a better all-around representation, complementing the RTI (See Fig.3, right).

Figure 3: Jewish Tombstones, Germany. Normal (left), RTI (centre) and SFM (right)

4.4 Cylinder Seals

Cylinder seals are small, carved stone cylinders that were used to make an impression in wet clay. When rolled out the seal left an impression that could prove ownership or identity.
Cylinder Seals are in most cases extremely difficult to view and decipher due to their size, material, and shape. Their sizes can vary between a mere 1 cm to possible 3-4 cm at most. Thus, unaided and non-invasive viewing is a challenge from the outset. Secondly, the hard, often shiny or dark surface coupled with shallow engravings add to the difficulty. Thirdly, even if the content can be made out, any specific angle would only present a small section of the picture. To this purpose, even today the preferred method of viewing the seal in its entirety is by rolling out an impression on clay. This is of course highly invasive and in any case is not a viewing of the object in itself.
In our tests seen here, RTI brought out incredible specular enhancement of a seal clay impression (See Fig. 4, left). Yet the seal itself yielded only partial information and even that far from perfect. Though highly detailed, the engraving was shallow, and the black stone did not respond well to raking light. The SFM, performed here on a different seal (BLMJ), while less detailed, offered the apparent ability to "roll" the seal itself in real time and manoeuvre the 3d light source to the best effect. This coupled with the Meshlab rendering filters, such as Lambertian Radiance Scaling and Ambient Occlusion, enabled stripping off the photographic texture map and concentrating solely on the surface texture. The Lambertian Radiance Scaling with Coloured Descriptor image (Meshlab) was brought into Adobe Photoshop where the RGB file was split into its three component channels. Each channel brought out other hitherto unseen details (See Fig. 4, right).

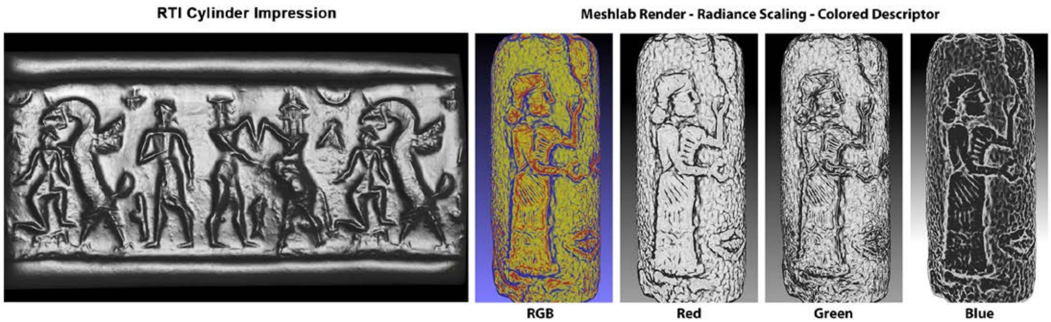

Figure 4: *Seal impression. Israel Museum (left). Cylinder Seal. Bible Lands Museum. SFM. Meshlab Lambertian Radiance Scaling with Coloured Descriptor image and three separated channels in Adobe Photoshop (right)..*

5. RTI TO 3D AND OTHER ENHANCEMENT TECHNIQUES

RTI and 3D representation of Cultural Heritage objects have their strengths and weaknesses; it is the combination of their relative strengths, which give these tools their usefulness in real-life situations.
Attempts to convert RTI files to 3D format (PLY) or combine their relative merits have been made, such as the workflow suggested by L. Pawlowicz. Further work has been suggested by Elfarargy, Rizq, and Rashwan [2013], based on surface normals.
Likewise, the Combination of 2D, 3D, and RTI Data has been demonstrated and proven effective on paintings [Aure, X. O'Dowd, P. Padfield, J., 2017]
Other techniques for the enhancement of our surface detail interpretation include ongoing projects, such as *Algorithmic Rendering* and the *CARE (Collaborative Algorithmic Rendering Engine)* tool in

joint development by CHI and Princeton University.
It is not the purpose of this paper however to concentrates on the ongoing scientific research and development, but rather to suggest the empiric application of common and cheap or open source tools to the benefit of the heritage specialist.

6. CONCLUSION

The several test cases presented here, along with many more, attest to the assumption that the needs, contexts, and substances subject to surface detection and analysis, call for a variety of imaging procedures. It would seem that in many, if not in most cases, one technique would not suffice in providing all the information necessary nor certainly all the visual information possible.

The two main tools, RTI and SFM, both have their strengths, and both are continually undergoing improvement.
As with many tools, however, it is our practical experience with both their strengths and their limitations which can guide us in their use. Neither technique can yet offer us the complete answer to our needs. The field of surface detection demands proficiency in photography, in lighting, in RTI and 3D construction, in image processing software, and above all in the willingness to harmonize, combine and assimilate these components in line with the demands of the task.
As image resolutions increase, as algorithms improve and as software and hardware become more and more cost-effective and easy to use, it is fair to assume that we will witness exciting developments in the years to come and the stories, still hidden within the surfaces of our heritage objects will yet emerge and yield their secrets.

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Tsevikah Tsuk.
Israel Nature & Parks Reserve
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CHATEAU DE CHAMBORD, A PERFECT ORDER

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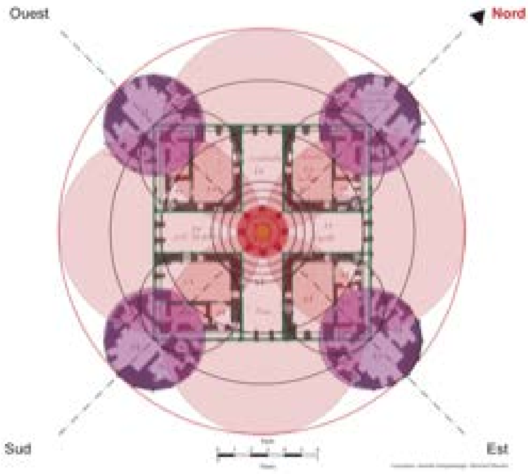
The architect of Chambord, the most famous castle of the Loire, remains an enigma. The absolutely innovative construction of this dynastic castle makes it a true marvel of the world, intended to immortalize his Majesty, the king-builder François 1er. On September 6, 1519, the day he became twenty-five years old, François 1er started the construction of the dungeon. From 1516 onwards, Leonardo da Vinci was the first painter, engineer and "architect" of the king, and housed by him at the manor of Clos Lucé d'Amboise, but unfortunately he died on May 2, 1519, that is just before the construction began.

The geometric design of a quatrefoil in Leonardo da Vinci's notes about the dividing of a circle and the quadrature, is our starting point. (*Codex Atlanticus,* Fol. 471, Biblioteca Ambrosiana, Pinacoteca de Milan). The circular towers of the castle give us the key. Measuring them we discovered that each tower is about 20 meters in diameter: 10 toises, which will be the module of the architectural plan. In those days, the masons used as measures the foot of the king (0.324 meters in length) and the toise (19.44 meters in length, or 6 feet). The measuring instruments of the time are the compass (maximum opening of 6 feet) and the chain of surveying (10 toises), these are also the elements according to which will be drawn the plan and the different scales of the castle of Chambord.

Our communication will outline the principle of the construction. A perfect set of proportions characterizes this ideal construction and coincides with the gold numbers of proportions. Could Leonardo da Vinci be the architect?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CULTURAL ACTIVITIES - REAL AND VIRTUAL GALLERIES AND RELATED INITIATIVES

V. Cappellini (a cura di), *Electronic Imaging & the Visual Arts. Eva 2019*, ISBN (online PDF) 978-88-6453-707-8,

ARCHITECTONIC DESIGN FOR MEDIATING CULTURAL HERITAGE

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At the intersection of research and visual arts we have developed a method for visualizing archaeological hypotheses that explicitly preserves the scientific content excluding any unintentional content. It consists of virtual modeling and virtual photography. Other than usual we do not consider the spatial model as the decisive core but as an integral part of the visual mediation, and its complementary counterpart, the virtual photography, as equally important. Contrasting the usual way to reconstruct architecture in a hyper-realistic way as in the movie industries, we consider our approach a unique 3D Development and Application in the Cultural Heritage Area.

INTRODUCTION

Contrasting the geometric abstraction of the model, strictly based on the verbal hypotheses, our way of depicting the scenery uses traditional methods of realistic architectural photography. Leaving out any of this staffage, the emphasis of our approach lies on translating scientific hypotheses from text to image without leaving the scientific grounds and enabling they images not only to illustrate science internally among scientists as well as toward the greater audience, but enabling them also to mediate the timeless qualities of European architecture as shared patrimony, yet contributing to architecture as European Heritage.

STATE OF THE ART

The usual way of mediating architecture of the past via visualisations has been extensively developed my the movie industry and furthermore by the gaming industry. These visualisations are maximized in their engagement and in their capturing the spectator. Their primary if not only purpose is to give the spectator a feeling of diving into the scenery, of becoming even part of the scenery. This is achieved by an immense amount of purely ficticious additions.

SUGGESTION

Our approach emphasizes on the contrary the scientific content of the visualisation. Vividness is pursued as well but only in second line. Primary targets for our scientific visualisations are:

- Their ability to serve as visual communication just as verbal hypotheses
- Their ability to mediate to the public not only the scientific content itself but also its scientific character, that is, including all uncertainties.

- Their ability to mediate architectural concepts as timeless intellectual achievements, not any longer bound to the era of their creation but serving as eternal sources of architectural inspirations.

The basis for this approach is the insight that also verbal hypotheses profit from their high degree of abstraction. Words are the most abstract means of communication. As just as verbal abstraction is highly if not uncompromisedly accepted, we suggest to use a lighter amount of this abstraction in visual communication means, too.

Fig. 1 Trajaneum, Pergamon, around 200 AD

Fig. 2 Skyline seen from opposite hill, Pergamon, around 200 AD

Verbal scientific hypotheses make use of the verbal abstractions and therefore there is a lot of uncertainty that remains unnoticed. But even if the uncertainty becomes explicit, the verbal habituation allows for vague descriptions and even contradictory alternatives.

The use of abstraction in visual communication reveals a number of benefits: It allows the spatial evaluation, an exchange in another media and therefore in a broader sense and an exploration that leads to further questions and ongoing research. Furthermore, if realized in transdisciplinary teams, visualisations offer the possibility for other disciplines to pose their respective questions, too.

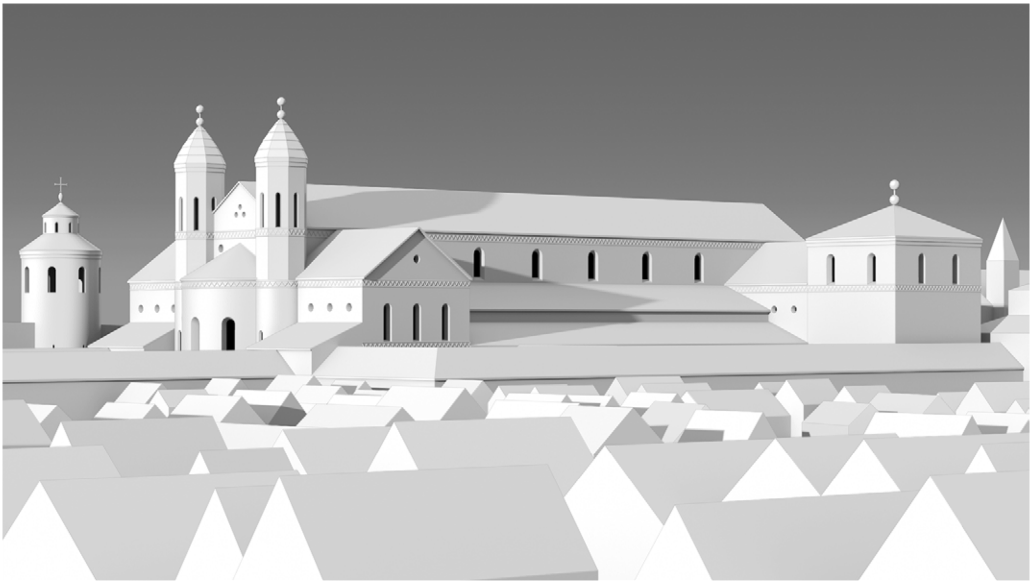

Fig. 3 Alter Dom, Cologne, around 1025

Fig. 4 Cologne Cathedral, around 1540

The public benefits from the combines mediation of scientific content in an insight into scientific uncertainty. It perceives and understands that knowledge may be based on evidence, on analogies and on well-founded hypotheses, and that hypotheses can even be contradictory. It realizes that similarly to reading a text, looking at a scientific visualisation challenges the personal imagination. The visual perception is a concept, reality is a matter of mind. Architecture as a concept may be depicted, but reality remains a matter of imagination. So far this is fine for the primary sciences archaeology, building history and art history. But there is another benefit that arises from scientific visualisations.

Fig. 5 Domus Severiana, Palatine Palace, Rome, second century AD

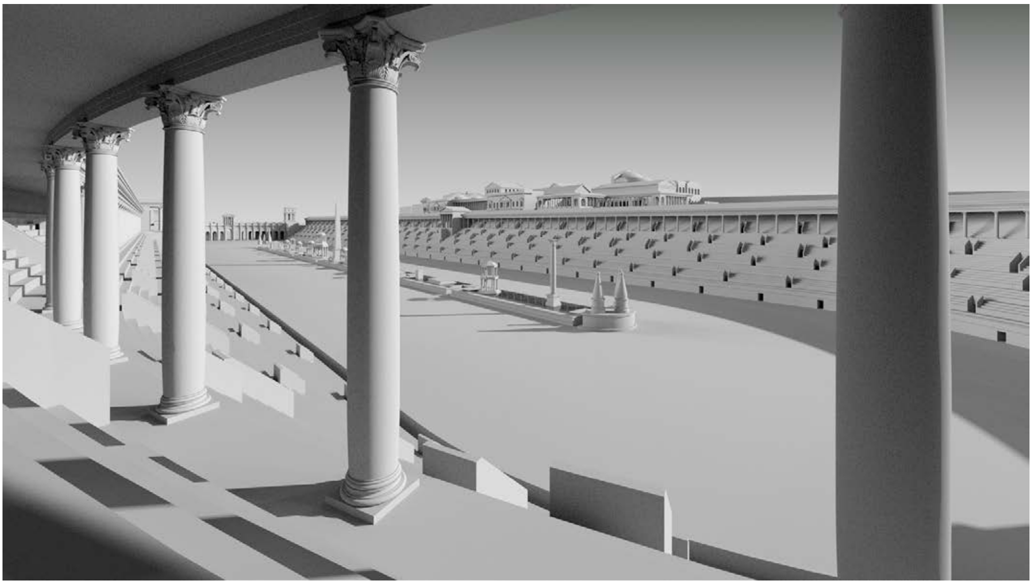

Fig. 6 Circus Maximus and Palatine Palace, Rome, second century AD

As scientific architectural visualisations are limited to the pure architectonic design concept, many other things are excluded that clearly connect with the past, especially the clothing of people, but also other everyday items. Leaving all this apart, the architectural concept of the spatial composition, the relationship of volumes and voids, the transgression in space, all of these are much more clearly perceptible. The supposed loss is actually a gain. The emphasis of the architectonic concept makes the concept timeless. The concept is capable of becoming a source of inspiration for today's design processes. But it also clearly demonstrates the timeless quality and the common foundations of architects of all times. European Heritage as such becomes visible.

Fig. 7 Interior of suggested ideal church by Julius Echter, Würzburg, seventeenth century

Fig. 8 Exterior of suggested ideal church by Julius Echter, Würzburg, seventeenth century

The challenge is to combine the abstraction of the verbal hypotheses with the necessary capability of the visualisation to engage and capture the spectator. This requires a coordinated set of parameters from the modeling to its projection. One major requirement is the coherence of the image. This means that every element is an integral part of the scenery. This cannot be achieved without compromises. But as we negotiate a lot with the primary scientists, we reach at least a state free from contradiction. The first step is to design abstract geometry that represents the hypothetical content together with its uncertainty. In the second step the abstract geometry is photographed as if it was real. Just like a photographer we search for suitable spots and illumination. We call this step „virtual photography".

Fig. 9 3D model and VR of suggested ideal church by Julius Echter, Würzburg, seventeenth century

If coherence defines the content of a visualisation, there are two major factors in photography that are responsible for a proper evaluation of the hypotheses. These are the unambiguous eye level and the unambiguous inclination of the view. On this basis, there is still an infinite range of design decisions. It is not trivial at all which time of day you take the photo at and which lense you use. The design quality of the photo determines the impact of the message.

Moving pictures enrich the spatial experience. Cross-fading makes changes easer to notice and to compare building phases over time. Moving cameras reinforce the spatial impression. Physical models close the circle from the spatial hypothesis via the verbal and visual representation to a fully spatial experience. They allow an immediate vision as the spectator can freely move around the object. Except they are not suitable for real scale buildings. Real scale experience is where Virtual Reality becomes indispensable. The scales in VR are flexible, architecture is at least visually perceivable close to reality. The visual field is limited, the viewer looks as through diving goggles. Apart from the visual constraints, the major difference is the lack of real movement. Also, the spectator does not see his own body apart from stylized hands separated. This enables the user to interact with the virtual objects. But visually the technology is not yet mature. The resolution grid is visible and the latency creates travel nausea at some users. As long as latency and resolution both do not match nature, VR is an experiment with advantages and disadvantages. Until this is resolved, a large perspective has its own qualities and “virtual photography” remains an important factor in the mediation of lost architecture.

Proximity to scientific hypotheses always includes compromises. Especially the weighing of geometry against polychromy constantly demands hard decisions. The scientists’ priority has so far always been to abandon the very uncertain polychromy in favour of the comparatively certain geometry. This applies to nearly every situation in classic antiquity although the buildings of the time have generally been polychrome.

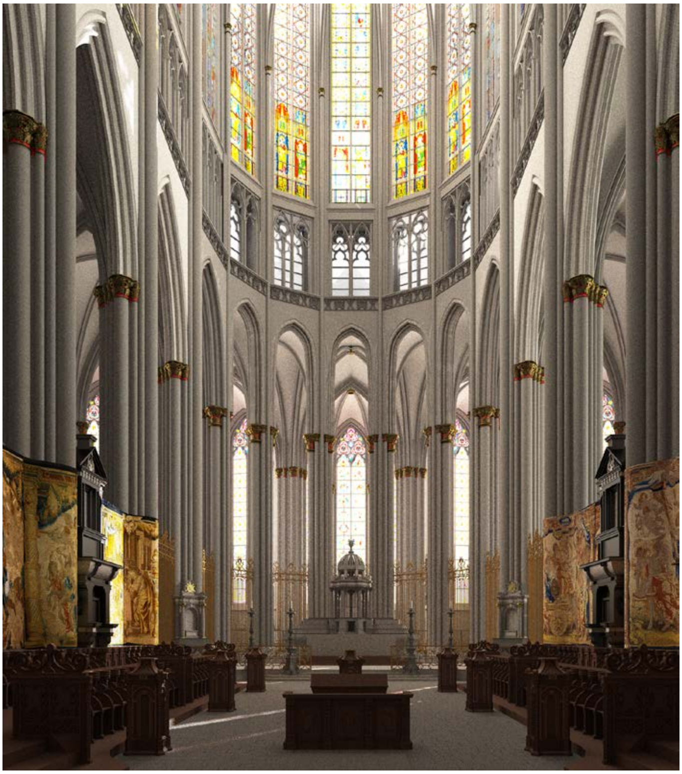

Fig. 10 Cologne Cathedral, Choir, around 1850

But colour is visually dominant, and because the colouring is in most cases so highly fictitious the geometry would nearly remain imperceptible. In later eras, the findings and therefore the knowledge becomes more certain, and in cases where the majority of the image parts are well knows in their particular polychromy, a scientific visualisation can be rendered polychrome under continuous consideration of the principles of proximity to the hypotheses.

The project of the metropolis of Pergamon (Fig. 1 and 2, by Dominik Lengel and Catherine Toulouse, BTU Cottbus-Senftenberg) [1,2] was funded by and elaborated in cooperation with the German Research Fund Excellence Cluster TOPOI. Its last monographic exhibition took place in Leipzig in 2018 as part of Sharing Heritage, the European Cultural Heritage Year 2018 and so being literally a European Commission project regarding cultural heritage, including 2D – 3D Digital image acquisition for the re-contextualisation of 3D scanned sculptures in their hypothetical original architectonic context. Since 2008 scientists work with the geometric accuracy of this first three-dimensional overall model of the metropolis. The model does not only evaluate spatial relations, it also reveals unforeseen visual phenomena.

The project of Cologne Cathedral and its Predecessors (Fig. 3 and 4, by Lengyel Toulouse Architects, Berlin) [3] was funded by and elaborated in cooperation with the cathedral hut. It is being exhibited in the entrance area of the archaeological zone in the cathedral since 2011. The choir (Fig. 10, by Lengyel Toulouse Architects, Berlin) [4] was funded by the choir of Cologne Cathedral and elaborated with the archive of Cologne Cathedral.

The project of the Palatine Palaces in Rome (Fig. 5 and 6, by Lengyel Toulouse Architects, Berlin) [5] was funded by and elaborated in cooperation with the German Archaeological Institute in Berlin and was first exhibited in the Pergamon Museum Berlin.

The project of the Ideal Church of Julius Echter of Mespelbrunn (Fig. 7–9, by Lengyel Toulouse Architects, Berlin) [6,7] was funded by the the Cultural Foundation of the German Federal States and the Bavarian Savings Bank Foundation and elaborated in cooperation with the former building master of Cologne Cathedral, Prof. Dr. Barbara Schock-Werner. It was first exhibited in the Martin von Wagner Museum in the Würzburg Residenz exploring human–computer interaction for cultural heritage applications by combining flat visualisations with physical models, an auto-stereoscopic explanatory video and an Oculus VR experience.

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Innovative methodologies and technologies.
Civil liability and "genetic code" of a work of art

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Abstract
The art world witnesses the path the evolution of mankind. Therefore its value derives not only from the conservation of the material of the work of art, but also from the recovery of the *intangible heritage* that determines its "*reason to exist*".
Modern times impose an adjustment to the cultural heritage sector that lays the foundation for its valorization and safeguard, in order to become a resource with a continuous growth.

Smarticon: a methodology to support the Cultural Heritage system

Smarticon is a patent demand number 102015000006508. It is a "*Method for the classification, cataloguing and tracking of valuable assets, in particular works of art*".
Innovation arises from the *awareness* of the needs and the critical aspects of a sector and it takes shape through the identification of avant-garde *solutions*: that are able to solve problems, improve the state of the art and adapt to the *needs* and *priorities* imposed by the frenetic progress that characterizes modern times.
The valorisation of an art work assumes the *awareness* of having to preserve and re-evaluate it according to two fundamental criteria: *conservation*, intended as the restoration of the material that forms the good and which is identified in the "**material heritage**"; but also the recovery of the *cognitive heritage*, which allows the "*comprehension*" of the meanings hidden behind the image and which represents the "**intangible heritage**" of an artefact.
The **heart of Smarticon** is a complex database within which the information assets lavished by the experts (the source of knowledge), assumes a **hermeneutical sorting** and becomes easily accessible by the user.
The method is **cognitive** and interrelates the characteristics of an artefact with all that information (currently without an order), suitable to trace the historical path and the origin of a good (published or unpublished).
The first step consists in the recognition of the subject portrayed in the work of art (of any type and origin), through the **identification of the iconographic attributes** that characterize it.
Once the represented subject is identified, the Smarticon system allows to study in deep the research (within the "subject record card"), to also **identify a historical and geographical origin.**
The iconographic typology, in fact, over the centuries, has undergone frequent variations, which allow us today to establish real and true "rules" useful to identify the historical context from which the artefact originates.
We can open a parenthesis. Think of the representation of the Crucifixion. Over the centuries it has undergone many iconographic variations, reflecting the dominant features of the thoughts and religious feelings of each period. For example, the Virgin, who was depicted standing next to the Cross until the Middle Ages, in the fifteenth century is now cowered on the ground because the artists emphasized her pain. The Council of Trent condemned this interpretation and re-established the iconographic "rules"

imposed by the texts of John the Evangelist: therefore, after the mid-sixteenth century, Mary was represented again standing.
These iconographic characteristics represent a reasonably shareable and demonstrable resource for the purposes of "*coding*" a work of art.
Other databases investigate the relevance of further information with the characteristics of the artwork under exam: the chemistry of pigments, ancient historical documents in which descriptions and/or ancient censuses are present, images of comparison between different types of manufacturing, old notary deeds, censuses in collections, publications, exhibitions, etc.
Smarticon, through engineered and methodical processes, *investigates* the recovery of the intangible heritage of an asset, enhancing it both from a historical and from an economic point of view.

"The noises of the world, of the weapons, of the conflicts strike me deeply. The severity of the crisis of society and of humanity have driven me to research at a radical level of theory, towards a progressive reorganization of the structure of knowledge"
Edgar Morin

The role of Smarticon and the blockchain in art

The blockchain other than a technology, is a paradigm in which the register is structured in a series of blocks that contain the transactions and whose validation is a consent mechanism distributed on all the knots of the network authorized to participate in the process of validation of transactions (Https://www.blockchain4innovation.it/esperti/blockchain-perche-e-cosi-importante/).

It allows the transfer of currencies, information and contracts in the framework of a decentralized infrastructure and **accepts all types of digitization**.

The blockchain is based on five fundamental concepts: decentralization, transparency, security, immutability and consent.

It is a "*platform that allows the development and the concretization of a* ***new form of democracy****, really distributed and able to guarantee everyone the possibility to verify, to" control ", to have a* ***total transparency on the deeds and decisions****, that are recorded in immutable and shared archives that have the characteristic of being* ***unalterable, unchangeable*** *and therefore* ***immune from corruption***". (https://www.blockchain4innovation.it/esperti/blockchain-perche-e-cosi-importante/)**.**

In the artistic sphere, the blockchain allows to equip the artefact of a code, within which all information relating to the asset is recorded (expertise, publications, diagnostic analyzes, transfer of ownership, prices, etc.).

"*The technological solutions defined as blockchains fall within the field of the Distributed Ledger Technologies, that means that it is about solutions based on Distributed Registers that allow the reading and modification by several subjects participating in the Network. The elements of differentiation between the various typologies of DLT are primarily in the* ***modes in which we "govern" the control and the verification of the writing actions on the Register, on the modalities and the type of Consent necessary to validate these actions and on the structure of the distributed register itself****."* (Article by Mauro Bellini: "Blockchain: what it is, how it works and the application areas in Italy").

The cognitive patrimony lavished through the processes of Smarticon, lends itself to become one of the "blocks" of the code of the blockchain and will assume a strategic valence because the recovered information derives from sources considered univocally certain, therefore they are to be assumed as "valid".

The goal is to obtain awareness of **the work of art as a whole**, since it is **at the same time a material good and an intangible heritage.**

This process of enrichment, codification and preservation of the "*genetic code*" of each artefact of art will allow to reach new horizons of knowledge and sharing; but it will also assume a strategic role in terms of safeguard and security within the sphere of law enforcement.

The recovery of this precious information represents an *objective* documentation also to support the *subjective* work of the experts, who are in any case entrusted with the task of definitively certifying the asset and, as an implicit and direct consequence, of certifying its value.

The time is ripe so that all contributions (methodologies and technologies of various kinds) may converge towards a single tool, to safeguard one of the most important sectors of each civilization.

Smarticon and machine learning

Computer sciences and communication networks have become essential tools for the researchers of humanistic science.

In the art world, the new challenge of information technology is to provide to industry insiders effective tools for data analysis, with the aim of facilitating their use and study and to promote digital heritage and cultural content accessible through archives, museums and libraries.

In this context, artificial intelligence (AI) is the tool to correctly process information, with the target of building and making available digital libraries that are easily accessible to any type of user.

The integration of methods, services, systems and interoperability between different data structures, metadata and components, are key issues that have to be addressed by the scientific community to provide appropriate solutions to the needs of the sector.

In this context, Smarticon's innovative contents lend themselves to support the community of scientists and researchers, offering them a patented method to collect and organize digital information from the Cultural Heritage sector in digital form.

Aside from this peculiar knowledge base, Smarticon will be usable as a cloud software application that will exploit artificial intelligence to apply cognitive methodologies to support the user (scientist, researcher, tourist, occasional user) in tracking down and discovering unknown information and / or not obvious relationships on the work of art being investigated.

The advancement of technology imposes to fulfil the need to be able to study the work of art through tools that allow to achieve a more focused and conscious comparison between the user and the artefact: be it a work of art, an architectural artefact or a complex system like an area of the city.

All the IT procedures, of course, will always be supervised for approval by the experts, since the human experience remains irreplaceable.

Artificial intelligence represents a strategic tool, since it harmonizes and enhances the functionality of innovative technologies, of the tools already available and of their effective application to the whole humanistic area.

In this sense, Smarticon will act as a sort of interactive encyclopedia in the sector of Cultural Heritage and will be able to advance hypotheses, identifications, information, diagnoses, relations with other works of art that are distant (or close) in time and space.

This "guardian" and "tutor" of culture, in the form of a software application, will make access to information much easier than an online encyclopedia and will obviously provide a much more vivid and profound cultural experience: an interaction and not a mere consultation will be created.

The management of Cultural Heritage. Innovative methodologies and technologies. Civil liability and "genetic code" of a work of art

Today, numerous companies vigorously practice the so-called "*civil liability*" towards the company. For example the pharmaceutical market and food production, which provide basic needs to people.

The Cultural Heritage also supplies the primary need for culture and civilization to society.

It is therefore beyond doubt that those who manage art must do so with a *civil, ethical* (choice of correct behaviour) and *deontological* (with sense of duty and professionality) towards *humanity*.

The world of art, besides being an inestimable cultural value, it has always represented an important resource to preserve and enhance: both for those who must administer it (museums, foundations, banks, etc.), and also for the antique market (auction houses, merchants, etc.) and for collectors.

Over the centuries, the figure of art dealers has nourished thriving businesses that, often and still today, can be definitely more profitable than many other investments.

The Cultural Heritage sector, in fact, through the course of recovering the preparatory information necessary for the enhancement of the asset, can generate enormous capital gains between the purchase price and the resale price on the market.

However, a fundamental aspect must be emphasized: the opportunity to generate substantial profits corresponds to the danger of high investment risk.

The authentication of the value of the good is "without question" subordinated to the consent of very few experts who represent the only figures of reference for the attribution of the artefact to a specific artist.

If the work of art is not recognized, the investment is irremediably lost and without any possible valid alternative.

A question has to be asked: how many times our investment in art will meet the favour of the experts responsible for approving and validating it?

This mechanism, although acceptable given the characteristics of the sector, also represents a considerable deterrent at the expence of the "*passion investment*" and, moreover, it witnesses an aspect that makes it largely "foreign" and "independent" compared to the practices that characterize the other business sectors.

The other market segments, in fact, have to adapt their strategies to the increasingly pressing need to comply with the "best practices" that influence both the longevity of a given business and the proposer's affirmation on the market.

In this regard it is interesting to mention one of the stimulating articles published in the book by Danilo Broggi, an expert in economics and finance (*"Diario di bordo. Tra innovazione e cambiamento"* (*"Logbook. Between innovation and changement"*). *Pu*blished by Guerini and Associates).

L'autore, nel capitolo 52 intitolato "*Il (falso) oro del reno*", afferma: "*…l'obiettivo di massimizzare il profitto senza rispettare dettami, norme, precetti e buone pratiche, esce dalla piattaforma del mercato e diventa mero capitalismo".*

The author, in chapter 52 entitled "*The (false) gold of the Rhine*", states: "*... the goal of maximizing profit without respecting dictates, norms, precepts and good practices, leaves the market platform and becomes mere capitalism*".

Broggi tells us how the company that invests the most in innovation in the world, the colossus Wolkswagen (the world's first company in the automotive sector), "*... behaving like a capitalist, but breaking the rules of the game*", "*... consuming the emissions scandal ...* "*has prompted the market reaction that" ... came with unprecedented violence ...* ", generating a loss of ten billion dollars for the value of the Wolkswagen brand, eighteen billion dollars for car collection and fines, the collapse of the worldwide sales and other consequences such as reputational damage.

The book states that "*... capitalism is unfinished without market behaviour ...*".

In the past, the field of Cultural Heritage has adapted to mechanisms which are too independent from the rules of the free market.

Lacking a decisive push towards innovation and the sharing of the mechanisms that regulate this segment compared to the current models, the critical aspects of the sector have left room for scope for action with the violation of rules and good practices. They also ended up nourishing illegitimate traffic and crime, which have found fertile ground in a multiplicity of "loopholes" to elude controls.

The police forces are still counteracting illegality without being able to count on the strategic support that could arise from the concept of a real shared "*system*". In this regard we will cover the topic in the next chapter.

Another fundamental aspect, that testifies how innovation implies an effort to adapt, is the awareness that until a few years ago it did not seem ethical to do business through art. The mentality of the sector employees was so reluctant to the vision of Cultural Heritage as a source of economic resources, and also skeptical in thinking of profiting from it by planning business strategies (as if economic resources belittled the value of the asset or as if to preserve it, restore it and to enhance it was not necessary to put in place strategies aimed at finding the funds to then make investments).

The efforts made have always been concentrated mostly on the enhancement of museum activities (which would benefit not negligible benefits from sharing knowledge by participating in the "market platform"). But today the mentality is changing.

An important seed of innovation has sprouted a few years ago, when a new horizon was opened oriented towards collaboration between public and private sectors and overcoming bureaucratic obstacles in favor of communicating a fundamental concept to the world: the awareness of a shared vision of Heritage Cultural as a *resource of humanity*.

I believe that this "partnership" has definitively consolidated with the financing of the businessman Diego Della Valle for the restoration of the Colosseum: an extraordinary enterprise of global resonance, which has switched on the spotlight on Tod's brand guaranteeing an enormous propaganda value on an scale international scale, with everything that with everything that follows. This operation has forever linked the name Tod's to one of the most important monuments, known and visited in the world!

The merits of the businessman are to be admired, he who, with his determination, has resolved every bureaucratic obstacle and marked an epochal turning point by setting a concrete precedent in the convergence between the interests and the mentality of the public and the private.

This strategy represents a striking example of how the relaunching of a company's production system can, at the same time, bring and benefit from the collaboration between two realities, two realities until recently independent one from the other.

Even in the context of projects finalized in innovative methodologies and technologies, strategic synergies can be created between the public and the private sector for the benefit of both!

Still quoting Broggi's book: "*... Digital innovation can / must become one of the fundamental levers both to improve (and greatly) the relationship between the citizen and the administrative bureaucracy, and to support the relaunch of the productive system ... it takes ... new tools, new methods and, above all, a* ***shared*** *vision on the challenges to be faced and the ways with which intervene ... A systemic approach is needed…*".

Does a question arise spontaneously? To what extent the market segment dedicated to Cultural Heritage will wait to adapt its "*best practices*" to the physiological and frenetic technological evolution that characterizes our times?

Innovating means enhancing and safeguarding Cultural Heritage, meeting the sharing needs, adapting its survival according to the actual needs, as well as consolidating the strategic role that this sector can perform at a social and humanistic level throughout the world.

It is necessary to integrate and adapt to the mechanisms that regulate the market, so that the economic resources necessary for investments can be produced; since there cannot be innovation without the use of economic resources.

But not only. *With the advent of the internet, it is becoming essential to adapt the "genetic make-up" of a work of art to the consent of a plurality of factors.*

There are many technologies and projects dedicated to the enhancement of Cultural Heritage and as many public and private efforts projected in this direction (for example, you can see the new indications of European directives).

The mechanisms that regulate Cultural Heritage will not be able to avoid dealing with the rules of the global market, with new technologies and with the *best practices* for the growth of each sector and for free competition.

Cultural heritage is a *resource of humanity* and, for this reason, the need for "*sharing"* is increasingly pressing ... and "*sharing*" can only be planned through the use of innovative methodologies and digital technologies.

The target is to create a *system* that makes interaction, comparison, monitoring and control of one of the most neuralgic sectors on a global scale possible.

The world of art projected towards the traceability of goods and free competition

The time is ripe for the art world to adapt to the laws of the market, harmonizing and aligning itself with the inevitable rules of *best practice* of every good business.

In 1904 the first *art found* fund dedicated to art was established (La Peau de l'Ours). It had an extraordinary success thanks to the prudence and foresight of the promoter of the investments, who bought only a few works of the highest level and at affordable prices.

Later a multiplicity of initiatives followed one another, but the only ones to achieve modest results are the "*British Rail Pension Fund*" (established by the English railways for the benefit of its employees in 1974 and which in any case had not success as the first), and the "*Fine Art Fund*".

The fact that both of these last two funds were linked to two important auction houses: respectively Sotheby's and Christie's, is not negligible. Namely the two realities that hold the "control" of the largest slice of the market segment on a global scale and, therefore, to be considered among the most expert and aware of the mechanisms of the market on a global scale.

All other funds have not recorded great results. Many have even remained inoperative. Why?

There are basically five factors that determine the success of an investment in art:

- the first is inherent in the foresight and intellectual honesty of the promoter;
- the second determinant element is in the state of conservation of the work of art, in its integrity and in a scrupulous and conscious restoration (material heritage);
- the third and not insignificant limit of investments in art (at least for what concerns the Italian legislation), focuses on the ability to find valuable works of art accompanied by certificates of free and legitimate circulation, since the international market offers better opportunities to generate capital gains;
- the fourth point is explicit in the ability to recover as much information as possible concerning the historical path of the work of art (immaterial heritage). Furthermore it is important that these data are

reliable, shareable and verifiable, in order to also support the study path of the experts in charge of certifying the good;
- the fifth step is the certification of the good by the experts (appraisal, exhibitions, publications, etc.).

Basically, the enhancement of the asset passes through the conservation of the material (material heritage) and the recovery of the "genetic code" of the work of art (immaterial heritage), for a better "guarantee" of authenticity and a prerequisite for its enhancement .

Improving the quality and reliability of the offer means containing the risk of losses of both the cultural and economic value.

Furthermore, protecting the capital of the investors, stimulates the growth of the demand and increases "*passion investments*" (which currently represent around 24% of the market) are increased.

The innovative methodologies for Cultural Heritage (such as Smarticon), artificial intelligence and blockchain technology represent the tools that generate knowledge and awareness of the good and that provide the contributions for that innovation that is essential not only to adapt to the times but also, as Broggi observes, to fulfill the need to *"... establish independent supervisory authorities with regulatory functions that, together, guarantee the application and respect of the rules, promote free competition and at last protect the weakest individuals to defend themselves who interact inside and outside the company areas ... "*.

These considerations, which represent the rules of good conduct in the other business sectors, assume an even more strategic value for the Cultural Heritage, as the particular critical aspects of the sector generate the even more vital need for greater *regulation* and *transparency* for the benefit, for example, of the fight against the illicit traffic of works of art.

The Cultural Heritage sector needs a sustainable business model, which arises out from the idea of conceiving a scheme that generates the presuppositions for an open and free competition, which allows to adapt to modern times and to provide fair tools for a greater guarantee of the investments and investors; since "*capitalism is unfinished without market behaviour*".

Greater monitoring of the ownership changes of the asset /origin and subsequent sales) and of the custody of the related information (appraisals, exhibitions, condition reports, etc.) is required. These data which accompany the artwork will have to be traceable, encrypted and recorded in immutable and shared archives that have the characteristic of being **unalterable, unchangeable** and therefore **immune to distortive manipulations.**

This strategy represents an essential tool for the fight against crime and a deterrent for the illicit market and for inexperienced collectors (especially if, living perhaps abroad, they think they can evade controls with more ease).

In the area of security, the aspect of monitoring the free movement of goods should not be neglected either, which is another neuralgic point of this sector.

Last but not least, money laundering and terrorism are also nourished by investments in art, which are well suited to justify substantial movements of money and buying and selling operations with very advantageous capital gains.

Today innovative methodologies and technologies can create a greater synergy through their harmonization and give life to a real "*system of Cultural Heritage*", in which each component is also monitored through the decentralization, transparency, security, the immutability and consent that govern the mechanisms of the blockchain.

The benefits would not be negligible and the effects would have positive consequences on the whole system.

In 2005, **a first version of the current Smarticon method** has been specifically designed to facilitate the identification and recovery of stolen works and **has been provided to the Carabinieri Corps for the Protection of Cultural Heritage for the "Leonardo System".**

The innovative contents have been the subject of commendations and awards (Site: www.smarticon.it).

It is hoped that the invaluable base of knowledge created by this first installation can be included as an integral part of the knowledge base of the new Smarticon, which implements the new technologies.

"... art is the instrument by which man has written the history of his civilization…
… the work of art is the expression of a refined culture, which will survive long after the death of its creator… in timeless space without borders…
… our artistic heritage represents the most precious good, allowing mankind to become aware of its origins and of the evolution that led us to be what we are today".
Sara Penco

INFORMATION TECHNOLOGY IN CONSERVATION AND RESTORATION OF ART WORKS: PERSPECTIVES OF UKRAINIAN UNIVERSITIES PROJECT

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This paper presents Ukrainian inter-university educational and scientific project on the introduction of information technologies to the restoration of works of art. The approach of increasing IT usage in the processes of conservation and restoration of artworks, and the use of data science and IoT methods in particular is considered. Further research ways and the project development directions are determined.

INTRODUCTION

Today IT supports all the spheres of life and conservation and restoration of art works should not be the exception. The coherent Ukrainian project working group for the introduction of IT to the field of art works conservation and restoration consists of the representatives of three universities: Taras Shevchenko National University of Kyiv, National Academy of Visual Arts and Architecture, Kyiv and State University of Telecommunications, Kyiv. The project objective is to improve the information-analytical, educational and practical aspects of conservation and restoration of art works based on the implementation of IT.

Traditional approaches to the conservation and restoration processes of art works can be characterized by the high influence of the human factor, the difficulty of the physical and mathematical description, and the considerable amount of data processed [1]. In addition, the preciousness and uniqueness of art works requires adequate decisions regarding the current state of a particular monument, the choice of methods of conservation and restoration and comparative estimation of the cost of conservation and restoration, localization and analysis of losses, late records and layers etc., and also the provision of the possibility of preliminary visualization of the expected result.

Not less important is the need to create appropriate microclimatic conditions for both conservation and restoration processes of art works and subsequent storage of monuments. This requires the use of modern IT such as data mining, machine learning, AI, IoT etc. The implementation of these technologies for solving the above-mentioned tasks of conservation and restoration of art works is what the activities of the project participants are devoted to. At the moment, the main areas of research within the project are identified, and being discussed below.

The informational and analytical part of our work includes the systematization of restoration passports and creation of a search engine, by standard, unified items, as well as according to special characteristics of the state of preservation of a particular artwork, restoration processes, used restorative materials and chemicals. Such a system makes it possible to combine the exhibits with similar technics and technological characteristics, to monitor and analyse the restoration processes and the results of the restoration measures taken. The significant base of photo fixation of exhibits (before, during and after restoration) in different types of lighting has existed since the foundation of the Department of Technology and Restoration of Works of Art of the National Academy of Fine Arts and Architecture in 1969. Consequently, this is a remarkable visual material that is also a subject to systematization, analysis and management of data.

The necessary component of our project is the expansion of the educational process features. The systematization of the search for information in the restoration passports opens up the possibility of connecting the points of search of the restoration measures taken to the curricula component parts of the discipline "Restoration of Easel Painting" (the author of the program T.R. Tymchenko). Also, this systematization of the search can be used for visual preparation for practical questions in students' tests. Such a systematic search is a unique unpublished database for students, postgraduates, lecturers, and scholars.

APPROACHES

To improve the modernization of the informational learning environment at the Department of Technology and Restoration of Works of Art of the National Academy of Fine Arts and Architecture, the project group is working on the creation of a unified data base for the accumulation, search and analysis of information. Such developments are relevant and will definitely serve to optimize the learning process. Ukraine already has successful examples of IT technologies implementation for the accumulation and systematization of information in the field of restoration [1-3]. Thus feature of our project is a multidirectional approach to the use of systematic information. The project organically combines informational and analytical, educational, methodological and research components.

There are many opportunities for using IT in the restoration of works of art [4-6]. In our opinion one of the most promising is the use of Data Science methods. This is primarily due to the presence of a significant amount of data in the subject area of restoration of works of art, on the basis of which a number of studies are required.

Consider the approach to applying data science methods in the restoration of works of art. The generally accepted algorithm for data analysis includes the following steps:

1. Receiving data
2. Preparation of data
3. Model training
4. Testing the accuracy of the model
5. Obtaining and visualizing the results of simulation.

At the first stage, digital projections of works of art are obtained from the results of various kinds of photography, like spectrographs, schematic images of various technological layers, stages of restoration processes, etc.

Then, data is being prepared. The resulting set of projections requires pre-processing to bring them to a single size and resolution. After bringing all the projections received into a single coordinate system, one can consider the digital model of the original in the form of a set of points, each of which contains a vector of numerical characteristics obtained from a set of corresponding projections. That is, the digital model of the original is presented in the form of a multi-layered object, each of the layers is presented in the form of a matrix (array) of points with corresponding characteristics derived from the construction of a separate projection. Summarized this digital model is a data set. On the basis of the data set, it is possible to build a variety of models to obtain a certain result. As a result of pre-processing, a unified set of projections is created, which uses a variety of mathematical methods, and data mining methods in particular.

At the model training stage, according to the problem, various data science methods such as linear and nonlinear regression, classification, clusterization, etc. are used. According to the results of the stage, parameters of the model are obtained, which allow to determine the necessary parameters of the result on the basis of a digital model (for the given example - assigning model points to damaged areas of a work surface, which, in proportion with the total number of points, will determine the fraction of the damaged (lost) surface).

To assess the accuracy of the model, its practical application for another set of data and the comparison of the results of simulation with the actual state of the work is carried out. When sufficient accuracy is achieved the model is considered suitable for further use.

Consider the proposed approach to determine the total area of the damaged (lost) surface of the work of art based on the clustering method. According to the method, data with similar attributes is combined into separate clusters, among which it is possible to select clusters which include points from damaged sites of the work (see fig. 1).

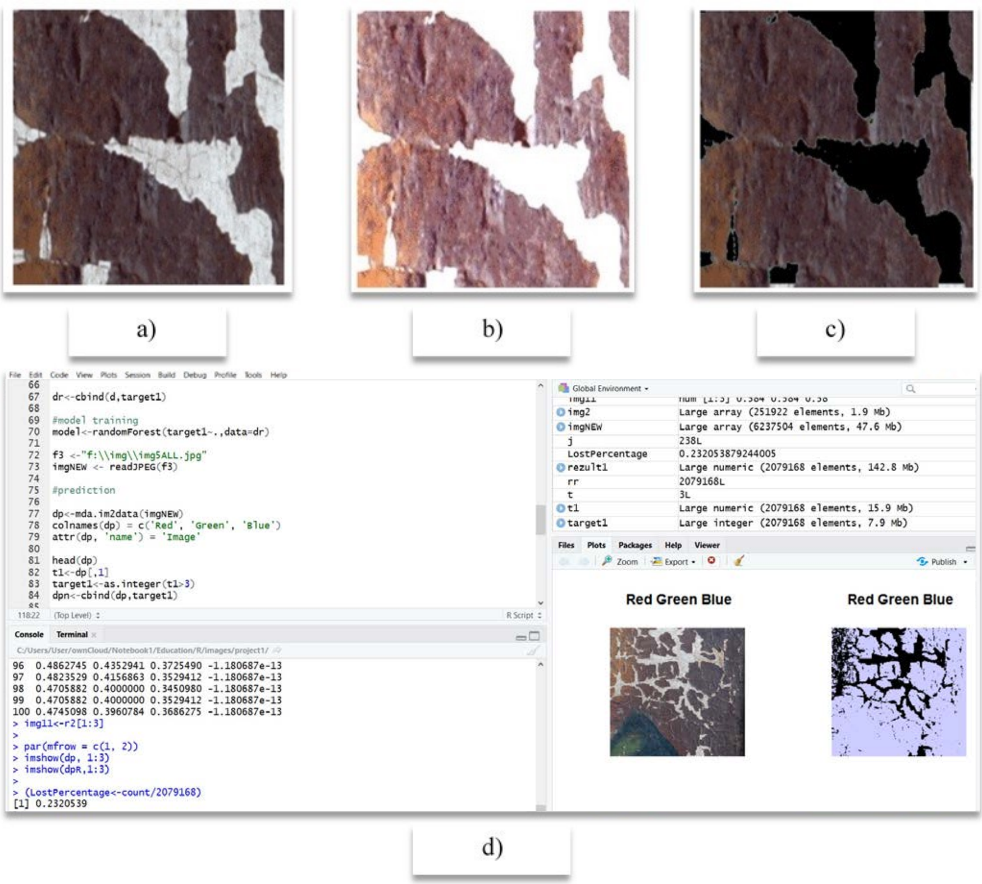


Figure 1. Determination of the area of the lost parts of the art works on the basis of data science approaches (a – art fragment, b – fragment pre-processing, c – clustering into the base data set visualization, d – lost parts determination using data science approaches)

Figure 1a shows a photo of a fragment of art work with lost parts. After pre-processing the image, we obtain a photo with increased contrast of the intact and damaged sections (see fig.1b). Applying the clustering method to this image, we obtain the initial set of data for further modelling (see fig.1c). In this set there is already a target areas distribution with the corresponding characteristics, which allows you to train the model and evaluate its reliability. After that, the model is used to determine the area of the lost sections of the whole work (see fig.1d). Similarly, it is possible to solve more complex image processing tasks to automate the restoration of works of art.

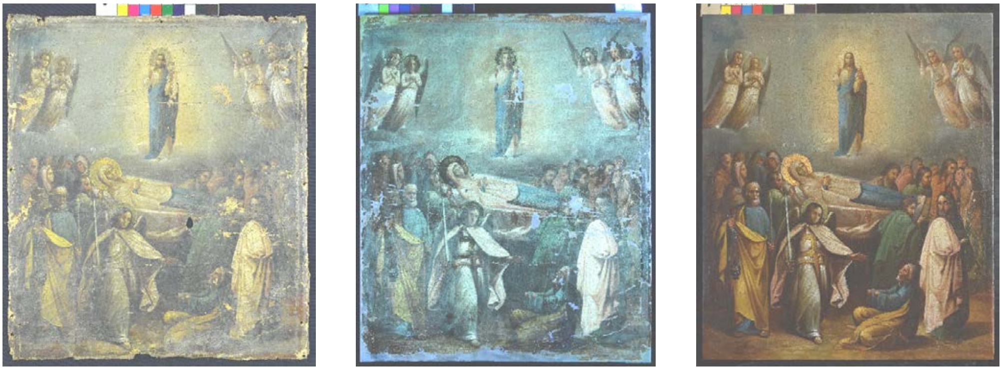
Also it is promising to create information and learning environment for organizing the data base for accumulation, search and analysis of data that can be used to develop, control and improve the educational process. On the basis of web development technologies, databases and big data, it is planned to create an Internet platform that will serve as a powerful tool for working with the information obtained from the experience of carrying out conservation and restoration work in the past, at the moment, as well as the prospects of the field. The possibility of integrating this platform with other projects, including international ones is being taken into consideration.

The research part of the project creates a wide array of practical applications. For example, for restorers, it has always been a difficult task to determine the volume loss of the base, the priming and the paint layer in relation to the total area of the picture, to determine the exact size of the losses and breakouts of canvas, and their coordinates (see fig. 2). The measurement process would take a lot of time and the result would be inaccurate. Application of IT technology significantly reduces the time and efforts involved in this process and gives more precise results.

Figure 2. General view of the Ukrainian icons of the 18^{th} – 19^{th} centuries before restoration, authors unknown.

Within the framework of the project, programs for analysing photo fixation in ultraviolet rays (see fig. 3) are being created. After all, the dark spots of overpainting, which are better shown in such a shooting, can be processed, amplified with the help of IT technologies, and impose on the photo taken in normal light. Such developments will facilitate the removal of overpainting.

The roentgenographic research is obligatory for restoration of artworks, having several layers of different time overpainting [7]. Digital images which are made by using a computer tomography also give an idea of the lower layers of painting (see fig. 4). Creating a program for overlaying a digital image of a computer tomography and a digital X-ray image into images in normal light is essential for understanding the layout of the lower layers of the image relative to the top layer and conducting other studies that are essential for the restoration of the exhibit.



a) b) c)

Figure 3. Ukrainian icon of the unknown author "Assumption of the Blessed Virgin Mary", 19th century. Bachelor's Diploma on Restoration of Artworks by Antonina Mykolaichuk, 2018. General view of the icon before restoration (a), photophixation of visible luminescence in ultraviolet rays in the process of restoration (b) and after restoration (c).

Figures 4. General view of Ukrainian icon "Christ Pantocrator", author unknown, the beginning of the 20th century and a snapshot of the computer tomography of the central part of the icon, on which we can observe the lower, author's layer of painting of the 18th century

In the curriculum of the master's degree at the Department of Technology and Restoration of Works of Art of the National Academy of Fine Arts and Architecture there is a discipline

"Examination of Works of Fine Arts", the program of which provides a comprehensive examination of the artwork and writing of an expert-attribution study of a painting.

Application of IT technologies for better reading of author's signatures and their counterfeits is already used for examination and attribution of artworks by the expert of painting Volodymyr Tsytovych [1]. Within our research is the introduction of computer programs, the use of different modes of detection of tone and colour contrast in order to improve the ability to identify half-effaced elements of the image and signatures.

The issue of the reconstruction of lost elements of the image of artworks has always been debatable in the context of restorative ethics. The variability of computer reconstruction makes it possible to choose the most appropriate method of reconstruction and conservation for a specific artwork.

Methods of computer reconstruction of lost parts of the image and signatures on the icons were described in the professional literature on restoration [8, 9], but are rarely used in practice. In our project, we explore the existing methods of image reconstruction, adapt them to a specific artworks and aim to make them more accessible to use.

DISCUSSION

Such an analysis will allow the virtual decomposition of art works, determine their current status as well as before and during the conservation and restoration, the degree and feasibility of restoration measures. Further it will allow to optimize the volume and sequence of conservation and restoration processes, and in the future, on the basis of IoT means, they could be partially automated. The subsequent development and improvement of these approaches to the projection materials analysis along with the accumulation of relevant experience will open the way to the use of machine learning and AI methods.

Managing information and learning environment is crucial for organizing the data base for accumulation, search and analysis of data. This will result in developing, controlling and improving the educational process. To achieve these goals, the Internet platform will be created on the basis of web development technologies, databases and big data. This platform will serve as a powerful tool for working with the information obtained from the experience of carrying out conservation and restoration work in the past, at the moment, as well as the prospects of the field. Such a platform is viewed as one which can be integral part of other projects including international ones as well as evolving other projects in its development and upgrading.

Moreover, one of the research directions of the project should be the use of modern IT facilities for the equipment of specialized premises for the conservation and restoration of art works. This direction involves the use of the capabilities of microcontrollers, sensors and other means of robotics to create separate elements with their further integration in complexes and networks. Among the main tasks of such complexes and networks are maintenance of the optimal microclimate of premises, robotic acquisition of projection materials, possible partial automation of the processes of conservation and restoration of art works.

Finally, the preliminary assessment of the above-mentioned directions of research has made a program of the project, and helped to distribute tasks between the participants in order to begin a series of works for obtaining initial results. At the same time, a sufficiently important factor in the success of the project is the study and taking into account the best world experiences in the field. It should be noted that the project is open and does not exclude the possibility of expanding the membership.

SUMMARY

Thus, the implementation of the project will ensure the creation of a powerful information technology surrounding in the field of conservation and restoration of art works, which will give an opportunity to provide support and maintenance of conservation and restoration processes, as well as their possible partial automation. It is also expected to intensify the scientific work of students, deepening the theoretical and strengthening the practical approaches of the educational process, further development of the universities cooperation. Project participants are interested in studying world experience and organization of international cooperation in the field of implementation of IT in conservation and restoration of art works.

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Museum Collections Using information and Digital 3D Technologies

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Abstract: While museums have many ways to innovate, the dissemination of information and communication technologies (ICTs) in this field has recently received some attention for their influence and the possibilities those tools offer to enhance innovative strategies. Based on the existing literature, the paper presents a new typology of ICTs' use in museums dividing technologies according to their characteristics, objective, and place of use. This paper investigates the creative engagement with digital 3D models of museum artefacts and gives insight into new uses of museum collections enabled by digital scanning, editing and 3D printing technologies.

Keywords: Museums, Innovation, ICT, Digital 3D technologies; Museum engagement; Artist intervention; Digital heritage.

Introduction

Museums and other cultural heritage institutions are one important part of the 'creative industries' and innovation in the creative industries provide major stimulating outputs towards economic evolution[1]. Innovation is essentially a social response to the changes in user behavior, however in 2 form of products/services designed based on the opinion and needs of the users. The active participation of users in today's industries has revolutionized the way products and knowledge are produced, diffused, and consumed. This revolution generally relates to the technological revolution that happens in the information and communication technology industry.

The new and social technologies have radically changed the way society functions from daily aspects to radical changes. The ICTs and other great inventions like the steam engine machine and electricity are compared with each other due to their ability of performing multiple functions through their practical and facilitating tools[2]. ICTs can serve as tools to enhance the way institutions use their internal operative systems, create revenue-generating activities, exhibit artifacts, communicate with its publics and the market, diffuse knowledge, conserve, and research.

Current ICT is defined by three features. The first one, computational virtuality, corresponds to the infinite potential actualizations of an element implemented by the computer through bidirectional communication and logic -mathematical operations [3]. At a general museological level, the limitations of the physical dimension disappear, and it is possible to build any exhibition, by putting together the images of objects located in different times and places.

The second feature, interactivity, has been defined as the nature of a system's capacity to receive and respond to a human input action. Although having a slightly different meaning, this concept also exists in museums where it was introduced as part of the museological and pedagogical renovation of the second half of the twentieth century. Studies conducted in both formal and informal environments have proved that the active, self-controlled and collaborative exploration of digital contents indirectly benefits learning, especially in the case of complex, abstract or non-visible phenomena.

The third feature corresponds to the multiplicity of interfaces. In its current state of development, ICT can take various forms and serve different communication purposes. This is directly linked with the museographic level of the exhibition. Finally, augmented reality systems, based on wearable or mobile devices, are useful for exhibitions in which the object is still at the centre of the discourse, since they provide an additional layer of information about them which can be modified to set-up different kinds of visits.

This paper presents the conclusions of an evaluative study conducted in the United Kingdom (UK) which brought three different contributions to the research field: it provided new empirical data about the effectiveness of high-tech exhibits; it tested a newly refined, specific evaluative methodology, and it changed the usual notion of 'integration' of ICT into exhibitions. A theoretical perspective might seem irrelevant in the design of high-tech exhibits, which are currently led by practical and technological aspects, but we agree with other authors that moving to a more abstract and general level is the key to understanding the relevant issues and enabling more effective solutions to be proposed.

3D scanning technologies offer the opportunity to capture the form of real objects, and to store them as digital files. 3D print technologies are swiftly bridging the gap between digital and physical objects: it is now possible to print physical objects directly from digital files.

Across the museum sector, research into the use of digital 3D technologies is focused on the implementation and support of core museum duties, including collection management, conservation, research and the interpretation of collections for the public [4]. A focus on knowledge-based and established museum practices risks ignoring more personal and subjective forms of museum experience, which can be explored through the use of digital technologies. To explore how creative engagement with digital 3D models can open up new forms of museum experience and new ways of understanding museum collections this paper examines two projects that promote the creative use of digital 3D models of museum artefacts, the *(Im)material Artifacts* project, undertaken by the researcher in collaboration with the National Museum Cardiff, and *Lincoln 3D Scans*, a project by the artist Oliver Laric in collaboration with the Usher Gallery and The Collection in Lincoln.

Specific use of ICTs in museums: a new typology

In the case of museums, the new technologies can improve and change institution's operative and conceptual aspects.

In pursuance of facilitating comprehension of their characteristics, divided the technologies addressed here into three main categories, in line with the innovative aspect they mostly correspond to, the theoretical review, and the empirical research material. It is important to highlight that this is a suggestion of typology of the technologies currently in use in museums, but it is true, likewise, that many of those technologies are multifunctional and are present, in different levels, among the other categories. Consequently, the suggestion of categories is:

a) *Informative and expositive technologies that enhance exhibition's design and the presentation of artifacts/content, mainly during the visit* (informative kiosks, audio and smart guides, interactive displays, 3D, holography, virtual and augmented realities);

b) *Technologies that foster communication and marketing activities, promoting further and deeper engagement by the audience, mainly before and after the visit* , and

c) *Technologies used mainly in organizational and managerial operations in the back-office of cultural institutions, in order to provide and combine the necessary elements for the exhibition and other more apparent technologies*.

Informative and expositive technologies at the exhibition level

The most common on-site informative technologies found in museums are predominantly compost by services found at the exhibition areas such as plant introduction (PI) stations, personal digital assistants

(PDAs, or 'pocket museum'), multimedia kiosks, dock systems, and audio and smart guides. The technologies at the service of the visitors in the hall or in the exhibition areas provide extra information, from the location plan to complementary information about the exhibition, permanent collection, and the institution. Info stations, kiosks, and docks were the first technological appliances at the service of visitors in museums[5]. Those appliances can offer from simple programmed information to joysticks, touch screens, and virtual reality tools. They are able to give basic information, enlarge understanding and contextualization of a piece, and to control equipment and systems(fig.1.).

fig.1.Diversified types of interactive technologies at KAUST Museum (http://www.kaust.edu.sa/).

PDAs and audio/smart guides are mobile and wireless options to acquire extra information while wandering around the institution. These devices work as interlocutors for visitors in search of extra knowledge on the way and inspire interplay and stimulation. In addition, these devices offer extra services to visitors, such as audio descriptions for the vision-impaired public, and diversified mediums like videos, photos, sound, and texts.

Visitors can also use technological tools as the quick response (QR) codes and applications in portable tablets and mobile phones, bringing the museum to the palm of people's hands. QR codes give extra information about the museum or a specific exhibition through bi-dimensional barcode detection of an image. These codes give from basic information to direct links to applications and web pages.

Applications also are tools that establish connection between the institution and the individual visitor, whom can download it directly to his/her personal mobile device and attain from practical information such as location and opening hours up to multimedia files and streaming [6]. Besides, one can customize it in accordance to his/her specific interests in a more dynamic and interactive way .

Informative technologies are tools that serve as complementary forms to provide additional information. In the case of expositive technologies, however, they mostly refer to a particular piece, or determined part of an exhibition. Some examples of these technologies are interactive screens, 3D, holography, and virtual and augmented realities. They make use of diverse tools as images, illumination, sounds, and even mechanic vibrations to recreate, contextualize, and give the observer a full experience in addition to the attainment of information. Yet, the separation frequently happens into two types conforming to the experience they provide: immersive or non-immersive. Immersive technology makes the visitors feel similar to being in another time, space, and/or context through digitally or mechanically simulation of aspects of the world surrounding the artifact, where the public can interact using their bodies and movements; an example is the augmented reality technology.

3D and holography

Tridimensional (3D) objects are geometric models created based on the real context where it can reproduce width, length, and depth of the chosen object. N Holography is the bi-dimensional (2D) projection of light in space, which the human eye can see and understand as 3D projections without the use of special apparatus like 3D glasses [7]. 3D technologies are usually more costly than holography once they require the use of complementary equipment or devices for the visualization of digitally created dimensional objects.

The virtual museum

Virtual museums have core functions such as exhibition, communication, research, and conservation of the pieces. Customization, interactivity, and content are some of key words when speaking of virtual museums, in addition to the informative objectives of a webpage.

Online museums should offer organic navigation interfaces for each and all kinds of publics and, simultaneously, provide interesting, participative, and almost realistic experiences through new and social technologies, engaging the public and adding value to institutions' image. The more authentic the online experience reveals to be, higher are the chances to bring online visitors into the real museum. Below, the figure 2 shows a suggestion for an art museum ontology combining actors and objects, which is apparently simple but sometimes difficult to apply. However, its implementation would produce a better model for museum's websites to combine objects, discourses, and information.

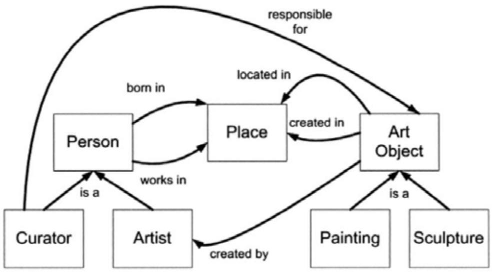

Fig. 2: virtual museum's ontology (Bailey, 2010, p.36).

Both real and virtual museums' professionals have similar curatorial objectives when selecting and defining the most appropriated communication methods to the prospective publics, working in accordance with the varied mediums, publics, and institutional goals. The objective is to use the digital element to add extra value and make more interesting online versions or even to create exhibitions available exclusively online. Conclusively, virtual museums should not become simply a digital replica of the physical museum but its extension, collaborating and cooperating to achieve institutions' mission. Therefore, virtual museums, as with the real museums, should rethink its attributes and functionality, repeatedly, as the environment change itself nonstop.

Information and communication technology (ICT) applications in UK museums

In the era of the Information Society, where a new paradigm of knowledge construction and transmission is being built, static, unidirectional, massmedia containing text and images are widely giving way to interactive and personalized media containing hypermedia information.

Many museums in the UK and the USA have long been using interaction as a means of interpretation; this trend had historically taken the form of hands-on activities [8] which now, with the advent of the technological era, incorporate computers' capacities in order to create displays enabling a full new range of communicational possibilities .

According to our analysis, the degree of ICT integration in exhibitions seemed to depend on three main factors, including the knowledge domain, the exhibit's specific communication goal and the age of the design. However, the conversations with the staff members corrected or fine-tuned the previous conclusions, providing a list of factors arranged not by their 'summative' importance, but by their more general, theoretical or more immediate and practical influence on the exhibition design.

One of the primary factors involved in the perception and general use of ICT in exhibitions is, more than the knowledge domain, the role attributed to objects. As previously mentioned, museum professionals consider that technology is aimed at enhancing the understanding of objects: in the case of science museums, by providing the dynamic aspects; in the case of history museums, by providing the context and in the case of art museums, by providing an interpretation.

The interviews confirmed that the second influential factor is the exhibit's specific communication goal. This determines the chosen interface and justifies why we find similar interfaces with similar uses across all museums. It is considered the most intuitive, as it allows access to the WWW and can deliver different kinds of content: database-like multimedia, game-like multimedia and virtual reconstructions.

The age of the exhibition had been considered to be the third influencing factor -the older an exhibition, the less integrated the ICT. As a result, they take ICT into account from the very beginning of the exhibition's conception.

The fourth influential factor is the awareness of the available technology. Choices are mainly made according to the content to be conveyed, but sometimes successful applications in other museums - i.e. mobile or immersive displays - can provide ideas for exhibits.

Effectiveness of information and communication technology (ICT) in exhibitions

The evaluation aimed to verify if the criteria that guided the design of the analyzed exhibitions were successful. To that end assessed those aspects that can be empirically evaluated: relationship with other exhibits and with objects, effectiveness with regard to the exhibit's communication goal, exploration in group, usability, target audience and engagement.

The weak relationship of ICT applications with other exhibits and with objects the interpretation of which they were supposed to enhance- appeared in all museums, regardless of their subject, the kind of exhibit or its goal. In the first case at IWMN, our survey and previous surveys showed that the spatial arrangement and contents of both high- and low tech exhibits, which were the majority, interrupted the linear and progressive thread of the visit and, at times, made it difficult for visitors to follow it. At MoSI, very few visitors interacted with high-tech exhibits in the way expected by the designers, because the different elements within the exhibition were not clearly articulated in a coherent spatial and conceptual discourse [9].

In the case of objects, observations confirmed the results of the evaluations conducted at MAG [10], which showed that, contrary to the main purpose of the interactive devices, visitors were not systematically linking the art works with them. The reasons for this are several: first, there are no identifying labels close to the art works; second, the mediators occupy a spatial prominent position within the whole exhibit and this situates the art work in a marginal position and finally, the activity is not always directly or clearly linked with the work's meaning and consequently visitors did not understand its message.

In general, high-tech exhibits achieved the goals for which they had been designed, and always related to the specific capacities of ICT. At MAG, families appreciated that they were invited to explore art works in an engaging and entertaining way, thanks to the interactivity and self-control provided by high-tech interactive devices.

Whenever ICT failed to serve its purpose, it was not due to the technological component but to a problem in the overall design of the exhibition. For example, at IWMN, the visitor surveys revealed there was not a sufficient spatial and conceptual relationship between objects and the 'action stations'.

At MoSI (Figure 3), the summative evaluation concluded that either the gallery's goal was not evident, or visitors did not retain the specific contents because of the structure and the communication strategies used by the external company, which came from modern design rather than from museography.

Group exploration was undermined in all exhibitions by the small size of screens and the computational, one-to-one communication paradigm of ICT applications.

This problem is especially relevant in UK museums, where families are the main visitors. Large, passive screens (at MoSI and IWMN) accommodated several viewers well, even if they were not visiting together. But touch screens only allowed one user and one observer. This had two consequences. First, as reported in previous studies, family groups adopted different exploration strategies, including splitting up if there was more than one adult, turn-taking of children (at IWMN and MAG) and male visitors adopting the leading role as mediators.

Second, inter-group communication happened mainly at hands-on exhibits because the observation at screens requires a physical proximity that can only happen amongst co-visitors.

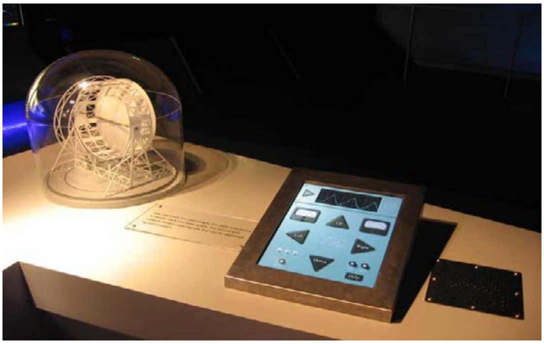

Fig. 3. The success of the exhibit was compromised because its goal was not clear at the Museum of Science and Industry of Manchester (MoSI).

Since all exhibitions use touch screens, they should show very similar results. However, the differences revealed by surveys demonstrate that it is not only a matter of interface, but also of the position inside the spatial structure of the exhibition, the behavior expected by the museum inside the gallery, the visitors' attitudes towards technology and the composition of the group. Moreover, the comparison of exhibits at IWMN and at the Science Museum showed that some 'hands-on' were designed, or located in such a way that they could only be explored by one visitor, and groups adapted their strategy exactly as described for ICT applications.

"Poaching" the museum artifact

Freely available photogrammetry [11] software has enabled museum visitors to create 3D models of museum artifacts using their digital cameras or mobile phones; "access to cheap, flexible tools removes many of the barriers to trying new things". In Māori belief and in other cultural belief systems the affective properties possessed by real artifacts are sometimes seen to "inhere in their digital surrogates" . Freely available photogrammetry software creates a possibility for museum artifacts to be digitally appropriated. When this happens to culturally sensitive materials it might be considered inappropriate or offensive by parties with a vested cultural interest. At the same time, it brings new opportunities to the engagement with museum artifacts.

Internet communities with the focus of sharing photogrammetric models are emerging and online collections house a diverse range of digital 3D models, including 3D models of historical artifacts from museums [12]. The creation and collection of photogrammetric models is emerging as a new hobby; it has the potential to change our understanding because it changes our relationship with objects.

(IM)Material artifacts

For this research the (Im)material Artifacts project was undertaken in collaboration with the National Museum Cardiff. A number of artifacts from the ceramics collections at the National Museum Cardiff were selected for 3D scanning, and the resulting digital 3D models were made accessible to participating artists online. Participants were recruited online to remix the digital scans.

The project culminated in an exhibition at the National Museum Cardiff, during which the participants' screen based and 3D printed submissions were displayed with the original artifacts .

Lincoln 3Dscans

The Lincoln 3D Scans project by the artist Oliver Laric in collaboration with the Usher Gallery and The Collection in Lincoln was also investigated as part of this research. The project started in 2012, when Laric was invited by the Usher Gallery and The Collection in Lincoln to propose an idea for the Contemporary Art Society's Annual Award for museums. Laric's proposal to 3D scan the museum collections and subsequently publish all data for free was chosen as the winning project.

This proposal led to the creation of the Lincoln 3D Scans website [13], where 3D models can be downloaded as STL files in order to be used without copyright restrictions. The Lincoln 3D Scans website includes a 'gallery', where the public can share images of the artworks they have created from the 3D scans. Users of the website are invited to treat the digital 3D models as starting points for new works and have the possibility of sharing their creative responses to the 3D models via the online gallery.

Artworks

Overarching themes emerge from the analysis of (Im)material Artifacts and Lincoln 3D Scans. The chief personal use for digital 3D models of heritage artifacts, created by users or accessed online, is 3D printing.

Digital 3D models of heritage artifacts can be edited and personalized. With the necessary editing skill users are able to turn digital 3D models of heritage artifacts into 'souvenirs' of their own real and imagined experiences. Jason Rouse's video game Postcards from Mexico, for example, blends the artist's memories of Mexico with the digital 3D model of a Teotihuacan artifact .

Postcards from Mexico was created for (Im)material Artifacts, a playable version of the game is available for download online [14]. The game transforms the 3D scan of a Mexican mask into a navigable virtual island.

National Museum Cardiff his engagement with its digital reproduction was a form of repatriation of the piece to its country and culture of origin. Since the archives at the National Museum Cardiff provided scarce information on the background of the piece Padilla undertook his own research. He approached experts from the National Museum in Mexico, and discovered that the mask is likely to have been the head of a Teotihuacan figurine, rather than a 'mask', as it is described in the museum archives.

Discussion

During the projects discussed in this paper artists explored their relationship to the past, present and future, personal memories and associations and the relationships between technology and culture through the creation of derivative works based on digital 3D reproductions of museum artifacts. They also explored personal memories, narratives and associations through the creative transformation of digital replicas of museum objects. Participants poached and recontextualized the digital 3D models.

The creative transformation of digital heritage communicates this ever-changing nature of our interpretation of the past. It reveals the importance of fantasy and the imagination and encourages a questioning stance towards circulated images and narratives.

The trajectory of the digital 3D models used for (Im)material Artifacts and Lincoln 3D Scans has continued to extend online beyond the scope of the respective projects. 3D models from both projects were re-shared via online repositories.

Digital 3D imaging and 3D printing technologies, especially DIY (Do It Yourself) and open source tools, are strongly tied into digital maker culture and the free culture movement. Today, the digital maker movement is a digital technology oriented extension of DIY culture and has roots in the Arts and Crafts movement of the late nineteenth and early twentieth century.

Creative engagement with digital 3D models of museum artifacts can promote digital literacy. On online 3D editing and printing theme boards and 3D file sharing websites users are able to share resources, tips and to communicate. When users begin to interact with each other 'communities of practice' can form; these can be viewed as social learning systems. They provide a "shared repertoire of communal resources – language routines, sensibilities, artifacts, tools, stories, styles, etc." [15].

Conclusion

In this thesis, explored the field of cultural heritage institutions, more specifically the case of museums, in order to identify the use and influence of the ICTs in respect to diverse types of innovation. The examination of innovation occurred through study of the creative industries due to the lack of material about innovation precisely in museums.

One of the services of museums has long been to provide artists with rich material to inspire their art making. Digital 3D technologies have potential to support this function of museums. Through the creation and release of digital 3D models from their collections, museums can continue their role as sources of artistic inspiration in a digital arena.

3D models from (Im)material Artifacts and Lincoln 3D Scans continue to be downloaded, remixed, printed and shared, and thus continually engage users with digital heritage and promoting increased understanding both of the original historical artifacts and the digital materials.

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ACCESS
TO THE CULTURE INFORMATION

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CONTEMPORARY METHODS OF FUNCTIONAL HARMONY TEACHING IN A HIGH SCHOOL CONTEXT

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Fast development of interactive learning technologies needs a special consideration in a higher music education context. The new ways of learning content presentation through 3D imagining and through the theory of graphs application in music harmony are presented in the article. The proposed methodology is programmatically implemented in a series of web and Android applications, embodying additional game patterns for a better engagement of students into a learning process. A series of web applications has been successfully tested in educational experiments held with students in France and Poland, each time showing the high efficiency of the proposed methods and learning strategies.

INTRODUCTION

Fast development of technologies changed the knowledge paradigms. The attempt to apply cognitive models to the artificial intelligence development results in a reverse assimilation of the artificial network's information circulation models by humans. The information society led to the emergence of the hypertextual logic, which became a new logic of narration in the 21st century [1]. The problem of the information conversion into nonverbal quantitative forms was pointed out by Jean-Francois Lyotard [2], who assumed that knowledge should be translated into quantities of information in order to be operational in new conditions; a partial resolution of above-mentioned problem provided a frame theory proposed by Marvin Minsky [3].

The origins of hypertextuality lie in neuroscience research on human brain, especially from the modes of a human neural network functionality, which was applied to the development of artificial intelligence in the beginning of cybernetics [4]. Not only the search for modes of interaction in such an artificial neural network, but also the search for structures, in which the information could circulate, led scientists to the application of a "frame" term, as a unit of information, and a "graph" as its graphical representation.

The cognitive aspects of the information, data organization and frames emerged as a reflection of the technical challenges of servers' communication, database management through operation systems and flowcharts representing the hierarchy in program commands execution. A large amount of information creates a database, which requires the application of quantitative methods of search, and, as a consequence, needs nonverbal ways of knowledge presentation which is frame and graph from a cognitive perspective. Operation systems represent a part of the artificial intelligence and use the frame logic for programs execution, which can be expressed in a form of the graph or a flowchart, therefore the frame and the graph can also be viewed from the cybernetics perspective. Therefore, quantitative methods of search correspond to the numerical artificial intelligence logic and such nonverbal ways of knowledge presentation as graph based on the frame is one of the ground principles for the information flow in artificial intelligence systems.

PEDAGOGICAL CONTEXT

Along with a data structuration discourse, the increasingly augmented role of visualization influences modern pedagogy. The role of a teacher has changed: teacher is no longer the source of knowledge [5], since no human can accumulate the amount of information mostly freely available online. The teacher instead can propose the systematization of a learning material by creation of the learning algorithms using modern interactive tools, including web and mobile learning games.

The learning attitude changes as well: the externalization of memory, mentioned by Michel Serres [6], leads to the search for ways of data structuring and compact nonverbal knowledge presentations. New tendencies in a learning material presentation assume it to become more interactive in order to fit the needs of modern students.

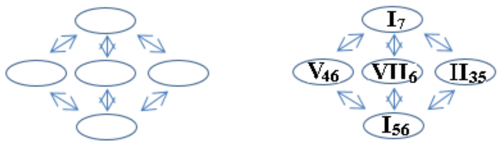
Finally, the 21st century students are accustomed to technology, multi-tasking, fun, graphics and the Internet [7], thus learning technologies should aspire for a better engagement of students into a learning process by using these specificities for development of the appropriate learning strategies.

A NEW THEORETICAL SYSTEM IN MUSIC HARMONY

The research in a domain of artificial intelligence is based on human cognitive models. One of such models is used to develop a semantic network – the future of the Internet, which will have to make the decisions based on accumulated and analyzed information from big data. Systematization and rearrangement of information in artificial intelligence systems goes by a frame filling, which represents the smallest unit of semantic information and can be represented visually in a form of the graph. Several graphs form graph trees, resulting in the most compact view, which allows representation of a large amount of information.

The system of graphs

As was mentioned above, the frame is a structured unit of information for different situations description. Unfilled frame is called "proto-frame", a frame being filled in is called "exo-frame". Let us build a proto-frame presenting music harmony knowledge, by taking a passing progression as a model, as it gives great possibilities of the elements variation (Fig.1).



a) b)

Fig.1. Two types of a frame: a) proto-frame b) exo-frame.

In the received graph structure the top and the bottom vertices contain data about seventh chords and their inversions (the beginning and the end of a passing progression), and three middle slots (edges) contain data about triads with their inversions (all possible passing chords between seventh chords in a given top and bottom vertices).

On the base of this proto-frame let us build the graphs for the rest of passing progressions possible between the first and the second, the second and the third inversions of the seventh chord of the 1st degree of a diatonic scale. The ensemble of all passing progressions for the tonic seventh chord forms a horizontal triad of graphs (Fig.2):

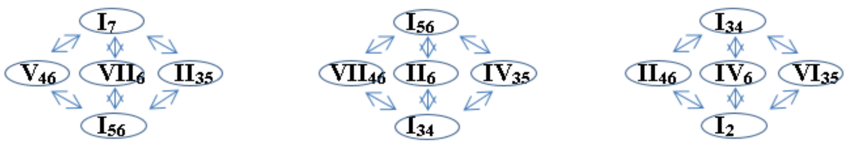


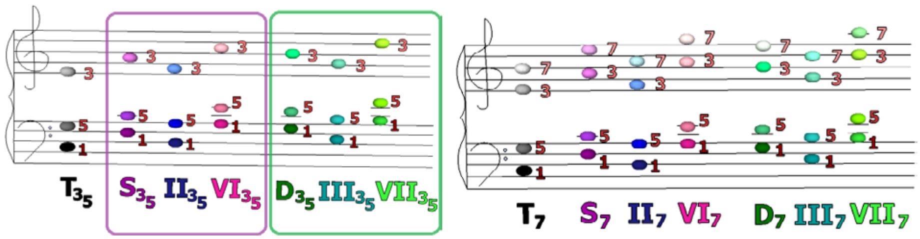
Figure 2. Horizontal triad of graphs.

The degrees used in the middle slots of each of the graphs within the same horizontal triad are repeating: V-VII-II, VII-II-IV, II-IV-VI and are in relation of a third between them. Only the inversion of a triad changes if the migration to the next graph in a horizontal triad occurs. For example, the II degree appeared in a ground state (II_{35}) in the first graph, then it appeared in its first inversion (II_6) in the second graph, and finally in its third inversion (II_{46}) in the third graph.

If we build such horizontal triads for the rest of the diatonic scale degrees (II, III, IV, V etc.), we receive a system, in which the placement of one horizontal triad below another horizontal triad will be determined by common passing triads, forming a vertical triad. Correlations between seventh chords of the vertical triad are guided by the same rule of a third interval (V-III-I etc.) as for passing chords inside each triad. Each top vertex of the graph can be connected through a common edge to each bottom vertex inside the vertical triad (the system will be used for the main activity of the Android-based solution and therefore shown later in the paper). The presented system has been successfully used in music learning [8] and music analysis [9].

The enrichment of the music notation-based visualization

The problem of the information structuration is not the only challenge which appeared in the information society context. The development of new media augmented our sensibility to the visual part of any matter of our existence. We became used to pay attention to charts, graphics, to get the substantial part of information from accompanying visualization before any verbal interpretation. In this context a traditional music notation used in a learning process needs to be reconsidered to become more informative regarding such crucial parameters in music harmony learning as a function of the chord and its structure. Thus, the enrichment of the traditional music notation with a color and its intensity has been applied in order to reveal these two fundamental parameters of harmonic sequences. The color groups were used to mark functional belonging to either dominant or subdominant group (Fig.3 a), and a color intensity was applied to highlight the structure of a chord in an open position. The decrease in the color intensity goes from the most important chord tones – fundamental and quint, to less important tones – third and seventh, accordingly (Fig.3 b).



a) b)

Figure 3. Color and its intensity mapping to the music function and chord construction: a) mapping application to triads; b) mapping application to seventh chords.

FRAMEWORKS FOR PRACTICAL IMPLEMENTATION

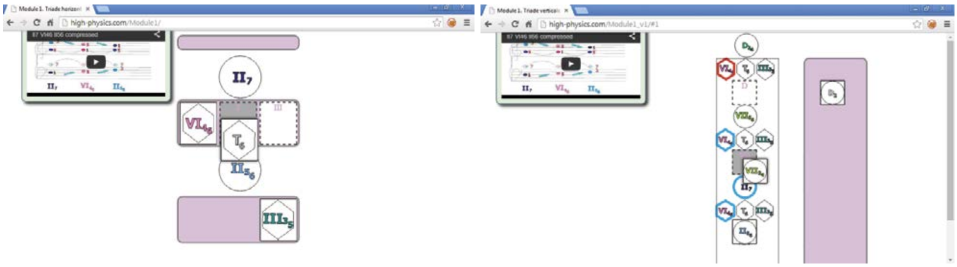
Web-based framework

The application of a new system of graphs to the learning process in a high school was done through the series of animated harmonic sequences visualizations and the interactive web applications. The developed interactive on-line activities for learning music harmony as well as created dynamic visualizations of the harmonic sequences represent two different pedagogical methodological approaches – the activity-based approach and the association-based approach. The association-based approach is widely used in the off-line education; however, the application of this method in the on-line education requires a large number of visualizations in order to be efficient. The activity-based method derives from the research of

Jean Piaget [10], which assumes that external activity causes an increase in mental and intellectual development, because the activity transforms not only the external object, but also the subject executing this activity.

The animated harmonic sequences visualizations contained the described color and color intensity mapping to mark the chord function and the importance of tons within the chord structure and allowed highlighting the moving tones. The animation was also applied to harmonic sequences in a graph representation, reflecting occurring musical processes in the accompanying sound track, synchronized with animated visualizations.

The interactive web applications consist of two types of learning activity. The first type comprehends the interactive graph filling by dragging and dropping the chord item: if the chord item was dropped correctly, the sound of this chord is played and the window of a whole 3D animated visualization of the sequence appears (Fig.4).



a) b)

Figure 4. Screenshot of the first type of interactive on-line application. a) Example with a horizontal triad element; b) Example with a vertical triad element.

This type of application differs by the form according to the use of either horizontal or vertical triad of graphs. The main goal of this activity is to provide a general view on a diversity of harmonization possibilities reflected in a graph representation.

The second type of activity comprises deeper work with tones and intervals forming the chords of the sequence. The 3D notes' visualizations showed in the graph part were the main material for work within this activity. When the cursor is placed on the pair of either two upper tons (top interval) or two bottom tons (bottom interval), the sound of this interval, as well as the degrees of the scale on which these tones are placed appear. After the first step of the chord intervals recognition, the second step follows, which consists of the similar top-bottom interval division of the chord but applied to the two last chords of the sequence (Fig.5).

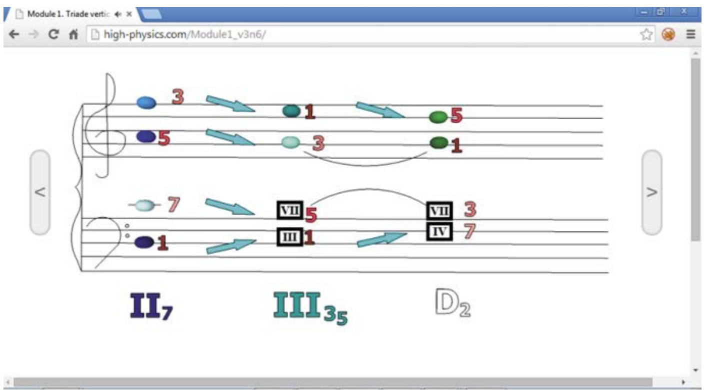


Figure 5. Screenshot presenting the second type of web applications.

The main goal of this activity is to show the basis of harmonization variation, assuming, that the same degree can be harmonized with different chords within the graph and can play different role in the chord structure representing different tones. The special task of the second step of this activity is to turn attention on the voices leading within the sequences.

In created web applications three basic game concepts have been used, such as finding a right match concept in the graph activity (also used in a card game), discovering a new property in the notes activity (used in Black Jack card game) or receiving a bonus after the right match has been found (a basic game motivation) in the graph activity, as the animation video of the concerned harmonic progression appears after a correctly dropped chord item.

Android-based framework

The extended possibilities of interaction with the learning material provide modern mobile operation systems (OS). Such features as touch technology, the change of view with the device rotation provided by Android OS can be used for methodological purposes [11]. In order to explore these possibilities using the system of graphs in music harmony, an Android-based game has been created. The main activity screen proposes 7 horizontal triads to choose (Fig.6). After the horizontal triad from the main menu is selected, a new activity starts proposing the interaction with each graph of a chosen triad.

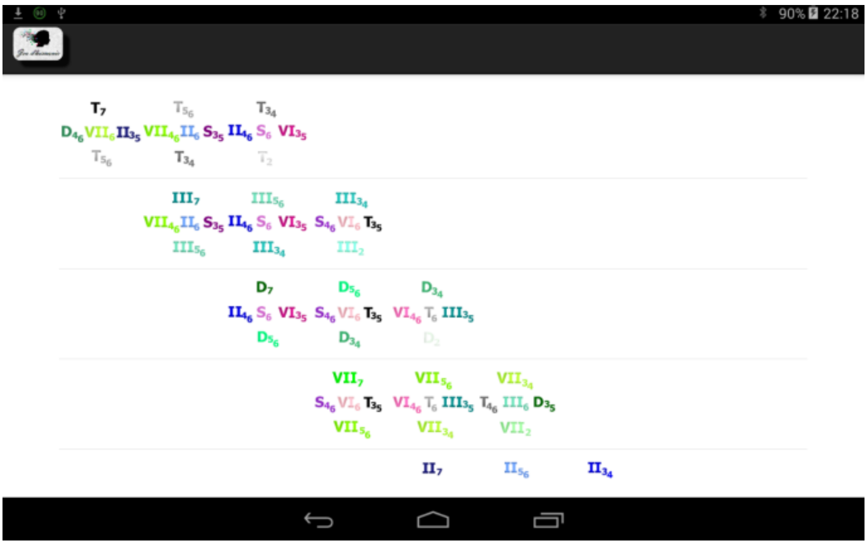
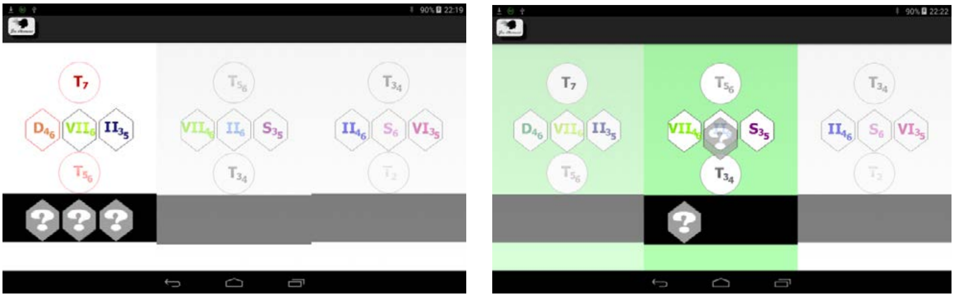


Fig 6. Screenshots of the Android game “Jeu d’harmonie”: main activity view.

User needs to touch the edges of the graph to be able to listen to the sequence; the vertices and a chosen edge are highlighted showing the sequence played (Fig.8 a). The black panel in the bottom of the screen contains the passing chords of the corresponding graph presented as items with an interrogation sign inside. When the item is touched the passing chord is played and user needs to recognize the sequence from which this chord has been taken. If the item has been dropped correctly, the background behind the graph becomes green and user receives one point (Fig.7 b). In case of the wrong match, the background color becomes red and no score is granted.

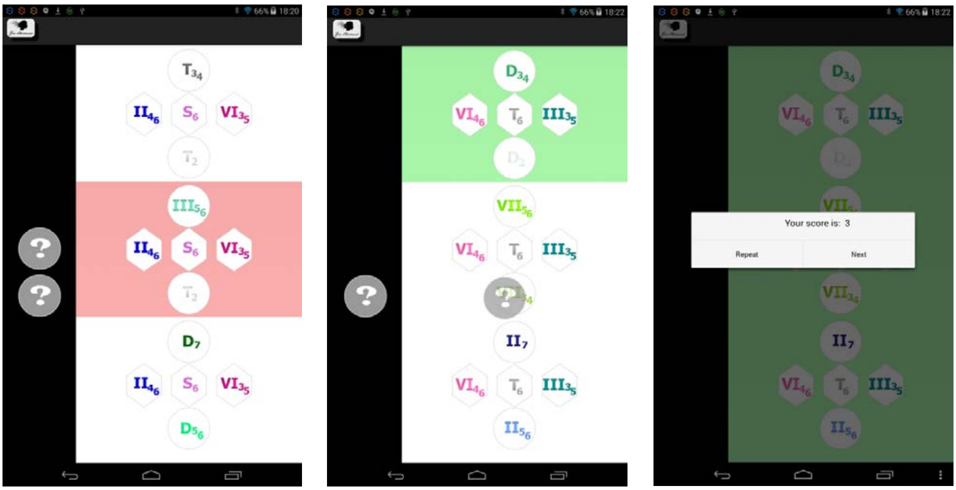


a) b)

Fig 7. Screenshot of a) highlighted chords while music progression execution, b) correctly dropped first passing chord and dropping of a second passing chord.

The horizontal triad activity can be changed to a vertical triad activity with the device rotation either from the main activity switched to the vertical mode or directly from the horizontal triad activity. It should be noted, that the vertical triad which will appear as a result of the device rotation directly from the horizontal triad activity, will contain the graph from horizontal triad which user was interacting with before rotation. In such a way the methodological feature of the system consisting of horizontal and vertical triads is implemented: the device rotation results in a new activity (vertical, instead of horizontal), containing only one graph of the related horizontal triad, and not just another configuration of graphs from the horizontal triad.

The functionality within the vertical triad activity resembles functionality described for the horizontal triad activity. However, instead of edges, representing passing chords, the bottom vertices representing the seventh chord inversions are given as a content of items which should be dropped accordingly in the bottom vertices slots (Fig.8 a, b). When all items are dropped, a pop-up window appears indicating the gained score and the actions to choose – repeat the activity or pass to the next activity (Fig.8 c).



a) b) c)

Fig 8. Screenshot of the vertical triad activity showing different states of the vertical triad activity: a) wrongly dropped fist seventh chord (bottom vertex of the graph), b) correctly dropped first seventh chord (third inversion of the dominant seventh chord: D_2) and dropping of a second seventh chord (second inversion of the VII seventh chord: VII_{34}), c) correctly dropped three seventh chords of the vertical triad and a score window.

PEDAGOGICAL EXPERIMENT

Experiment conditions

Student groups. The final expertise of the web applications efficiency has been investigated within the experiments held with 41 undergraduate students in musicology of the Michel de Montaigne Bordeaux 3 University (France) and later with 20 undergraduate students from the Institute of Music of Maria Curie-Sklodowska University in Lublin (Poland).

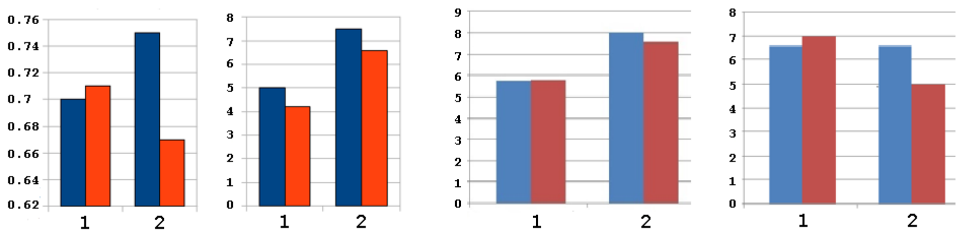
Learning content. The amount of learning hours and the learning program was equal for control and experimental groups. Both groups worked in a computer classroom with the Moodle platform for distance education of Maria Curie-Sklodowska University, but in different on-line classes. The control group had the learning content organized as ordinary Moodle lessons with different pages. These pages contained described 3D animated visualizations, embedded as *youtube* videos with appropriate text description. Within the content of the lesson for the experimental group the links to pop-up windows were placed, leading to the described above interactive web applications. The experimental group had no text description in the proposed activities. The post-lessons tests were similar for both groups.

Experiment results. All students had to pass two main tests: the pre-test and the post-test. During the course they also received the points for the post-lessons' tests. The final estimation consisted of the overage estimation between final test estimation and a number of post-lessons' tests estimations. Such a mixed estimation allowed measuring the engagement of students during the course.

The impact of the interactive web applications on music harmony knowledge assimilation

The students' activity during the course was measured by estimations given for post-lessons tests. The measurements were done each two weeks, which was equal to one module within four lessons. The penalty for a delayed response consisted to 50% of the last received estimation. As mentioned above, the final estimation consisted of the overage taken from the final test estimation and three other estimations received for post-lessons test within each of three modules during the course, therefore the impact of the final examination was 25%.

The charts below are based on the final grade, showing the overage estimation (Fig.9 a) at the beginning and at the end of the experiment in both – the control group (marked with a red color) and in the experimental group (marked with the blue color). The estimation of quality of knowledge shows a proportional increase in both groups in the first experiment (Fig.9 b). Better engagement of students from the experimental group, impacted the overage estimation and the quality of knowledge in the second experiment (Fig.9 c, d).



a) b) c) d)

Fig 9. The result of two experiments showing the estimations at the beginning and in the end of the experiment: a) first experiment: overage estimation; b) first experiment:

quality of knowledge; c) second experiment: overage estimation; d) second experiment: quality of knowledge.

SUMMARIZATION

The article presented possibilities of the learning process amelioration in a higher music education on example of the music harmony course. The appearance of such notions as "frame" and "graph" are explained as a result of the information society context and the proposed system of graphs in music harmony corresponds to the described phenomena. The article shows that the graph unit filled in with the information about chords, participating in a given sequence is a good alternative to the notation representation during the learning process, allowing the reduction of visual details and concentration on the phonic properties of the chord. Promising experimental results confirm the efficiency of the proposed methods application in a web framework with the use of basic game concepts. The created Android application for harmony learning presents a new edge of the subject development translating the problematics of the game-based music learning in a high school to mobile platforms.

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THE AESTHETICS OF VOLUMETRIC PHOTOGRAPHY FOR VIRTUAL REALITY

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ABSTRACT

Volumetric imaging (true 3D image capture, as opposed to left/right stereo imaging) is being recognised as a new arena for recording images of the real world. Much of the current work in this arena investigates the technical aspects of volumetric moving image capture for Virtual Reality, often used for experimental immersive documentary and storytelling eg [1]. This paper presents an alternative, hereto unrepresented area, discussing the visual aesthetics of volumetric still image capture for Virtual Reality, as a subject for experimental photography. Based upon the results of a long term (three years at time of writing) development of the Volca project [2, 3] for experimental volumetric still image cameras, this presentation discusses the various techniques for capture, their particular aesthetic qualities, opportunities and limitations, and compares the variety of aesthetic characteristics of various rendering, representation and dissemination processes and techniques for emerging area of experimental 3D imaging.

INTRODUCTION

The Volca [2, 3] project has been focused on development of experimental volumetric (true3d depth detection, as opposed to stereo- left/right depth simulation) cameras for still image portrait and street photography. Over the course of the project the technical development has investigated numerous depth sensors, capture hardware, software processes algorithms and visualisation techniques. The project has also explored in depth the challenges of disseminating and representing the depth-image content captured from the various iterations of hardware and software. Via this research through design process particular aesthetic trends and styles have emerged that through careful investigation and observation are discussed here and that this paper presents as an emerging aesthetic of volumetric photography.

Principles Of Volumetric Photography

Volumetric photography is based upon the recording of colour visual image data with per-pixel depth data, (sometimes referred to as RGBD data, [4] Red Green Blue colour and Depth) this depth data allows virtual reconstruction of a captured scene from a variety of angles with a wide degree of freedom. Comparatively stereo images such as the current slew of ‘3D’ movies in mainstream cinema rely on a limited simulation of depth in a chosen scene by providing a separated left/right pair of images (often viewed through coloured or polarised glasses) that give limited depth information from a pre-determined single viewpoint.

Special hardware is commonly used to capture depth data in additional to colour visual data. This is predominantly visible light stereo pair cameras (such as the Stereolabs ZED camera [5]) where the left and right images are processed algorithmically to produce a *disparity* map [6] between the two images and therefore infer depth for individual points. Alternatively infra-red (the two main processes being *structured light* (eg the Occipital Structure sensor [7] where patterns of infra-red light are emitted and then read back or *time of flight* (such as the Microsoft Kinect II sensor) where light is emitted and the time it takes to reflect off nearby objects is recorded)

Fig 1. Kinect based DIY portable volumetric capture system 2018, Daniel Buzzo, sensor head and control hardware, Copyright the author.

Each particular sensor method has implications for data quality and context usability [8]. The visible light stereo pair cameras have large effective range (commonly in excess of 15m) and work well in bright daylight, whereas infra-red sensing methods are limited in range (often less than 8m) and work poorly in daylight, conversely the infra-red sensors will work (at least regarding depth data) perfectly well in complete darkness where visible light sensing (and unfortunately the associated RGB image recording) can fail completely.

Both visible light and infra-red techniques return depth values per pixel from a 2 dimensional raster array, up to the maximum x,y resolution of the respective sensors. (The Kinect 1 sensor is a structured light sensor and has a depth image resolution of 320 x 240 pixels and the Kinect 2 is a time of flight sensor with a higher depth resolution of 512 x 424 pixels. The Occipital Structure sensor is a structured light sensor with a maximum depth image resolution of 640 x 480. By contrast, the Stereolabs ZED stereo-pair depth camera has a stated maximum depth image resolution of 4416 x 1242 pixels) They are also limited in their depth resolution, commonly becoming less accurate in their depth estimation the farther away an object is. (Structured light and time of flight infra-red sensors commonly have maximum effective ranges of 5-8m with accuracy of depth data diminishing with distance. By contrast the ZED stereo pair visible light camera has a stated range of up to 20m, though at maximum range the disparity map process this type of sensor utilizes become increasingly inaccurate).

Depth sensing scenarios have a particular challenge compared with RGB photography in that objects beyond the sensing range of depth hardware are returned as null data [9]. Essentially creating ‘holes’ in the depth image - as opposed to areas of no light in RGB images (eg, shadows or night sky) it cannot necessarily be inferred what the null data in a depth image may be - it could be objects at great distance, or sensor failure, or equally nearby objects that are in ‘shadow’ from the infra-red emitter signal or sensor. The decision of how to represent this null data has the challenge that RGB image data for these null depth areas may exist and have useful subject data in.
Representation of this null data has two basic options - either the data is discounted and the ‘data holes’ are translated into holes in a generated 3d surface (see figure 2) or alternatively the data is

‘back walled’ (see figure 3) - eg given an arbitrary maximum value that appears as a scenic, diorama style maximum value. Each has their own advantages and particular aesthetic qualities, and also representational challenges when viewing back pre-recorded RGBD images.

Choices in volumetric capture

Once depth sensing hardware is selected there are choices to be established regarding how data is processed and recorded from the hardware system. Depth sensors generally give depth per pixel (up to their maximum sensing range) across an x,y raster array. This depth data is most simply represented as individual points having x,y and z values. When viewed back as a 3d dimensional scene this data becomes what is referred to as a ‘point cloud’ (see figure 4) each point having arbitrary size and commonly coloured based upon the RGB value of an aligned colour image captured by a 2d visible light camera. Whilst this point cloud data is truest to what a depth camera is actually detecting other techniques can offer very different aesthetic interpretations of a captured scene.

Fig 2. Wanchai Street market, 2018, Daniel Buzzo, volumetric street photography with meshed surface, Hong Kong, Copyright the author.

Fig 3. *Mother and toddler*, *Backwalled volumetric image*, 2016, Daniel Buzzo, volumetric street photography, Hong Kong, Copyright the author.

Translating the captured point values into surfaces requires skinning or meshing of the point cloud (commonly as contiguous triangles though sometimes as quadrilaterals) this also allows high resolution RGB data to be 'painted‘ as a texture onto the surfaces of the generated mesh. It also allows the generated surface mesh to be synthetically illuminated by virtual lights rendered in a 3D viewing environment.

Decisions on how to treat null depth data (that now become visible as holes in the surface mesh) become important. Null data, possibly caused by objects beyond the range of the depth sensor, cause non-contiguous points in the point cloud to become joined during the mesh generation - sometimes causing triangles, or quadrilaterals, to stretch from very near to very far objects creating ‘false’ surfaces. Routines can be added to the mesh generation process to pre-clean and normalise point data and eliminate these false surfaces. Common routines also allow data interpolation to create interim data to remove ‘pinholes’ in surfaces and smooth them.

Fig 4. *Man on Tram*, *point cloud rendered image*, 2017, Daniel Buzzo, volumetric street photography, Amsterdam, Copyright the author.

SLAM VS single shot

There are also two significantly different approaches to the capture, processing and recording of depth data that greatly influence the results and aesthetics of subsequent volumetric images. Once a scene has been selected to be recorded, the data from the hardware can be sampled in two distinct ways. The first, and simplest is as a single 'shot' recorded over a brief (generally less than 0.1s) period. (see figure 3) In the same fashion as a visible light camera such as a DSLR has an exposure time a single shot volumetric camera will record depth and RGB data from a single view point over a short period of time. This has the advantage of being fast, allowing recording of moving or complex subjects, and giving control or greater choice of composition and intended viewpoint for the subsequent viewer. It has the necessary disadvantage that the depth data is only available for front, or sensor facing, data from the composition or subject. It also means that areas of the composition in the shadow of elements of the subject (from the infra-red emitters position) will have null depth data in the final rendering. Due to the nature of common hardware setups where the infra-red sensor and the RGB sensor are displaced from each other horizontally there can be parallax errors, i.e. discrepancies in registration between the apparent spatial positions of colour data and depth data, on objects close to the camera apparatus. This is commonly compensated for with calibration and registration corrections to align depth and colour data accurately.

The second main process employed in capturing volumetric images utilise a technique from robot or autonomous vehicle navigation and mapping systems. The technique known as Simultaneous Location and Mapping (SLAM) [10, 11] is used to create and locate an observer viewpoint in an environment at the same time as generating a map of the environment. The SLAM technique samples data from a depth sensor and attempts to build a consistent 3D model of the surroundings over an extended period of time. [12] With each successive sample of depth data taken from a moving sensor the technique compares new data against stored data to create complex representations of environments beyond what can be ascertained from a single viewpoint. In practice this means that a volumetric camera will record depth information over an extended period of time, possibly many tens of seconds, as the sensor array is moved over and around the subject or scene. This allows capture of volumetric information of all sides of objects or of complete scenes. This has the advantage of being able to eliminate infra-red shadow occlusion and capture data of the sides and backs of objects and scenes. It has the disadvantage of being suitable mostly for static or inert objects. Objects that move can create ripping or distortion effects where the SLAM algorithm attempts to reconcile data of a single surface in multiple positions. It can also cause disparity between captured RGB data used for texturing surface meshes and the shape and position of the generated meshes themselves.

Image and subject choice and composition - depth, scale and aesthetic limitations

Once RGBD data has been captured and processed the subject volumetric images can be recorded in a number of common 3d data formats. Common formats include the geometry definition format OBJ (or .obj) [13], originally developed by Wavefront Technologies, the format describes 3D geometry alone but can include Material Template Library (.MTL) files as a companion that describes surface shading (material) properties of objects. In the example of volumetric RGBD data the MTL file will principally reference an RGB image texture file captured by the RGB sensor with positional data for mapping of the photographic texture to the geometry described in the corresponding .obj file. The other common format in use is the Polygon File - PLY (.ply) format, also known as Stanford Triangle Format [14]. Each of these file formats describe the vertices or points in a volumetric image in x,y and z co-ordinates but also the relation of points that make up mesh surfaces. Such as lists of points at the corner of triangles making up surface meshes, their *normals* (a normal is a line perpendicular to the surface and is used in calculating how lighting affects a 3d graphic surface) their materials and the position of any texture image that may be part of the surface material.

Surface representation techniques. point, mesh, surface, lighting - cleanup

As noted above, depth data is originally generated, and captured as per pixel depth values creating point cloud information. These data points are commonly coloured via information extracted from the RGB data captured alongside the depth data. This colour information is necessarily limited to the resolution of the point cloud density. Viewers commonly infer contiguous surfaces from proximal points in a point cloud, making the ‘reading’ of dense point cloud representations relatively easy. From a view perspective, Point cloud representation also has the added benefit of not occluding rear or distant surfaces, often contributing to the viewer's sense of the depth and visual ‘weight’ of the represented objects. When interacting with point clouds, the parallax movement of near and far (from the viewers perspective) points dramatically demonstrates the depth nature of volumetric images and makes a strong distinction, style wise, between captured volumetric images of real world objects and computer graphic (CGI) style generated models, such as animated 3d game characters and the like.

Fig 5. *Arex - portrait*, 2018, Daniel Buzzo, volumetric street photography with exposed vertices, Hong Kong, Copyright the author.

Fig 6. *Sewing*, 2018, Daniel Buzzo, volumetric portrait photography with exposed vertices, Belgium, Copyright the author.

When approaching suitable visual rendering of volumetric data this comparison, or confusion, can be one of the greatest drawbacks in appreciation of volumetric photography as an art medium in its own right and as an extension of photography. This is in strong contrast to exemplar 3D animated models that an audience is often more familiar with from cinema and TV advertising CGI work and gaming characters.
As we discussed, the alternative to using point cloud representation is to use a surface mesh, either triangle or quad divided. This creates contiguous faces that are commonly shaded from a virtual light source and textured with the RGB data captured alongside the depth data.

This method of surface representation allows more RGB texture data to be utilised as the mesh faces, being mathematical vectors between points, are rendered at the base resolution of whatever display medium is being used. Generally these mesh surfaces create occlusion of back surfaces and can sometime reduce the sense of depth and weight in a rendered scene compared to point cloud rendering. Surface rendered models can also run the risk, as discussed previously, of appearing as CGI-like renderings rather than real-world representations. A technique used to good effect in the recent exhibition of volumetric portraits in VR is to use surface rendering and accentuate the underlying mesh and vertex data, (see figures 5 and 6) deliberately illustrating the faceted nature of the captured data. This deliberate exposure of the relatively crude nature of approximations of real world subjects helps differentiate the volumetric images from modeled, game-style 3d objects and also engages viewers with the capture process, and by inference the captured nature of the images, directly situating the viewer with the original context of capture. In the same way that a 2D photograph can transport a viewer to the situation and subject of the photographic image rather than viewing the surface of the image as an image only. This area digs deep into the much wider arena of image, representation, surfaces and media theory and sadly is beyond the scope of this specific paper, it being directly related to volumetric aesthetics rather than the place of volumetric imaging in the philosophy of photography.

Image dissemination and viewing

Once captured, processed, meshed, surfaced, textured, cleaned and saved our attention comes to viewing and dissemination of volumetric images. Whilst the world of volumetric photography is in its infancy and it is difficult to say with any certainty how audiences of the future may use images, and how this may in turn affect the design of the apparatus (as Vilem Flusser [15] would term any kind of photographic imaging equipment [16]). Currently there are three principal methods of viewing volumetric images.

1) interactive 2D displays such as laptop or desktop computers
2) lenticular or light field 2D displays (including pseudo holographic desktop or 'fishtank' displays) such as the 3D spherical displays of Fels et al [17] and the recent developments in light field displays such as Looking Glass [18]
3) VR 3d headsets

Each of these has their own particular sets of advantages and disadvantages and the context of viewing scenarios can greatly influence the audience's reaction and expectations. Exhibiting volumetric portraiture in VR can be beset with problems base on the pre-conceptions of the medium. At the exhibition of Volca (ibid) volumetric portraiture in VR in Montreal in spring 2018 a small number of viewers were confused by the contemplative nature of viewing only, asking what the volumetric portraits 'did' and what they were supposed to 'click on' in expectation of a game-like interaction scenario.

Particular promise has been shown in using desktop 'fishtank' style pseudo holographic displays [19] that allow headset free viewing of images with a string visual depth component. This style of display has a sense of pace and presence akin to viewing artist photographic books or collections. Giving the viewer a stronger sense of control and contemplation of the image as a complete element - not requiring additional interactivity or animation.

Given the parameters and constraints and opportunities discussed the previous sections, several aesthetic choices can be made regarding subject, composition, capture process and subsequent render and viewing conditions. As one gains experience in the various factors involved in the origination, capture, manipulation, rendering, viewing and dissemination of volumetric photographs the influence of subject choice and scene composition became apparent. Because of the nature of depth sensor efficacy and accuracy over medium to long distances (20m or more) it is difficult to establish scale and context that in traditional photography buildings or landscape may give to a scene. Therefore small intimate observations appear more effective, particularly where there are people or there are easily recognised (and cognitively 'sizeable', commonly recognisable objects such as bicycles, coffee mugs, fruit etc) elements. In this way some parts of the current forms of volumetric photography may share elements with Renaissance oil painting, particularly the practice of still-life painting and posed portraiture.

Discussion and conclusion

Volumetric photography is in its infancy and what examples there are extant and commonly from the world of experimental creative technology rather than photographic development where practitioners are building their own hardware and software systems with which to experiment. However, as both hardware, such as depth sensors and portable computer systems, and software techniques become more understood and readily available there is a growing body of knowledge and co-incidentally a growing body of images accessible. The renewed interest in Virtual Reality and the parallel developments in pseudo-holographic displays may find that mass volumetric photography available to and generated and consumed by a wider public will be a significant medium in the near to mid future.

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Optimising 3D cultural environments with large amount of texts for 3D Web. The Santo Stefano Lapidarium to the dead soldiers of the Great War, a case study

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Abstract - Digital Cultural Heritage can often take great advantage from 3D reconstructions. 3DWeb can be considered as a great opportunity for communicating this kind of contents, both as reconstructions relevant in themselves or as a tridimensional portal towards databases and other cultural resources. Often cultural environments are full of details, even long commemorative texts, as in the case of the Santo Stefano Lapidarium. In these eventualities, a good management of the 3D assets and a smart optimisation are of relevance.

INTRODUCTION

3D online cultural virtual environments are particularly effective to present themselves. This task can be achieved using 3D reconstructions of historical sites or 3D interfaces enabling the retrieval and access to further contents, such as multimedia data, documents or other cultural resources [1,2,3,4]. An example of 3D online environment for accessing data was performed at VisitLab Cineca (Visual Information Technology Laboratory) in 2004 for the project "Certosa Virtual Museum in Bologna", with the virtual reconstructions of some commemorative monuments linked to a very large database dedicated to the First and Second World War and the Neoclassical third cloister of the Certosa cemetery [5].

In order to easily reuse and update the 3D environments and ensure cross-media outputs, Visit Lab has shifted in time towards an Open Source approach, adopting a pipeline based on Blender (www.blender.org) and WebGL libraries. In recent years 3D online deployments have been delivered in Blend4Web (https://www.blend4web.com/), as in the case of the MUVI project (Virtual Museum of Daily Life in XX century - https://muvi.cineca.it) - with the 3D reconstruction of a house of the 1930's ported from the Virtual Theatre space, a Cineca's semi-immersive facility where these 3D models can be virtually navigated, to a 3D online application [6]. A new 3D interface taking advantage of 3DWeb is under construction also for the Horizon 2020 I-Media-Cities project (https://imediacities.eu/) [7]. In this case a modular and adaptable 3D environment, called Virtual Collection Creator, will host and exhibit selections of audiovisual contents, coming from the thematic "collections" previously created by archives and researchers during their own investigations, automatically adapting its exhibiting virtual rooms to the number of items to be displayed.

In any case, the need of optimising the virtual environments in order to be effectively explored online is a permanent challenge, with a direct correlation to the complexity of the cultural environment to be reproduced. The recent release by the Museum of the

Risorgimento in Bologna of a web application for navigating the 3D models of the Lapidarium in St. Stefano Bologna, a memorial dedicated to the dead soldiers of the Great War, can be considered as a possible example of specific difficulties to be overcome when opening online a virtual environment with a huge number of elements to be visualised. In this case, the application presents the 2536 names of the soldiers that were readable on the 64 commemorative plaques of the Lapidarium and that are now, in some cases, washed-up and unreadable.

The paper will present the technical solutions adopted in order to improve the management of the various elements of the application.

WORLD WAR I LAPIDARIUM DEDICATED TO THE BOLOGNESE SOLDIERS

The Lapidarium project is an evolution of the Certosa Virtual Museum, whose aim was to promote the knowledge of the Monumental Cemetery in Bologna by using it as an open air museum, telling the history of the city through its monuments and graves. The concept laying behind Certosa Virtual Museum was that of the so called "Talking Monuments", that consists in making monuments capable of telling all the stories celebrated or mourned through them. Three locations of the Monumental Cemetery were chosen for an in depth in three different historical topics: the two monumental ossuaries dedicated to the First and Second World War and the neoclassical tombs, with their relevance for the history of art, of the third cloister. Each point of interest was transformed in a 3D model and connected to databases about people, places and historical events. At present, the online 3D models, used as a portal towards the three historical scenarios and deployed at the time with Exhibit 3D, a commercial plug-in, for technical obsolescence are not available on the project's website anymore, while the database still exists on its own and is constantly enriched with new contents and multimedia resources by the Museum of Risorgimento in Bologna (http://www.storiaememoriadibologna.it/scenari). The current project about the Lapidarium tap into this same database. The Lapidarium, hosted in the cloister of St. Stefano church in Bologna, commemorates 2536 Bolognese soldiers listed on 64 commemorative plaques. The large database about the facts of the First World War in the Bolognese province contains, among its record, also all the biographies of the soldiers honored within this Lapidarium. In 2018 the existing 3D model of the St. Stefano cloister, created in SketchUp by the Museum of the Risorgimento in Bologna, was ported by VisitLab Cineca in Blender, adapted to online navigation using Blend4Web framework and linked to the database records (https://www.storiaememoriadibologna.it/lapidario-di-santo-stefano-in-3d). Through the application it is possible to switch between the cloister as it is nowadays and as it was in 1925, the year when the memorial was opened to the public. The 1925 scenario allows to virtually visit the Lapidarium as it was originally conceived, with all the plaques in place. Navigating the version of the cloister as it is at present, a more effective contextualisation to the reconstruction is given, as the user can recognize the actual spaces of St. Stefano, with also some of the plaques removed in order to make space for the opening of some passageways in the walls (Fig. 1).

Fig. 1 - The World War I lapidarium: a view of the cloister hosting commemorative plaques

Through the commemorative plaques themselves it is possible to access the database web pages. By clicking these objects, users enter a different navigation mode where they can both read the soldiers' name inscribed on each plaque, due to the point of view located in front of it and the pan and zoom tools given, and they can find the link to the web pages related to the single plaque and the people commemorated by it. The user interface inside the "plaque's inspection mode" (Fig. 2) reflects the importance given to the database links, since the side box containing them occupies a large portion of the screen.

The virtual Lapidarium application aims at using a virtual reconstruction as a database's records background: the 3D models become a sort of new user interface for the database itself. In this way the application can increase people's interest in searching the database, since the investigation is made more engaging by setting some historical informations in the physical location where they come from. Links to already existing HTML pages coming from the digital database were used. Therefore, 3D Web enables new applications to take advantage of elements coming from previous phases of the projects and already available online. Since the main focus of the application is about the commemorative plaques, an excellent legibility for the engraved names is needed. The surface of the original plaques got ruined over time and, in some cases, the soldiers' names became illegible. For this reason an *ad hoc* texture had to be created. The challenge was both in finding a way to have the highest possible texture resolution, given that the application had to be web navigated in real time, and of developing an efficient pipeline to insert in an automatic (or at least semi-automatic) way such a number of names in the 3D world.

Fig. 2 - Viewing a plaque in the "plaque's inspection mode"

MANAGING THE TEXTS

As we already said, photos of the real commemorative plaques in the St. Stefano church could not be used to texture the virtual ones due to their current maintenance status. The low maintenance status of some plaques, in fact, led to the inadequate legibility of their engraved names. The appearance of the plaques in the current photos is also in contradiction with the time period setting of the virtual reconstruction, coinciding with the Lapidarium's inauguration year, when, obviously, the newly set up plaques were still clean and legible. In addition to that, as we already said, some plaques were removed and got lost over time. As a consequence, their virtual reconstruction could not have been based on their photographs.
In order to have a perfect legibility of the names, high resolution textures were needed but their use in a 3DWeb application for such a number of objects would have resulted in an excessive slowing down of the navigation. Indeed, a real time 3DWeb application in order to be displayed at a proper frame rate by as many different devices as possible, cannot load too many heavy resources, such as high resolution textures.
For these reasons the main aim in managing the plaques reconstruction was to look for the names best legibility possible, limiting the use and the size of textures, keeping in mind that 3D geometry is lighter than raster images in terms of file size (Fig. 3).

Figure 3: A view of the walls of the cloister covered in commemorative plaques. Plaques are readable even outside the "inspection modality".

The adopted method is based on the use of a bitmap texture atlas, a technique commonly used for text rendering in the 3D gaming industry. In video games developing, when a bitmap texture atlas is used, all relevant characters and symbols from a chosen font are typed in a single large texture known as bitmap font. Each character, known as glyph, has a specific region of texture coordinates associated with it, and its size and location are described in a text data file. Every time a text is rendered, its specific constituent glyphs are selected via script (through a vertex array or VBO) and the corresponding bitmap font section is rendered to a 2D quad.

Fig. 4 - Example of planes making up the plaques texts and UV mapped on the bitmap font

Likewise, in our case a bitmap font is created and 3D planes, UV mapped on the texture atlas and placed on the 3D models of the different plaques, constitute the single letters of the engraved names (Fig. 4). This method has benefits in terms of optimization of both textures and geometry effects on the application final size file. Instead of one texture for each of the 64 commemorative plaques, only two high resolution textures, the bitmap font for the golden letters of the names of the soldiers awarded with a gold medal of military valour and the one for the red letters of the other names, are used. Moreover, using planes for each letter instead of its mesh, made by lines and curves, means a considerable decrease in terms of 3D models number of vertices. While in video games texts are dynamically created in scene and rendered in real time as they usually have to change during the gameplay, in this case texts were created during the modeling phase and then exported in the real time asset. Coding was not used for text displaying, as usually is in video game implementation. It was used, instead, in order to make the pipeline for the texts creation more efficient. Python programming in Blender was used, in particular some addons developed by the Blender community and modified according to our needs. The steps of the texts creation pipeline were as follows:

- Creation of the True Type Font (.ttf) file of the original chars actually used on the real plaques;
- Automatic text formatting using a spreadsheet with all the texts from the original records with soldiers names commemorated in the Lapidarium. The text layout comes from the analysis of the real plaques and their spatial layout and contents arrangement;
- Copy and paste of the layed out text in the 3D world using Blender internal text tool;
- Bitmap font creation with a raster graphics editor;
- Creation of planes, one for each bitmap font glyph, UV mapped on the same texture atlas previously created;
- Transformation of texts from curves to geometry and text separation in different objects, one for each character, using *Animation nodes* (AN) addon; [https://github.com/JacquesLucke/animation_nodes]. The addon was modified to name each object as the character constituting its geometry;
- Replacement of the geometries of the single character with instances of the plane mesh containing the corresponding glyph. All the characters of the same type were selected and replaced at once taking advantage of the fact that, thanks to the AN addon modification, they had the same name.

As all the single characters were replaced with instances of the same plane mesh of the respective glyph (thousands of objects which refers to only 33 planes, considering letters and special characters), texts can be easily editable in their properties as, for example, those of size, color, rotation or appearance.

Therefore, as text displaying does not rely on coding, texts can be edited at any time also by people who have not programming skills, sach as museum curators.

Since the application has a dissemination aim, the target audience has to be as wide as possible, as well as the kind of devices able to run it at a proper frame rate. For this reason, even if the technique presented in this paper has a very reduced effect in terms of increasing the final file size, in comparison with other methods that could have been used, further optimizations were needed to cope with the possibility of navigating the application with

devices with low performing graphic cards.
The working copy was kept unoptimized in order to be easily editable, while in the models intended for the real-time navigation the number of scene objects was highly reduced by merging the different planes making up the single plaque texts into a single object, one for each different plaque. Level of Details were also created. All texts of the plaques set up on the same cloyster side were baked in a single low resolution texture. At a distance, where high resolution texts are no longer needed, the object made up by the single characters planes is replaced by a plain textured with the baked texts, speeding considerably up the rendering time.

CONCLUSIONS

An important question, when dealing with digital heritage simulations, is the one posed also by Champion: "Does the resulting simulation add a new perspective, which would be more difficult to design and deliver in other media?" [8] Furthermore, what does a virtual heritage app can offer that real resources cannot? In our case, for example, in comparison with the physical lapidarium, we have a database offering the sum of a huge quantity of information coming from different archive funds. Information that, otherwise, would be accessible only as single physical resources at the Museum of the Risorgimento. Besides, the engraved plaques are now readable thanks to the virtual restoration, and it is possible to peruse also those that have been stored in the warehouse or went lost in time. Hence, this application presents the reconstruction of the lapidarium as it is now, making it visitable by faraway people, and its original version, capable of joining the database to elements that are no longer visible.
The economic limitations of this project forced us to find strategies to reduce the programming effort. The approach taken to deal with texts, presented in this paper, was not already provided by Blend4Web framework and shifted a lot of work from developers to artists, compressing the costs. Furthermore, in this way the most relevant aspect for the curators of the Museum of Risorgimento, that is the possibility of editing and correcting the names of the deceased, was kept feasible without the need to request for technical support/personnel. When the application was released the open codes were an opportunity for the Museum for modifying its aesthetics according to their taste (at present, therefore, the application looks different from our release presented in this paper). In future, they will have the possibility of creating further 3DWeb resources using other 3D reconstructions of commemorative monuments.
The care used in making the names of the dead soldiers readable again is a way of paying them homage and preserve and consolidate their fading memory.

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A TECHNO SOCIAL COLLABORATIVE PLATFORM TO OPTIMIZE CULTURAL HERITAGE FUNDING: FINAL RESULTS FROM THE VALIDATION PHASE

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Abstract – This paper presents the final results of HERIBITS, a research project co-funded by the Tuscany Region Government, under the Operative Regional Program FESR POR 2014-2020. The project proposes an innovative methodology and a platform enabling bottom-up and top-down management of cultural heritage initiatives. The techno-social platform integrates collaborative tools for CrowdSourcing, analysis tools for rating project ideas and evaluate socio-economic impact, to propose best practices and to detect similar initiatives in order to avoid project duplications. The platform also integrates an ad-hoc CrowdFunding shop.

SUMMARY

Management of cultural project ideas and proposals in the framework of research and market oriented public funding programmes requires significant effort and resources, and faces several challenges: (i) a chronic inability in Public Administration to effectively engage and spend substantial community and national resources for underdeveloped areas; (ii) a lack of structured methodologies that provide the correct time to market of planned initiatives, enabling the alignment of projects to industry best practices and a coordination of cost centers, avoiding duplications and lack of critical mass; (iii) the need to improve the use of EU and national funds within the framework of regional development, for cultural heritage protection and valorization initiatives, as well as local identity promotion and cultural tourism.

This paper presents the final results of the project HERIBITS, an ambitious research initiative co-funded by the industrial research program "Bando Unico della Ricerca" of the Tuscany Region. The project proposes an innovative method as well as advanced technologies enabling a new hybrid paradigm of bottom-up and top-down management of cultural heritage initiatives to improve collective awareness in the planning, sourcing and execution of Cultural Heritage initiatives and to optimize the allocation of public funds.

The project developed a "techno-social" web platform supporting the entire process of evaluating cultural project proposals and ideas from selection, to planning, implementation and management of results, adopting a collaborative approach, to support public administration and their technostructures in the process of selection, design and implementation of a large scale of initiatives of cultural interest.

End users of the platform are citizens desiring to promote their cultural ideas (bottom-up approach), while customers B2B are public administrations in need to optimizes their mechanisms of allocation of public funding to cultural initiatives (top-down approach).

The techno-social platform integrates collaborative tools for CrowdSourcing, as well as analysis tools for rating project ideas and evaluate socio-economic impact, using the emerging Logical Framework Analysis (LFA) method and integrating a third party analysis tool, Asset from K4D, for socio-economic statistical analysis dedicated to public administrations in Italy.

The platform proposes best practices based on project matchmaking techniques, also enabling to detect similar initiatives in order to avoid project duplications. The platform provides also social network capabilities and integrates an ad-hoc CrowdFunding shop, integrating the public contribution for exploitation activities to ensure sustainability of cultural projects, especially after project conclusion.

After developing and testing the software platform with alfa and beta users the project ended with a validation phase involving cultural heritage offices in Italian local public administrations.

Business planning based on the emerging Lean Startup approach completed the project activities by devising a Business Model for the Heribits initiative. After a better definition of user and customers requirements by means of a field research during the first part of the project, we pivoted our Business Model from B2C to B2B, finally targeting local public administrations. The CrowdFunding emerged as a key aspect of the process of project proposals evaluation. A success of a CrowdFunding campaign for a project idea increases, in fact, the probability of success of the prospective project, as it shows commitment and interests of potential customers, in line with the Minimum Viable Product and Continuous Deployment concepts proposed by the Lean Startup approach adopted.

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