digital cultural heritage: FUTURE VISIONS

Edited by Kelly Greenop and Chris Landorf

Papers presented at the
digital cultural heritage: FUTURE VISIONS Conference
19–20 April 2017 in Brisbane, Australia
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The papers published in these proceedings are a record of the conference mentioned on the title page. They reflect the authors' opinions and, in the interests of timely dissemination, are published as submitted in their final form without change. Their inclusion in this publication does not necessarily constitute endorsement by the editors.

Editors: Kelly Greenop and Chris Landorf

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The Conference Convenors received a total of 44 abstracts. Abstracts underwent a double-blind peer review by two members of the Conference Organising Committee. Authors of accepted abstracts (32) were invited to submit a full paper. All submitted full papers (18) were again double-blind peer reviewed by two reviewers. Papers were matched as closely as possible to referees in a related field and with similar interests to the authors. Sixteen full papers were accepted for presentation at the conference and a further 6 papers were invited to present based on submitted abstracts and work-in-progress. Revised papers underwent a final post-conference review before notification of acceptance for publication in these conference proceedings.

Please note that papers displayed as abstracts only in the proceedings are currently being developed for submission to a digital cultural heritage special edition of an academic journal.

digital cultural heritage : FUTURE VISIONS

19-20 April 2017 in Brisbane, Australia
Conference convenors Dr Kelly Greenop and Dr Chris Landorf

DAY 1 Morning

Wednesday, 19 April 2017

08:00 – 08:30	**Conference registration**	*State Library of Queensland Level 2*
08:30 – 09.00	**Conference opening**	*Auditorium 2*
09:00 – 10:00	**KEYNOTE 1** **Professor Mike Robinson** Re-assembled Pasts: Emotional engagements and empty encounters with digital heritage	*Auditorium 2*
10:00 – 10:30	Morning tea	*River Decks*

10:30 – 13:00

SESSION 1 – Theory case studies
Auditorium 2

Session Chair: Tom Brigden

Vince Dziekan
(Adventures in) Culturescraping

Hannah Lewi and Steven Cooke
Teaching Memory: Digital interpretation at the Shrine of Remembrance, Melbourne

Jane-Heloise Nancarrow
Countering the Uncanny and Replicating "Real-ness": Establishing parameters for post-processing in 3D digital cultural heritage

SESSION 2 – Practice case studies
Heritage Gallery

Session Chair: Joann Russell

Julie Nichols, Darren Fong and Sue Avery
Multi-Modal Archiving: Re-envisioning Acehnese built cultural heritage

M. Brinker Ferguson
Museum Preservation and Contract Zones: The politics of stewardships and the physical/digital repatriation of Te Hau Ki Turanga

Marc Aurel Schnabel and Yi He
Digital Fabrication of Parametrically Generated Māori Carvings

David Beynon, Sambit Datta and Joshua Hollick
Digitised Connections: Reflections on the image analysis and spatial modelling of Southeast Asian temples

13:00 – 14:00	Lunch	*River Decks*

DAY 1 Afternoon

Wednesday, 19 April 2017

14:30 – 15:30	**KEYNOTE 2** **Elizabeth Vines OAM** Digital Cultural Heritage – Progress or Hindrance?	*Auditorium 2*
15:00 – 15:30	Afternoon tea	*River Decks*

15:30 – 17:30

SESSION 3 – Practice case studies
Auditorium 2

Session Chair: David Mitchell

Justin Barton
Ancient Merv: Digital cultural heritage over an extended period of time

Ann Hardy, Gionnia di Gravio, Charles Martin, Russell Rigby and Tim Davidson
Newcastle Time Machine – A multi-disciplinary approach to digital cultural heritage

Richard Tuffin, Peter Rigozzi, David Roe and Jody Steele
Old v New? Comparing the use of traditional recording methodologies with photogrammetry in archaeological practice at the Port Arthur Historic Site

Chen Yang and Feng Han
Capturing Spatial Patterns of Traditional Rural Landscapes with 3D Point Cloud – A case study of Tunpu Villages in Guizhou Province, China

SESSION 4 – Theory case studies
Heritage Gallery

Session Chair: Maartin Liefooghe

Cheng Chun Patrick Hwang
Re-Evaluating the Rationality of Etienne-Louis Boullée Through Digitising and Analysing the geometry of the Cenotaph of Turenne

Natsuko Akagawa
The Question of Authenticity, Feeling and Emotion and Digital Medium in Heritage

Cristina Garduño Freeman, Marco Antonio Chavez Aguayo and Sonia Sonia González Velázquez
Google Images: a site for understanding the social and symbolic connection between World Heritage and their cities

17:30 – 18:30	Taxis from State Library of Queensland to Fort Lytton	
18:30 – 20:15	'Fort Lytton at Night' A unique promenade theatre performance, using sound and light to bring Fort Lytton's colonial fortifications to life. A light meal will be provided and numbers are limited to 30.	*Fort Lytton Historic Military Precinct*
20-30 – 21:00	Taxis from Fort Lytton to State Library of Queensland	

DAY 2 Morning

Thursday, 20 April 2017

08:30 – 09:00	**Conference registration**	*Auditorium 2*
09:00 – 10:00	**KEYNOTE 3** Professor David Mitchell Digital Technologies and Cultural Heritage - Cultural diplomacy, education and conservation management	*Auditorium 2*
10:00 – 10:30	Morning tea	*River Decks*
10:30 – 13:00	**SESSION 5 – Theory case studies** *Auditorium 2* **Session Chair: Mike Robinson** **Guido Cimadomo** Heritage as an Asset: how to involve local communities in the protection of cultural heritage **Amy Clarke and Ashley Paine** Built Heritage in the Age of Digital Reproduction **Susan Hood, David Roe and Jody Steele** Reading the Past, Visualising the Future: The practicalities of moving from an analogue to a digital world	**SESSION 6 – Practice case studies** *Heritage Gallery* **Session Chair: Elizabeth Vines** **Lisa-Marie Daunt and David Gole** Revitalising Ethiopia's Africa Hall: Using new digital technologies to conserve Africa's heritage **John Stephenson, Jody Steele, David Roe** Simple Models for Complex Ideas: Understanding nineteenth century landscapes of juvenile convict detention and reform **Joanne Tompkins and Julie Hollege** The Queen's Theatre: Using virtual reality to reconstruct performance and social cohesion in the 1840s-1850s **Joann Russell and David Mitchell** Practical Applications of Digital Technologies in the Conservation, Management and Education Fields by Scotland's National Heritage Body
13:00 – 14:00	Conference closure, virtual reality exhibition and lunch Virtual Perspective presents: "A Portal To The Past" Our Heritage in Virtual Reality	*River Decks*
14:00 – 16:00	Historic Brisbane walking tour from State Library of Queensland	

***digital cultural heritage: FUTURE VISIONS Conference,* Brisbane, Australia**

Innovative new data collection and digital visualisations capture historic artefacts, places and practices faster, in greater detail and shared amongst a wider community than ever before. Creative virtual environments that provide interactive interpretations of place, archives enriched with digital film and audio recordings, histories augmented by crowdsourced data all have the potential to engage new audiences, engender alternative meanings and enhance current heritage management practice. At a less tangible level, new technologies can contribute to debates about societal relationships with the historical past, contemporary present and possible futures, as well as drive questions about authenticity, integrity, authorship and the democratisation of heritage.

Yet for many, a gap still exists between these evolving technologies and their application in everyday heritage practice. The papers contained in this volume of proceedings represent a record of the *digital cultural heritage: FUTURE VISIONS* conference held on 19-20 April 2017 in Brisbane, Australia. The conference focused on the emerging disciplines of digital cultural heritage and the established practices of heritage management. The conference aimed to provide a platform for critical debate between those developing and applying innovative digital technology, and those seeking to integrate best practice into the preservation, presentation and sustainable management of cultural heritage.

The conference was designed to encourage critical debate across a wide range of heritage-related disciplines. The conference convenors welcomed papers from cultural heritage and tourism practitioners and academics, as well as architecture, anthropology, archaeology, geography, media studies, museum studies and other cultural heritage-related fields. Particularly encouraged were papers that explored the technical challenges of digitising tangible and intangible cultural heritage, those that identified issues with digitisation and digital interaction, and those that addressed the philosophical or theoretical challenges posed by digital cultural heritage.

Kelly Greenop and Chris Landorf
Editors and Conference Convenors

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Vince Dziekan
Monash Art Design & Architecture (MADA),
Monash University

(Adventures in) Culturescaping

Abstract

In July 2016, a group of design students from Monash University were presented with the opportunity to engage their communication design practice with the emerging interdisciplinary field of digital cultural heritage through participating in the 2016 Culturescape study abroad course. As part of an immersive research studio run in conjunction with the Biennale Sessions programme of the 15th Venice Architecture Biennale, these undergraduate students were challenged to conceive of designed interventions that respond to the "experimental preservation" of Venice. Taking inspiration from the Victoria & Albert Museum's special exhibition at the biennale, A World of Fragile Parts, their resulting speculative designs offer a platform for thinking critically and creatively about contemporary themes related to cultural heritage by offering creative propositions for how historical objects, places and everyday social practices can be experienced in the postdigital era.

This short paper will focus its discussion to considerations associated with establishing a situated learning experience, inspirations driving the immersive research studio, the "culturescraping" design brief and the design concepts that were generated through this programme.

Keywords: *A World of Fragile Parts*, Communication Design, Culturescape, Curatorial Design, Digital Cultural Heritage, Teaching/Research Nexus

No longer residing exclusively in physical monuments or collections of artefacts, by acknowledging the "living expressions" contained in oral traditions, social practices and rituals (UNESCO 2017) cultural heritage has evolved into a defining element of the contemporary, globalized world; this is especially so in regards to ensuring that cultural diversity is maintained in the face of the pressures of globalization and through promoting the essential value of intercultural dialogue. Heritage is described by historian Steven Hoelscher (2006) as a foundation of personal and collective identity; and found *everywhere*, not just in national history museums. While significant growth in the number of museums, historic sites and conservation zones over the recent past supports the importance of heritage in quantitative terms, even more importantly, it can be argued, the 'scope of what is deemed worth preserving has also expanded dramatically, extending now to environments, artefacts and activities that, in the past, would have been considered beyond the scope of historical attention.' (Hoelscher 2006, 201). It is on these two scores –of the proliferation of heritage and the diversification of cultural forms– that the speculative designs produced by students engaged in the 2016 instalment of the *Culturescape* programme have something to contribute to the developing discourse around digital cultural heritage.

Exemplifying a commitment to ensuring that its students are equipped to engage fully as "global citizens" in their chosen fields, MADA (Monash Art Design and Architecture) conducts a regular series of study abroad programs at the university's key presence in Europe: the Monash University Prato Centre, located just outside of Florence. In this distinctive setting, the cultural legacy of the Italian Renaissance is brought into sharp relief with the "culturescape" (Appadurai 1996) of the present day. This conjunction offers unique opportunities for conducting intensive studios where art and design students can be challenged to develop their critical and creative faculties in response to the juxtaposition of the past, present and imagined futures. (Figure 1) *Culturescape* (*CS*) is one such programme. Delivered

on four separate occasions since 2009, *CS* operates as a flexible learning programme that promotes attentiveness to cultural specificity and the situatedness of studio learning experience. While adapting to different curricular contexts with each of its previous deliveries, the programme has consistently demonstrated a pedagogical approach that emphasises participants engaging in meta-cognitive activities that encourage each student to become increasingly aware of the contexts and institutional settings in which their learning takes place. *Situated learning* acknowledges how the process of knowledge co-construction occurs in context and is embedded within a particular social environment. (Lave & Wenger 1991) Theoretically, situated learning stands in contrast to most conventional forms of teaching and learning activity where knowledge (and "know how") is largely abstracted by being imparted out of context. *CS* produces a composite "learning environment" by designing a curricular structure that interrelates closely with its cultural setting and social situation. Through the integration of fieldwork, creative process and studio critique, students are provided with an immersive studio experience enabling them to explore their creative practices by developing cultural content for emerging art and design practices. In the case of *CS2016*, particular emphasis was directed towards exploring the role of communication design in the *curatorial design* of cross-platform, transmedia experiences in digital cultural heritage. As part of its conceptual framework, curatorial design emphasises the integration of digital mediation and spatial practice by recognizing that digital technologies and their associated cultural practices have become increasingly interwoven into the museological communications of contemporary, *postdigital* museums and heritage institutions. (Dziekan 2012)

Figure 1. Culturescape 2016 participants (Dr. Cameron Rose and Dr. Pamela Salen, Faculty of Art Design and Architecture, Monash University; Emily Anderson, Mariah Arvanitakis, Marya Bautista, Molly Breckler, Anthony Campus, Serena Chen, Lillian Cordell, Marcus Cozzi, Berber de Moel, Jessica Eastman, Elizabeth Gregory, Lucas Hatzisavas, Rebecca Hranilovic, Samantha Ireland, Josephine Ivanoff, Amber Johnson, Fiona Lam, Ho Ying Leung, Ashley McVea, Dyann Obtinalla, Brooke Page, Olivia Parry, Swathi Sankaran, Natasha Smart, Emilia Thompson, Andrea Tralongo, Natlie Tunstill and Kierra Walshe-Urbancic, Department of Design, Monash University). Florence, Italy. Photo: Vince Dziekan.

Culturescape

CS2016 was delivered as part of an overall five-week study abroad course in which the role of design in society was investigated through a discursive focus on cultural heritage, foregrounding contemporary issues in museum studies, as well as innovative recent developments associated with emerging forms of digital cultural heritage. While a supporting series of coursework assignments were explicitly formulated to introduce and engage students with theoretical content relevant to designing for cultural heritage, including curatorial studies and museum media and communication, an immersive research studio conducted over a dedicated week in Venice acted as the principal focal point of exploring these critical ideas through practice. Framed as a *speculative design* (Dunne and Raby 2013) activity, the *"culturescrape"* project that will be elaborated upon shortly drew inspiration from the exhibition, *A World of Fragile Parts,* curated by the Victoria and Albert Museum (V&A) as part of its newly established partnership with the Venice Biennale. By engaging with the exhibition in an immediate and highly situated manner, the students were challenged to act in response to the threats facing the preservation of global heritage sites and how the production of copies can aid in the preservation of cultural artefacts by looking, thinking and doing, interpretively and imaginatively.

Before proceeding further, it may appear that the terms "*Culturescape"* and *"culturescrape"* (or *"culturescraping"*) are being used interchangeably in the account that follows. Briefly, as a point of clarification: *Culturescape* refers directly to the curricular framework and programme related aspects of the study abroad course itself; whereas the term *"culturescrape*" designates the creative brief that was undertaken as part of the immersive research studio conducted in association with the Biennale Sessions programme as part of the 15th Venice Architecture Biennale.

A World of Fragile Parts proposes that in a world where material culture is fragile and increasingly at risk, digital copies can aid in the preservation of cultural artefacts. (Figure 2) Historically, the V&A took the lead in advocating for the practice of copying as part of its founding mission and is best exemplified by Sir Henry Cole's 'Convention for promoting universally Reproductions of Works of Art for the benefit of Museums of all countries' of 1867. (Figure 3) As the museum's founding director, Cole advocated for a pan-European museum-lead commissioning programme to collect and produce reproductions of artworks, in the form of plaster casts, electrotypes and photographs. The V&A's iconic Cast Courts are an enduring manifestation of the nineteenth-century museum's idealized vision of the copy. Built in the 1870s (and currently undergoing major capital redevelopment), these galleries still display many of the museum's most magnificent plaster casts including Michelangelo's David and the Trajan's Column. Originally conceived

as pedagogical tools for public education and the training of art and design students, the perceived value of facsimiles fluctuated dramatically during the twentieth-century, when copies became viewed as increasingly anachronistic, decorative affectations lacking in substance or "auratic" value. Today, instigated in large part by advances in digitalization and fabrication technologies, copying has taken on new relevance to the service of conservation, as well as cultural, social and political activation. (Latour and Lowe 2010; Cameron and Kenderdine 2007) To this end, architect/artist Jorge Otero-Pailos' practice of "experimental preservation" imparts an ethical value on processes of reproduction by materializing time,

Figure 2. Installation view of A World of Fragile Parts, 2016. The 15th Venice Architecture Biennale. Venice, Italy. Photo: Vince Dziekan.

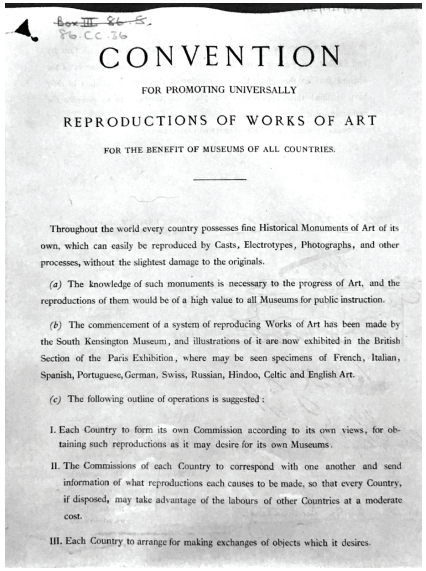
turning otherwise overlooked traces into 'a historical document [that] places them in a new vision of architecture.' (Battistella 2009, 118)

Otero-Pailos' exemplary practice-based research provides an intriguing demonstration of the dynamic interplay that can exist between the residual past and presence. Otero-Pailos draws upon conventional conservation practices to realize spatial artworks that reveal the history of buildings and objects through painstakingly removing built up layers of dust using sheets of latex, as commonly used in restoration work. A quintessential example from his ongoing *Ethics of Dust* project was an installation staged in the V&A's Cast Court. This intervention was commissioned as part of the exhibition, *All This Belongs to You* (2015)

and entailed exhibiting a formidable latex "cast-of-a-cast" adjacent to the "original" cast of Trajan's Column. In this case, rather than choosing to reproduce the battle scenes that spiral around the exterior of the column, Otero-Pailos instead chose to *cast his attention* to the internal brick structure supporting the column itself. Through engaging in this act of "reverse restitution", Otero-Pailos quite literally inverts conventional understanding of the cast as a form of reproduction by revealing the production process of the object instead; returning the thing itself to the origins of its own making. In the process, this intervention subtly reveals how the Museum's enduring civic commitment is in turn reflected through the duty of care it takes towards the conservation of the public collection. A related example, *Scrape: the Ethics of Dust* (2009) was the product of spatial research involved in harvesting the built up pollutants from a wall behind the second floor loggia of the Doge's Palace off Piazza San Marco in Venice. Included in *Making Worlds: the 53rd International art exhibition of the Venice Biennale* (2009), the title of this work informed the portmanteau *"culturescrape"* as it was applied to *CS2016's* design brief.

Immersive research studio

In addition to the inspirational example provided by Jorge Otero-Pailos, central ideas motivating the curatorial theme of *A World of Fragile Parts* were translated into *CS2016's* immersive research studio: a week-long series of integrative creative research activities whereby participants were challenged to think and act upon the questions and issues precipitated by this exhibition in response to cultural creation and preservation issues. This student-focused activity was incorporated into the Biennale Sessions program, and a seminar convened at the Arsenale in the Sale d'Armi to explore contemporary themes related to digital cultural heritage and how the imaginative processes of artists and designers can be applied to the creation, interpretation and activation of cultural artefacts. The dedicated seminar facilitated a critique of the exhibition and the implications to digital cultural heritage practice



CONVENTION

FOR PROMOTING UNIVERSALLY

REPRODUCTIONS OF WORKS OF ART

FOR THE BENEFIT OF MUSEUMS OF ALL COUNTRIES.

Throughout the world every country possesses fine Historical Monuments of Art of its own, which can easily be reproduced by Casts, Electrotypes, Photographs, and other processes, without the slightest damage to the originals.

(a) The knowledge of such monuments is necessary to the progress of Art, and the reproductions of them would be of a high value to all Museums for public instruction.

(b) The commencement of a system of reproducing Works of Art has been made by the South Kensington Museum, and illustrations of it are now exhibited in the British Section of the Paris Exhibition, where may be seen specimens of French, Italian, Spanish, Portuguese, German, Swiss, Russian, Hindoo, Celtic and English Art.

(c) The following outline of operations is suggested:

I. Each Country to form its own Commission according to its own views, for obtaining such reproductions as it may desire for its own Museums.

II. The Commissions of each Country to correspond with one another and send information of what reproductions each causes to be made, so that every Country, if disposed, may take advantage of the labours of other Countries at a moderate cost.

III. Each Country to arrange for making exchanges of objects which it desires.

Figure 3. 'Convention for promoting universally Reproductions of Works of Art for the benefit of Museums of all countries', 1867. Archival document displayed in A World of Fragile Parts, 2016. The 15th Venice Architecture Biennale. Venice, Italy. Photo: Vince Dziekan.

raised by a number of representative works that employed new and emerging technologies to aid in the preservation of cultural artefacts through the production of copies. (Figures 3-5) Thought-provoking projects by Nora al-Badriand and Jan Nikolai Nelleshave (*The Other Nefertiti*) and Morehshin Allahyari (*Material Speculations: ISIS*), crowd-sourcing initiatives (*New Palmyra Project*; *Project Mosul*) and the transdisciplinary practice of Forensic Architecture brought a creative voice to an otherwise critical debate about the philosophical and theoretical challenges posed by mediation (digital, and otherwise).

Figures 4-6. Student interaction with exhibits in *A World of Fragile Parts,* 2016. The 15th Venice Architecture Biennale. Venice, Italy. Photo: Vince Dziekan.

The accompanying speculative design brief sought to provoke a reconsideration of museums and their institutional practices (of collecting, conserving and exhibiting) by turning attention instead towards speculating upon the catalysing role that cultural institutions can play in the future. Design *futurescaping* provided the conceptual basis for doing so. According to Superflux studio co-founder Anab Jain, futurescaping workshops serve as a springboard for strategic thinking and invention. Applied to design in an effort to more fully grasp the meaning of cultural communications, futurescaping borrows from the ethnographic concept of "thick description" raised by anthropologist Clifford Geertz. It is through analysing actions, objects and practices from the deeply immersive perspective of an engaged practice that

'we can begin to detail a "slice" through future society – the product of multiple trends, actors, agents, technologies, and "thick" meanings'. (Superflux 2011, 7) Jain makes an important clarification about the way that futurescaping can be used to support how design works with existing structures, cultural content and social values when stating that 'when we talk about the future, this isn't something that comes at the expense of the present'. Rather, she continues: 'When we talk about the future, we are expressing our interest in the processes and dynamics that shape the present moment: in the tools and products we use, the things we experience, the ways we think about ourselves, and the world we inhabit'. (Jain 2012)

Introduced as part of an initial briefing hosted in the inspirational surrounds of the chapel of the Casa Caburlotto, the students were issued with the challenge to develop concept designs that imaginatively preserve a chosen site in Venice. Working in groups, initial *placemaking* activity was undertaken to identify an object, locale or situation that would serve as the inspirational basis for their design intervention. This exercise might be considered an analogue form of "webscraping" –a term that encompasses a variety of methods used to collect or "data mine" information from across the Internet. Once a site was duly identified, members of each group were challenged to develop a creative concept with the objective of activating historical evidence or intangible experience as a dynamic, immersive and psychologically engaged "open work".

The creative inspiration underscoring this exercise drew upon the following convergence of ideas: In 1964, the International Council on Monuments and Sites formulated an International Charter for the Conservation and Restoration of Monuments and Sites. Known thereafter as the "Venice Charter", this document codified internationally accepted standards of conservation practice relating to monuments by setting out principles of conservation based on the concept of authenticity and the importance of maintaining the physical context of a site along with conserving its historical evidence. The Venice Charter

provides the following approved definitions:

> Article 1. The concept of a historic monument embraces not only the single architectural work but also the urban or rural setting in which is found the evidence of a particular civilization, a significant development or a historic event. This applies not only to great works of art but also to more modest works of the past that have acquired cultural significance with the passing of time.
>
> Article 2. The conservation and restoration of monuments must have recourse to all the sciences and techniques that can contribute to the study and safeguarding of the architectural heritage.
>
> Article 3. The intention in conserving and restoring monuments is to safeguard them no less as works of art than as historical evidence. (ICOMOS 1964)

In that same year, celebrated Italian writer and semiotician Umberto (Eco 1994a) wrote '*Apocalittici e integrati*' (translated into English as 'Apocalyptic and Integrated Intellectuals: Mass communications and theories of mass culture'), which analyzed the emerging conditions of mass communication from the sociological perspective of the "culture industry". During this formative period, Eco would develop his ideas on semiotics and the "open text", subsequently writing a number of highly influential books and speculative essays on these subjects; including amongst these, an essay entitled 'On the Impossibility of Drawing a Map of the Empire at a Scale of 1 to 1'. (Eco 1994b)

The more speculative aspects of the creative brief were situated pedagogically by the urgent, real-world issues raised by *A World of Fragile Parts*, while the Venice Architecture Biennale encouraged meta-learning by exposing the students to a plethora of inspiring projects demonstrating the integration of theory and practice. Having their own creative motivations at the forefront of their minds meant that certain projects encountered at the biennale were identified as useful precedents. These exemplars helped the students to visualize ways of realizing their highly propositional concepts.

Design Concepts

Ultimately, the immersive research studio resulted in a series of design proposals that imaginatively translate a chosen site-specific encounter or distinctive experience associated with Venice. Drawing upon the integrative mix of field research experiences (placemaking, fieldwork, exposure to a variety of exhibitions), the resulting creative concepts activate historical evidence or intangible social practices as dynamic and engaging mediated interventions or recreations. It is, of course, worth reiterating that the students responsible for creating this set of diverse conceptual responses were largely unfamiliar nor conversant with the weight of issues broached by cultural heritage. Therefore it should not be surprising that the creative orientation of these representative projects approached their heritage purpose through communication strategies ranging from simulated recreation on the one hand to documenting otherwise inconsequential, ephemeral experiences on the other. In the main, landmarks were approached as performative sites rather than as historical subjects in their own right. Perhaps because they were not inclined to approach the brief as a strict conservation exercise, their designed interventions privilege the subjectivities associated with a contemporary experience of culture and heritage more broadly, rather than striving to record or capture physical artefacts or sites in a more objective, empirical or scientific fashion. Instead, these projects opt to embrace the confluence of heritage, tourism and auto-ethnographic modes of interpretation that "perform" the process of cultural heritage. (Kidd 2011) Drawn to 'processes and conditions rather than products' (UNESCO 2017), their design intentions range from presenting informational content (for example, highlighting the implications of climate change) to multi-sensory encounters that exist at the more experiential end of the spectrum. After all, our human experience of the world is shaped by our senses.

This phenomenological orientation inspired a number of the resulting design proposals. For example,

S-Squared conceptualizes a full sensory experience of being in Piazza San Marco by re-activating elements associated with the five human senses. The design for this immersive and participatory museum installation draws upon the full range of senses –of sight, hearing, taste, touch and smell– to aid our memory of time, activity and place. Notionally reproduced at a 1:2 scale, the exhibition arena is demarcated by a variety of spatial environments. Combining both expansive spaces alongside more intimate enclosures, the installations recreate visual aspects through large-scale projection, replicate the tactility of physical surroundings, expose the visitor to tastes and odours, as well as a variety of acoustic experiences (from highly focalized sounds to enveloping, atmospheric sound scapes). This panoply of sensory experiences is connected together by employing digital mediation in the form of a location-aware mobile guide. While an audio playlist is designed to guide individual experience within the installation, this visitor-centred mode is disrupted and over-ridden on an hourly basis by the sound of a bell tower. This event signals a simulated "flood": an audiovisual experience that envelops the entire installation in a simulated recreation of the flooding that consumes the square during the "acqua alta". Drawing upon a simular experiential approach, the *Touchpoints* project highlights the sense of disorientation one inevitably encounters on first visiting Venice. Developing from the experience of five different students, this concept emphasises sight and touch as means of navigating the maze of Venice. Recreating five divergent routes, distinctive objects and textures are relied upon as cues that assist personal wayfinding between Dorsoduro and L'Accademia. Rather than collecting impersonal information and artefacts, this exhibition opts instead to re-collect highly subjective memories. In terms of design, the project seeks to create conditions for an intimate experience by relying upon lighting, scale, media, materiality and temperature along with highly personalized accounts that relate these punctuated sensory experiences (described as "touchpoints") to individualized journey maps.

Aptly illustrated by these abovementioned projects, it is through appealing to our senses that we become fully immersed in heritage environments; In the following section I take the opportunity to represent two further design concepts that engage with the notion of "experimental preservation" in more detail.

Acqua Alta

Developed in response to the environmental issues that threaten Venice's rich cultural history, *Acqua Alta* is conceived as a speculative design for a museum of the not-too-distant future dedicated to the sinking city. The term "acqua alta" refers to the exceptional tide peaks that occur periodically in the region and engulf Venice itself on a regular basis. The overall spatial design leads the visitor sequentially through a series of discrete experiences that relate the past, present and (impending) future of Venice at the mercy of this seasonal flooding. (Figure 7)

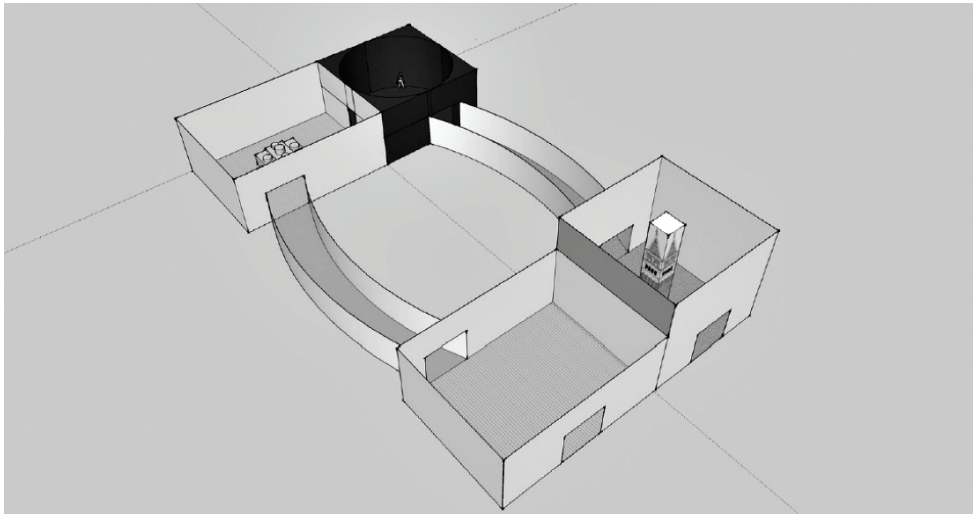


Figure 7. 'Acqua Alta'. Design response to *culturescrape* project brief. Concept Design: Lillian Cordell, Emilia Thompson, Natasha Smart, Dyann Obtinalla & Berber de Moel.

A description of the experience design proceeds accordingly: After being introduced to information about the environmental threats facing Venice, the visitor enters a gently curving tunnel lined with LCD panels displaying video footage that depicts travelling along the Grand Canal towards Piazza San Marco. Further amplifying the sense of visual immersion, sound effects and an artificial breeze reinforce the sense of being carried along the watercourse. At the end of the tunnel the viewer arrives in a small gallery featuring a hyper-realistic, scaled model of the Basilica di San Marco. While the model itself is the dominant element of the room, an otherwise innocuous black strip runs continuously around the walls at approximately eye-level (this line signifies the fact that the floor of the crypt found below the basilica has dropped by 168 cm since the ninth century). This gallery is connected to an adjoining cinema room in which a high-definition video of the basilica's ornately detailed interior spaces is presented on a 360-degree screen. From here the visitor enters a second tunnel zone in which, this time, imagery of a typical Venetian street lines the walls, while underfoot, a reactive surface of clear Perspex flooring is laid over a shallow channel of water. At the end of this tunnel, the audience reaches the final gallery dedicated to the iconic Campanile. Standing as an important symbol of the hardship that Venice has withstood over centuries, its reconstruction following collapse in 1902 was guided by a conscious effort to retain its heritage value, encapsulated in the credo, "Where it was and as it was". In this installation, the belltower will be recreated as a virtual projection onto four-sides of an imposing freestanding planar structure rising from the centre of the room. At regular intervals, the space descends into darkness for a programmed audio/visual show depicting the tower slowly disintegrating and sinking completely

Watermarked

As with the preceding project, *Watermarked* serves as a call to action promoting the urgency of working towards a sustainable solution in response to the issue of global warming.

The design concept is for a distributed site-specific installation and mobile experience. Overlooking the Grand Canal from L'Accademia and Rialto Bridges at either end, two temporary architectural structures anchor augmented reality experiences foreshadowing how Venice might appear in the future when devastated by the effects of flooding. At night, a route through the labyrinthine streets connecting both locations is marked at key junctures by environmental projections onto buildings creating the impression of flooding occurring along the route. (Figure 8) The journey ultimately leads the viewer to a designated building in which an immersive spatial experience is staged that depicts a simulated scenario of a family home affected by the floods. Audience members can enter this domestic space (which will be filled with water and scattered furniture) and interactively control aspects of the environment using smart

Figure 8. 'Watermarked'. Design response to culturescrape project brief. Concept Design: Serena Chen, Talia D'Aquino, Rebecca Hranilovic, Fiona Lam & Brooke Page.

DZIEKAN

technologies. Upon reaching the upper level of the apartment, a series of projections will be triggered to play throughout the environment showing time-lapse footage of "home movies" designed to create an empathetic portrayal of a "real" family affected by this apocalyptic scenario. This immersive narrative extends to other supplementary sites along the designated route where a number of smaller installation sites modelled using actual houses, shops and restaurants that passers-by can look into. An important feature of this proposal is the role played by an integrated mobile app, whose features include a navigable map (or "trail"), a "live feed" (supported by screens found in locations dotted along the route to promote public engagement) and augmented reality content, plus additional information pertaining to the underlying public awareness and fund-raising campaign.

Conclusion

It has been noted that different measures are needed to safeguard intangible cultural heritage from those established to conserve the physical state of monuments, sites and natural spaces: 'For intangible to be kept alive, it must remain relevant to a culture and be regularly practiced and learned within communities and between generations.' (UNESCO 2017) The application of digital mediation towards creating the kinds of interactive communication experiences associated with "public interactives" (Balsamo 2016) and the ways in which this media form manifests cultural value and performs cultural work should not be discounted in this regard.

Taking account of the political, cultural, and social usage of the past, Steven Hoelscher identifies a number of key features and premises that exert an influence on contemporary heritage. Of these, the design proposals produced during *CS2016* most closely align with the qualities he notes alongside heritage experiences applying to "place" and "time" in particular. Heritage displays operate at dramatically different physical scales, 'from the body to a building to a street to a neighbourhood to a city to a region to a nation to the globe.' (Hoelscher 2006, 204) In deference to the highly influential work of Pierre Nora, "sites of memory" are both materialized in concrete ways, as well as through non-material expressions. In his effort to describe sites of collective identity, Nora defines their existence between history and memory as complex: 'At once natural and artificial, simple and ambiguous, concrete and abstract, they are lieux—places, sites, causes—in three senses—material, symbolic and functional.' (Nora 1997, 14) Likewise, temporality presents its own paradoxes, particularly reflected in efforts striving to stabilize history in contrast to cultural heritage's more elusive, lived constitution. While heritage may look old, upon closer inspection, it is more than likely that contemporary concerns will reveal themselves. When approached from this perspective, heritage most clearly exhibits its "processual" nature as 'a social process that is continually unfolding, changing and transforming.' (Hoelscher 2006, 206) The concepts developed as outcomes of this "*culturescraping*" process are designed to activate cultural heritage across these dimensions.

In his curatorial statement for *A World of Fragile Parts*, Brendan Cormier (2016, 136) writes:

> Galleries, Libraries, Archives and Museums are time-honored institutions that we entrust to collect, care for and communicate our cultural history. The use of emerging digital technologies to activate, engage, and transform this cultural legacy runs parallel with transformations happening in the way these institutions are safe-guarding our collective past through digital formats. Broadly speaking, Digital Cultural Heritage is concerned with the curation, critique and evaluation of museums and heritage work at this pivotal moment when the relationships between cultural material, knowledge, society and technology are radically changing. Moreover, it entails the creative and critical application of digital technologies towards the investigation, interrogation and imaginative exploration of the relationships found within cultural complexes.

And so, it is with the final assertion of Cormier's statement that this account of *CS2016* and the

Culturescrape project will be drawn to a close. What these creative outcomes reveal –especially through applying *curatorial design* as a mode of contemporary curating that extends the narrative and communicational possibilities of cultural experience by drawing particular attention to the mediating role of the exhibition between artwork, viewer and postdigital environment– is that heritage representations, whether objects, images, or events, are not mute, impassive containers, but rather "active vehicles" (Hoelscher 2006, 203) that play a part in sharing meaning and producing knowledge of-, about- and through engaging with the past, here, in the present. Whether expressed as creative interpretations or representations that draw upon more empirical forms of knowledge, grounded in fact or animated by fictional flights of imagination, heritage, as a mode of understanding, is inseparable from the ways we choose to create it.

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References

Appadurai, A. 1996. *Modernity at Large: cultural dimensions of globalization*. Minneapolis: University of Minnesota Press.

Balsamo, A. 2016. "The Cultural Work of Public Interactives." In *A Companion to Digital Art*, edited by Christiane Paul, 330-351. Hoboken, NJ: John Wiley & Sons.

Battistella, C. 2009. "Jorge Otero-Pailos." In *Making Worlds: 53rd International Art Exhibition*, 118. Venice: Marsilio.

Cameron, F. and S. Kenderdine. 2007. *Theorizing Digital Cultural Heritage: A Critical Discourse*. Cambridge, Massachusetts and London, England: The MIT Press.

Cormier, B. 2016. "A World of Fragile Parts." In *Reporting from the Front: The 15th International Architecture Exhibition*. Venice: Marsilio.

Dunne, A. and F. Raby. 2013. *Speculative Everything: design, fiction, and social dreaming*. Cambridge, Massachusetts and London, England: The MIT Press.

Dziekan, V. 2012. *Virtuality and the Art of Exhibition: Curatorial Design for the Multimedial Museum*. Bristol: Intellect.

Eco, U. 1994a. "Apocalyptic and Integrated Intellectuals: Mass communications and theories of mass culture." In *Apocalypse Postponed*, edited by Robert Lumley, 17-35. Bloomington and Indianapolis: Indiana University Press.

Eco, U. 1994b. "On the Impossibility of Drawing a Map of the Empire at a Scale of 1 to 1." In *How to Travel with a Salmon and Other Essays*, 84-94. London: Seeker & Warburg.

Hoelscher, S. 2006. "Heritage." In *A Companion to Museum Studies*, edited by Sharon Macdonald, 198-218. Malden: Blackwell.

ICOMOS. 1964. "International Charter for the Conservation and restoration of Monuments and Sites." Charter adopted by the IInd International Congress of Architects and Technicians of Historic Monuments, Venice, 1964.

Jain, A. 2012. "Design Futurescaping: Where's the value?" *Superflux blog*, January 11. http://superflux.in/blog/design-futurescaping-value/.

Kidd, J. 2011. "Performing the knowing archive: Heritage performance and authenticity." *International Journal of Heritage Studies*, 17 (1): 22-35.

Latour, B, and A. Lowe. 2010. "The migration of the aura or how to explore the original through its fac similes." In *Switching Codes*, edited by Thomas Bartscherer, 1-18. Chicago: University of Chicago Press.

Lave, J. and E.Wenger. 1991. *Situated Learning: Legitimate peripheral participation*. Cambridge: University of Cambridge Press.

Nora, P. 1997. *The Realms of Memory: Rethinking the French past*. New York: Columbia University Press.

Superflux (Anab Jain, Jon Ardern and Justin Pickard). 2011. "Design Futurescaping." In *The Era of Objects*, edited by Michelle Kasprzak, 6-14. Rotterdam: V2_Blowup reader #3.

UNESCO. 2017. "What is Intangible Cultural Heritage." Accessed January 26. http://www.unesco.org/culture/ich/doc/src/01851-EN.pdf.

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Teaching memory: digital interpretation at the Shrine of Remembrance, Melbourne

Abstract

This paper investigates how digital formats are reframing collective remembrance, commemoration, and history telling at Melbourne's Shrine of Remembrance. The Shrine's recently completed redevelopment includes new gallery spaces containing digital interventions and 'interactives' on display. With these additions to the suite of on-site interpretation experiences, longstanding issues encompassed in places of public commemoration become amplified. These include tensions between education, personal and collective commemoration, and tourism, but also issues including regimes of bodily experience and movement shaped by the digital mobile technology; evolving expectations of social behaviour in a place that is understood to hold some sense of shared respect; continuing expectations that such sites challenge the world view of the visitors, and the sense of custodial voice and authority which is evident in digital applications. This paper examines the interaction between various 'technologies of remembrance' (Jones 2003), the active participation of the material world in eliciting remembrance, which includes the digital, and also the architectural spaces through which visitors engage with the digital. We argue that these technologies, aiming to 'teach memory', are an attempt to position the visitor as a 'witness', an active participant in the ongoing work of memory, with the potential to create spaces for critique.

Keywords: Commemoration; digital heritage; monuments; digital curation

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Countering the 'digital uncanny': Post-processing for 3-D digital heritage

Abstract

An undesirable result of photogrammetry and laser scanning in the cultural heritage context can flatten shadows, light, and surface textural variations on-three dimensional digital models of original artefacts. Many of these important visual cues contribute to our understanding of digital models as "historical objects", and the resulting overly digitised replicas – lacking visual context and depth – can impede user interactivity. Viewers of digital heritage can become deterred by the uncanny, static or unreal aesthetic of some photogrammetric and laser scans. Yet digital curators have the opportunity to address some of these issues.

This paper interrogates curatorial decisions relating to digital post-processing; assessing the relevance of theories of the 'uncanny' and the 'uncanny valley', as well authenticity in digital intervention. The Emotions3D project applied considerable post-processing modification to align models with their original photorealistic state and create visual context. In contrast, the Smithsonian Apollo 11 module project left model data 'raw', with the invitation for users to experiment with available datasets. While 3-D digital visualisation in museums poses significant technical and curatorial challenges, subtle post-processing choices are deeply emotionally internalised by viewers. This article argues that accessibility and user engagement with digital artefacts can therefore be enhanced through best-practice post-processing techniques.

Keywords: Photogrammetry, structure-from-motion modelling, 'uncanny valley', post-processing, user-engagement, emotional interactivity.

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Multi-modal archiving: re-envisioning Acehnese built cultural heritage

Abstract

Post-tsunami Aceh Indonesia represents a contemporary example of lost built cultural heritage, with the destruction of significant buildings, whole communities and archival materials in 2004. This paper proposes reconsidering 'the archive' as an interactive set of multi-modal representations. Framed from one perspective, as a disaster recovery tool, is a research method combining outcome and process to safeguard against future losses of built and socio-cultural heritage. Immersive research methods engage onsite interaction, community shared experiences, engagement, collective remembering for purposes beyond recording built heritage. The production of research in the absence of community collaboration or situational immersion represents an intellectual exercise that is detached from any 'real' physical appreciation of the subject. Architectural anthropology underpins a process that employs material in digital and virtual representational modes, simultaneously, to record traditional Acehnese built forms and related socio-cultural practices. Collated virtual modelling technologies have the capabilities to innovatively re-imagine sensorial and experimental spatialities of lost Acehnese urban environments, activating new archival collections. The research process discussed aims to record, produce and reimagine data, producing interactive archival material in a form accessible to audiences beyond language and cultural boundaries, to reflect on the human condition for disaster relief situations.

Keywords: Interactive heritage archive; BIM; VERNADOC; re-envisioning; multi-

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Digital fabrication of parametrically generated Māori carvings

Abstract

Wood carving is one of the important carriers of indigenous culture. In New Zealand, Māori carving forms a distinctive part of its culture. Traditional carvings require skilful handicraft techniques and complex knowledge of carving patterns. The emerging technologies of digital fabrication can provide highly efficient fabrication solutions. This motivates us to intersect traditional indigenous wood carving in conjunction with computational instruments and methodologies. Our research focuses on underlying parametric systems to develop a rule-based algorithm that allows for the automatic generation of 'koru'-patterns for CNC and robotic supported fabrication. First, we study the topology and culture context of the carving. Next, we model parametrically the koru patterns according to the underlying logic of the patterns. In the forward-reverse translation process of form and algorithm, cultural heritage and digital realm, we intend to make the overall process more accessible and interpretable. After the digital modelling, digital fabrication is carried out using a CNC machine or single arm industrial robots. Our research proves the feasibility of a digital generation and fabrication process in the heritage realm of Māori wood-carvings. We end the paper with a discussion of how our methodology can be used to investigate the potential for indigenous development, cultural empowerment and innovation. A contemporary translation of cultural heritage into the current realm of digital technologies and possibilities has research potential that needs to be debated further.

Keywords: Māori carving; digital fabrication; indigenous parametric patterns; robotics; CNC

Introduction

Koru is a spiral shape based on the shape of a new unfurling silver fern symbolizing new life, growth, strength and peace (Royal 2009). The plant silver fern, also known as the *cyathea dealbata*, silver tree-fern, ponga or punga, is a species of medium-sized tree fern, endemic to New Zealand. It has been treated by Māori people as a god comes from the sea. It is a symbol commonly associated with the country both overseas and by New Zealanders themselves (Wilson 2017) (Figure 1, left).

The Māori wood carving forms a distinctive part of its indigenous culture. Skilful handicraft techniques, complex knowledge are some requirements for the traditional carvings. The high-efficient fabrication solutions provided by emerging technologies of digital fabrication motivates us to further develop the intersection of traditional indigenous design techniques, in this case wood carving, in conjunction with computational instruments and methodologies (Kawiti *et al.* 2016). Our research focuses in this study on the digital fabrication of koru patterns. First the topology and culture context of the carving is explored. Then we parametrically model the koru patterns according to the underlying logic of the patterns. After the digital modelling, digital fabrication is carried out using a CNC machine. We intend to prove the feasibility of a digital generation and fabrication process in the heritage realm of Māori wood-carvings. We believe the methodology can be used to investigate the potential for indigenous development, cultural empowerment and innovation (Kawiti and Gordine 2017). We acknowledge that it is not simple to translate a culturally rich artefact into a computational code that may lose its spiritual and cultural context. At this point however, we are interested in exploring the underlying geometrical descriptions of the patterns to be able to explore novel avenues, so then these descriptions can be applied in the right contextual settings.

Manual modelling and fabrication test

The test is meant to explore manual modelling and verify the capability of fabrication hardware. We generate the models manually according to a carving sample. The model is exhaustive enough to reflect all levels of details (Figure 1, middle). Then the model is transferred into a file that can be used by a CNC machine. According to our test result, the precision of the CNC machine has been proved capable enough to produce a high-quality artefact. We test that it is suitable to fabricate more sophisticated wood carvings. Then, if the manually-made model can be fabricated well, it should be the same as the situation of parametric modelled samples (Figure 1, right).

Figure 1. The silver fern plant (left), the manual modelling (centre) and the test outcome of the CNC machine (right). (Source: © Alkalyne/Getty Images)

The generation mechanics behind the spiral patterns

The koru patterns are formed by spiral curves. So, the methodology of generating the spiral curves is one of the key foci of this research. In this section, the generation mechanics behind the spiral curves are explained in detail. For the curve-creating, the basic idea is to locate the control points first and then link them to form the curves. After studying and testing, we have developed three 'rotate- and move algorithms', as well as 'evaluate- and point-cylindrical algorithms' to create point coordinates spirally in a parametric computational environment using

Grasshopper3D and *Rhinoceros3D* Software (Payne and Issa 2009).

The rotate and move algorithm is to use the basic 'Rotate' component and 'Move' component for spiral curve generation. By using the series component, arithmetic sequences can be created to set the translation vectors for defining the movements of an original point. After generating a column of points, then we can use the Rotate component to rotate them accordingly for spiral points. The key point of the 'evaluate algorithm' is the mathematical application of the modified sine and cosine formulae. In the context of point construction, we develop two different formulae for the 'Evaluate' component to define the values of X and Y coordinates.

Spiral curve generated by point cylindrical algorithm

After testing and evaluating the three algorithms, the point cylindrical algorithm is chosen for further research development. The reason is that using the 'Point Cylindrical' component makes the algorithm become the most concise one of the three (Figure 2). Theoretically, fewer components lead to quicker calculation speed to gain a result, which means the program runs faster. Another reason for choosing the algorithm is that the input and output parameters are easier to be dealt with, which means that we can control the pattern generation more easily. The main idea of the algorithm is to use the principles of point cylindrical and series. We use arithmetic sequences to define the regularly-increasing angle and radius of the points for their spiral coordinates generation. The synergistic effect of their combination can produce a group of cylindrical points.

When creating these points by the cylindrical component (point cylindrical), the four input parameters include plane defining cylindrical coordinate space, angles in radians for P(x, y) rotation, radius of cylinder and elevation of point. The only output is the cylindrical point coordinate. To set up the point cylindrical component, we have to use the series component to create the series of parameters. These parameters can be spaced according to the

{Step} value. The input parameters of it include the first number in the series, step size for each successive number and number of values in the series. To define the angle in radians for the points' rotation, we use one series component with the step input being the product of π and a controllable constant. For the radius of cylinder, we use another series component and share the same number of values with integers input. As the angle and radius increase regularly according to the two arithmetic sequences created by series components, the related spiral points' coordinates are generated.

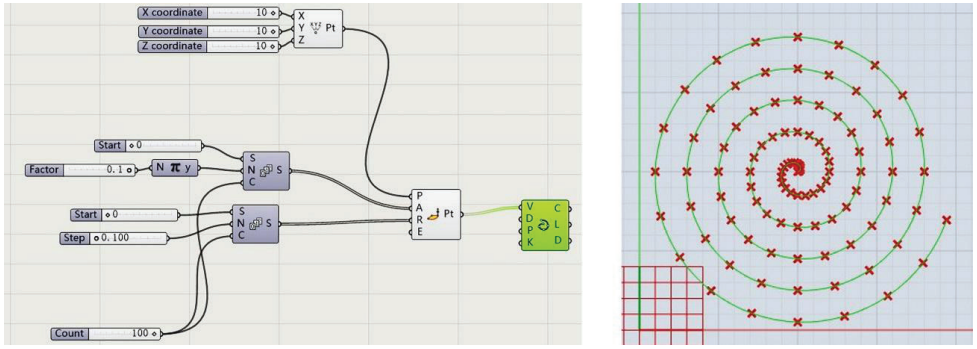

Figure 2. Screenshot of the script in Grasshopper3D (left) and the outcome of the point cylindrical algorithm (right). (Source: authors)

The unit modification

By studying the samples of the traditional hand-made carvings, we notice that the unit is formed by not only one curve but often two opposite spiral curves. The method of generating the unit is to use 'Move' and 'Rotate' components to do the proper movement of the original curve. So, we use the 'Rotate' component to rotate the original curve by 180 degrees. However, a gap can be found between the original curve and the rotated one, as their ends are not connected. And the further expression of the curves shows that it doesn't fit exactly with the samples. In order to improve it, we develop another algorithm module.

The main idea behind this is to extend the original spiral curve to fit our sample. This can also make the

gap between the two curves become smaller by one unit. Though the gap between the original spiral curve and the new one becomes smaller, it can still be detected. To improve it further, a specific component is used to extract the end points of a curve. After inputting the curve to evaluate, its outputs can conclude the start and end points. Then we can use the 'start point' and its 'closest point' to create a vector between them. The vector is for moving the new generated curve to the proper position connected with the original one. Through this modification algorithm, the gap between the two curves can be eliminated significantly.

The interactions within pattern groups

For complex patterns, there are different relationships within the basic units. After categorization, the underlying logic can be summarized as linked, intersected and tangent relations. The main difficulties of developing such algorithms include the continuously changing radii of spiral curves and their unclear boundaries. In this section, we are explaining how we develop these algorithms and how the units react to their neighbours.

The linked relationship of spiral-patterns units

For the linked relationship, the main strategy is to generate a major unit first, then the left units are attached to it. To do this, a group of spiral-curve patterns has been created by duplicating the unit script modular we explained in the previous section (Figure 3). The distribution of them can be adjusted by altering the parameters of the start points' coordinates. Their orientations can also be modified by altering the parameters of the 'Series' components which related to the angles in radians in the 'Point Cylindrical' component. After adjusting, the units should be surrounded by the main one, and their ends are rotated to be orientated to it.

Then the 'curve closest point' components mentioned above are used to create another script modular to find the closest point on the major curves from the

ends of the minor units. The 'end points' components are applied to locate the ends of each minor unit. After that, we can create the vectors from the ends to their closest points on the major unit. By using these vectors, the minor units can be moved to the target points on the major one. In the end, the linked relationship has been built up. To improve the patterns' overall expressions, the positions and orientations of the attached units can be adjusted minutely by re-defining the parameters of each modular.

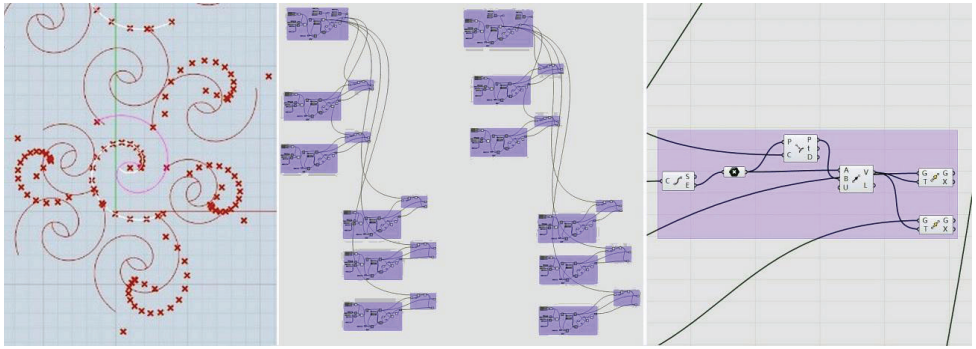

Figure 3. The linked relationship of spiral-pattern units showing an example of the outcome (left), groups of the script modular with different functions (centre) and the key script modular to make the minor units connect to the major curves (right). (Source: authors)

The intersected relationship of spiral-pattern units

In the creation of the intersected relationship of spiral-pattern units, the first step is similar to the operation in the linked relationship situation (Figure 4). A group of spiral-curve patterns has been created by duplicating the unit script modular. Their orientations can be modified by altering the start angles in radians in the 'Point Cylindrical' component. After the adjustment of the distributions and orientations accordingly, an intersection within units can be generated.

Considering the intersected relationship, our first reaction is to use the split commands to cut the curves. However, there is no suitable component to deal with the curves in this way. What is more difficult is how to make the overlapping spiral curves go on extending

after being cut. So, we develop an algorithm for this. Our strategy is using the curves to create the meshes for splitting first; secondly, these meshes are used to cut the curves; at last, the segments we wanted are selected and preserved.

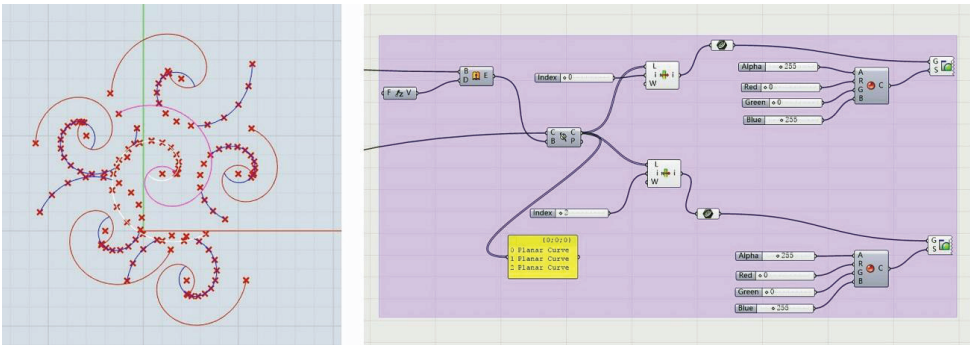

Figure 4. The linked relationship of spiral-pattern units showing an example of the outcome (left) and the key script modular to split the minor units and select the certain segments (right). (Source: authors).

The 'Extrude' component is applied to extrude curves along the setting vector in 'Z' direction. The component includes input parameters of the geometry and the vector. The geometry can be profile curve or surface. Here, it is linked to the major spiral curve patterns. Then the minor curves can be split by the previous extrusion result through the 'Split with Brep' component.

Though the curves have been split, the results are all mixed. So, we use the 'List Item' component to select certain segments and preserve them. The function of this component is to retrieve a specific item from a list. The split result is input to the component as the base list of generic data. After linking the integer slider to the input of item index, we can choose the wanted segments of the curves by changing the parameters of integers. That means certain items have been selected from the base list. All the unchosen curves can be eliminated (hidden) by cancelling the preview option of the components. We set the components group as a functional modular and use them for the object

curves. In the end, the intersected relationship of the spiral-pattern units can be built up.

The tangent relationship of spiral-pattern units

The strategy of the generation of the tangent relationship is to create a group of the units along the major spiral curves (Figure 5). Their distributions just need to be in the range of the certain area. Our script offers a variation to calculate the vectors of moving the minor spiral curves to the tangent positions automatically. In the creation of the tangent relationship of spiral-pattern units, the first step is nearly the same as operation in the linked relationship situation. After a group of spiral-curve patterns has been created by duplicating the unit script modular, their positions and orientations can be modified by altering the start angles in radians in the 'Point Cylindrical' component.

The complex algorithm of the vectors calculation works based on the application of auxiliary lines in geometry. As there are overlaps within the minor and the major curves, their intersection points can be used for creating the line. These points can be solved through the 'Curve Intersection' component. After creating a line between the two points using the 'Line' component, we can find the middle point on it. The 'Curve Closest Point' component is applied to locate the closest points on both curves from the middle point. By using the 'Move' component to create the movement on the vector generated through the two points, the spiral-pattern unit can be moved to the tangent position on the major curve.

Discussion

Through these algorithms, interactions such as 'linked', 'intersected' and 'tangent' relationships can be achieved. Using a combination of these script modules, a vast majority of situations of koru patterns can be generated. To simplify the modelling process, we have developed an algorithm of tangent pattern units. These algorithms have already shown their potential

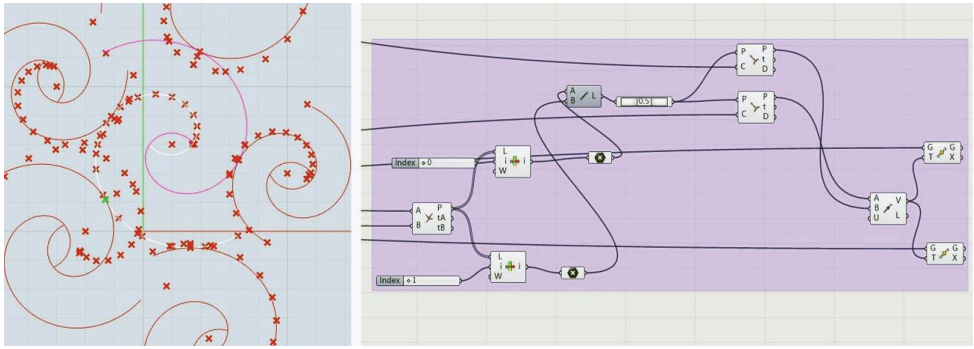

Figure 5. The tangent relationship of spiral-pattern units showing an example of the outcome (left) and the key script modular to calculate and move the minor units to the tangent position (left) (Source: authors).

in developing more complicated patterns. Besides, we also explored some additional algorithms such as the 'Arithmetic Sequence Array', 'Rectangular Array', to increase the pattern diversity.

The 3D-model generation and the fabrication

In this section, we mainly focus on explaining the algorithm that bridges the 2D patterns to 3D models, and how the modelling links to the fabrication process.

The generation of the 3D models

After studying the carving samples, we found that they can be categorized into two parts. One is the main body of the spiral geometry; another one is the affiliated ridges attached to the main body that fills the gaps within them. So, our strategy is to develop two algorithms for these two cases individually (Figure 6).

The main idea is to offset the spiral curve twice in different directions with the same distances. Then these curves are elevated to certain heights before using them as the boundaries to create the surfaces. The main inputs of the 'Offset' component include the curve to offset and the offset distance. Finally, we use the 'Ruled Surface' components to create the surfaces between the curves one by one. The component contains only two input parameters of the first and

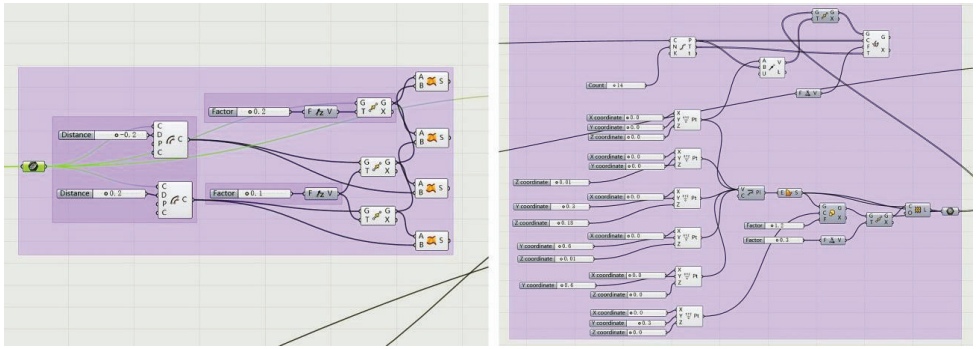

Figure 6. The algorithms behind the generation of 3D models. (Source: authors)

second curves, so we utilize these four for the main body generation.

To the affiliate ridges, the situation is intricate because of the ridges' complicated shape. The strategy is to create the ridge unit first, then use the common 'Move' and 'Rotate' components to make the array of them along the main body of the spiral curves. In the process of the generation of 3D models, the models sometimes need adjustment by modifying the parameters. Most modifications are the ratio of certain shapes. The advantage of parametric modelling makes the adjustment easy. But in some situations, assistant algorithms are developed to improve the final 3D models. Some modifications are necessary, especially considering the characters of the fabrication tools (Figure 7).

The fabrication

For the fabrication of the outcomes we used a Roland MDX-40A CNC machine. It is a versatile CNC mill that handles a wide variety of non-proprietary plastic and resin materials, including ABS, nylon, acrylic, chemical wood and tooling board. Everything from smooth art sculptures to high-precision parts and prototypes can be created with the machine, helping transform concepts into functional objects.

Figure 7. The 3D models of the patterns. (Source: authors)

Before using the machine, the models have to be transferred and exported in 'stl' format. Then the files can be uploaded to the operation interface on the computer that is linked to the CNC machine. A five-step workflow takes us through effortless milling, while speed, cursor and cutting tools offer further control. After setting all the parameters of the machine, the machine will calculate the fabricating route automatically by itself. Then we can place the prepared timber board on the base of the machine. After final checking and setting the local origin-coordinates on the centre of the board, we can begin with the fabrication. The whole process usually takes more than ten hours, which depends on the complexity of the models, required quality and accuracy, the hardness of the timber, as well as the size of the drilling head and the overall pattern (Figure 8).

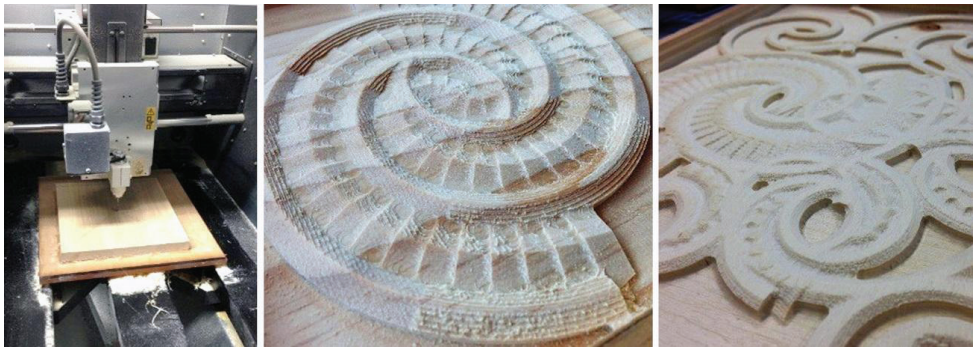

Figure 8. The digital fabrication using the CNC machine. (Source: authors)

Discussion and conclusion

Intersecting traditional indigenous wood carving in conjunction with computational instruments and methodologies, we can use the emerging technologies of digital fabrication to provide high-efficient fabrication solutions. In our research, we have studied a methodology of applying these evolving technologies in the context of heritage by developing a rule based algorithm of a parametric system that produces a koru pattern using CNC aided fabrication techniques. The research continues our explorations of a contemporary translation of cultural heritage into the current realm of digital technologies (Ballantyne *et al.* 2016; Kawiti *et al.* 2016). The conclusion of this study can be summarized as follows.

First, based on study of the topology and culture, we have developed the algorithms of Kuro pattern generation according to the underlying logic. The study of parametric modelling has included the generation of spiral curves, interaction within the pattern units and the transformation of 2D-3D modelling. By using our computerized interpretation of the pattern, we are able to offer current interpretations and variations to expressions of the koru.

Second, our study has made the overall forward-reverse translation process of form and algorithm, cultural heritage and digital realm become more accessible and interpretable. The feasibility of a digital generation and fabrication process in the heritage realm of Māori wood-carvings has been proved.

Third, our study has proved the integrated development of parametrical modelling and digital fabrication can be achieved through the methodology we developed. The methodology can be used to investigate the potential for indigenous development,

cultural empowerment and innovation (Sass 2007). Koru patterns in the Māori cultural context come in many varieties and interpretations. The here presented research is only a starting point from which individual variations and interpretations can easily be generated to match the spiritual and cultural heritage context.

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References

Ballantyne, A. J, D. Kawiti, and M. A. Schnabel. 2016. "Urban Papakainga: Programming Cultural Criteria by Using Multi-agent Systems." In *Fifty Years Later: Revisiting the Role of Architectural Science in Design and Practice, 50th International Conference of the Architectural Science Association 2016,* edited by L. Zuo, L. Daniels, and V. Soebarto, 79–88. Adelaide: The Architectural Science Association and The University of Adelaide.

Kawiti, D., and S. Gordine. 2017. "Ornamental Structuration: Digital Tool Use with Māori SGeometries." In *Protocols, Flows and Glitches: Proceedings of the 22nd International Conference of the Association for Computer-Aided Architectural Design Research in Asia CAADRIA*, edited by P. Loh, 67-72. Melbourne: The Association for Computer-Aided Architectural Design Research in Asia.

Kawiti, D., M. A. Schnabel, and J. Durcan. 2016. "Indigenous Parametricism – Material Computation: The Implementation of a Collaborative Indigenous Domain Based Research Lab." In *Living Systems and Micro-Utopias: Towards Continuous Designing, 21st International Conference of the Association for Computer-Aided Architectural Design Research in Asia CAADRIA,* edited by S. Chien, S. Choo, M. A. Schnabel, W. Nakapan, M. J. Kim, S. Roudavski, 63-72. Melbourne: The University of Melbourne.

Payne, A., and R. Issa. 2009. *Grasshopper Primer, Second Edition-for version 0.6.0007.* Cambridge, MA: LIFT architects and Robert McNeel and Associates.

Royal, T. A. C. 2017 "Māori Creation Traditions – Common Threads in Creation Stories." *Te Ara - The Encyclopedia of New Zealand.* Accessed 10 January 2017. http://www.TeAra.govt.nz/en/photograph/2422/the-koru

Sass, L. 2007. "Synthesis of Design Production with Integrated Digital Fabrication." *Automation in Construction* 16 (3): 298-310.

Wilson, J. 2017 "Nation and Government – Nationhood and Identity." *Te Ara – The Encyclopedia of New Zealand.* Accessed 11 January 2017. http://www.TeAra.govt.nz/en/nation-and-government/page-9

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Digitised connections: reflections on the image analysis and spatial modelling of Southeast Asian temples

Abstract

Following the arrival of Brahmanic/Hindu/Buddhist culture, a great number of temples were constructed across Southeast Asia. Epigraphic evidence, along with the architectural and stylistic similarities between temples in these regions, is strongly indicative of historic cross-cultural links that evolved through a process of long experimentation with philosophies, world-views and architectonic methods. A wide-ranging analysis of the canonical geometry and compositional form of temples in India, Cambodia and Java, with reference to Indic texts, local antecedents and archetypal South Asian temple forms has previously been undertaken. In comparing the relationships between canonical geometry and the form of temples, the bases for the architectural composition of these temples have been reconstructed by the authors, using spatial information modelling (e.g. parametric models, rule-based design and mathematical development of rule-based surfaces). These reconstructions augment the fragmentary written or epigraphic evidence available for these temples and gradually establish the range of early South and Southeast Asian temple forms and geometric characteristics. Presently, these comparisons between geometry and form are being extended through a combination of photogrammetry and image-based analysis methods with flexible graphical simulation and visual immersion techniques. These methods serve to reassemble evidence of the architectonic links between different temple sites across South and Southeast Asia. This paper reflects on the use of these methods in developing 'reverse-architected' geometric/architectonic models to mediate historical and formal propositions about lineages of historical architecture.

Keywords: Projection; photogrammetry; visualisation; spatial modelling; 'reverse-architecting'; temple architecture

Introduction

Projection operates on the intervals between things. It is always transitive (Evans 1990, 366).

Photo-based modelling provides a robust methodology for researching temple architecture in South and Southeast Asia. Using photogrammetric methods, fragmentary physical evidence of connections between different temple sites can be pieced together to create three-dimensional reconstructions. These reconstructions constitute the empirical basis for the study of linkages (or lack thereof) in the genesis and development of these temples. Our research has examined the extent to which digital temple typologies can be related directly to Indic canons or historic architectural sequences determined by archaeological or historiographical methods (Datta and Beynon 2014, 2005). The affordances of digital methods make these questions prescient as they impact the very meaning of the represented artefact and the parallel histories of subject and method: firstly, the history of the subject – understanding the origins, evolution, development and geographic spread of ancient temples in South and Southeast Asia; secondly, the history of the method, of how these buildings have been recorded and interpreted, and more precisely how the method of their recording has influenced and been influenced by their interpretations.

We are interested in the role of representation as an active constituent in the evolution of how these buildings are understood. Changing methods of representation means changing ways of seeing and new means of representation indicate new possibilities for interpretation. Affleck and Kvan (2005, 169) observe that the majority of virtual heritage projects attempt to create a realistic computer representation of their subject. The emergence of digital technologies provides powerful tools for the acquisition, representation and archiving of historic architecture. Digital acquisition techniques such as photogrammetry, combined with rapid prototyping technologies such as 3D printing, compose a digitally driven method for researching the genesis and evolution of temples. Contemporary scanning techniques can capture the emergent form to a greater degree of detail than is perceptible to the human eye, but in an indiscriminate manner. A digitally scanned model can be interpreted as capturing a series of instructions for particular lengths, widths, and heights, recorded to a much greater degree of accuracy than in a traditional model; for instance, minute changes in surface definition due to weathering may be detected and measured – but this exactitude is of a very specific kind related to the object as found, rather than the object as conceived or created. Variations from the ideal geometry of a temple can be put down to a number of possible factors: inaccuracies in initial construction, on-site contingencies, expediencies in craft, and then weathering, indifferent, hostile of inadvertent human interaction, subsidence, insect infestation. The combination of such factors can render a complete, observed building different to its conceptualised state even without serious erosion or destruction of its parts. It is the human eye that has to detect patterns within the scanned image or model and then make informed assumptions as to which parts are important, which are redundant, as well as about the alignment, proportion, and disposition of important parts in relation to the whole. It is this judgement that is critical in its incorporation into the model – as the resultant information alters what is measured from the observable in a profound manner. From a myriad of points, a few are chosen as significant and their relationships with each other prioritised and codified. The ability to represent temples in plan and section or in three-dimensional form endows the researcher with new tools of spatial and temporal presence as well as degrees of abstraction. This freedom permits new interpretations, experimentation and contestability not afforded in other media.

However, this is not the primary intent of this study. While our methods allow for the accurate and realistic development of digital replicas of individual artefacts, ranging in scale from architectural elements, through buildings to entire cities, our concern in

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reconstruction is the degree of accuracy, realism and reproduction of the underlying composition of the original artefact that can be attained. Therefore, when data is missing or eroded or the artefact is partially destroyed due to the ravages of time, other means of filling in the missing data are required. Key missing data consists not only of the embedded geometric information in the artefact itself, but also of its evolutionary lineage over time; that is, missing objects of similar use and appearance that precede or follow it. This method of investigating the underlying geometries of temples as a means of understanding the connections between them, differs from archaeological, art historical and architectural methods of study of physical elements and details. The process of measurement and computation in order to discover aspects of the underlying geometry of temples requires a certain suspension of the vision-based sensibility that practices based on photography of artifacts and buildings naturally bring to scholarly fieldwork. This does not mean that photographs have no visual importance, but their primary functions are as conceptual aids in our aim to trace the genesis and evolution of temples in India and Southeast Asia from early experimentation (400 CE) to the beginnings of the mature expression (c 900 CE). Each reconstruction is a point in the design space of possible temple adaptions.

As noted back in the 1990s (Mitchell 1994, p. 6), the value of 3D computer graphics techniques is that they mathematically construct perspectival views, applying projection and shading procedures in a way that both continues and redefines traditions of perspectival construction that began in the Renaissance. In our work, there is a series of ontological translations from actual temples as considered geometrically in terms of lines, surfaces and solids, to reproductions of these lines, surfaces and solids in virtual environments. These translations become a useful means for reconstructing reality from multiple sources of partial evidence. The geometry generated from temples is projective in the sense that it projects a geometrical representation of cosmology into three dimensions, but it is not projective in the sense of an image.

However, before continuing with this methodological speculation, the following section will give a brief account of the architectural/historical basis of our project.

Historical connections between South and Southeast Asia

It has long been speculated whether the architecture of ancient South and Southeast Asian temples owes its compositional characteristics to adherence to treatises, the interpretation of priest-architects or the usage of earlier examples as architectural models for later ones. The fragmented discontinuity of textual accounts, lack of graphical representations and heavily eroded early remains, make the process of establishing the lineage of formal continuity difficult. To further develop our understanding of these buildings, traditional methods of architectural analysis need supplementation by the innovative application of digital techniques.

It is known that Indian contact with Southeast Asia is of considerably greater antiquity than the earliest extant temples. There are the remains of extensive settlements in the Mekong Delta dating back to at least 2000 BCE (Higham 2002, p. 86) and to the origin of polities in the region between 300 BCE and 300 CE. The earliest brick or stone architecture in Southeast Asia (other than that of plinths and footings) has been dated to around 650-700 CE. This is considerably later than the earliest evidence of brick or stone architecture in India, and about 500 years after the beginnings of Indian influence in the region (Brown 1996, p. 263). The increasing strength of local polities across Southeast Asia happened alongside the increasing adoption of Indic cultural traits by Southeast Asian peoples. Around this time in Southeast Asia, there is also the first appearance of images of Indian deities, inscriptions in Sanskrit (and even of local languages in Indian-derived scripts – there being no indigenous Southeast Asian writing found), and monumental architecture based on the Indic *cella*.

Possible connections between Indian architecture and that of Java and Cambodia have been both promoted and contested by different scholars. Sometimes stated connections are not really explained, such has how the *rathas* of Mamallapuram were prototypes for Southeast Asian temples (Chihara 1996, p. 79), though connections have been postulated based on structural or technical similarities, such as the relationship between load-bearing structure and architectural expression (Dumarçay and Royère 2001, p. 110). For much of the nineteenth and twentieth centuries, it was assumed by most scholars that early Southeast Asian states were heavily dependent on Indic culture for their development. The question was how this dependency had occurred, and to this end, theories of Indian conquest, colonisation or migration were postulated. The problem with these theories was their lack of evidence, except for occasional parallels in myths of origin. However, more definite clues lie in the physical form of the temples, and the basis of this form in sacred geometry.

Temple geometry

The physical form of the temple is fundamental to its purpose. As Coomaraswamy points out, in the Hindu cosmic structure, 'The human frame, the constructed temple, and the universe being analogical equivalents, the parts of the temple correspond to those of the human body no less than to those of the universe itself' (1997, p. 178). Each is a microcosm of the other. The temple does not just symbolise this sacred geometry. It 'is', immanently, the universe. The temple makes manifest the connection between the everyday world of the senses and the world of divinity, but more than this, makes them one. Scholars have explained the use of geometry in temple plans by tracing their basis in canonical text, sacred diagrams and cosmogony (Chandra 1975; Chihara 1996). Specifically, the constructive and implicit relationships between geometric canon and individual monuments are explained through studies of temple geometry. The morphology of the Indian temple and its progressive geometric complexity can thus be followed from the

earliest extant *cellae* in the fifth century to entire thirteenth century complexes and temple cities across India and Southeast Asia (Meister et al. 1983). Textual and graphic descriptions of mathematical and geometric constructions governing the form of temples are described in the literature.

Embedded in the plan of most temples is a ritual grid diagram of 8 x 8 = 64 squares (the mandala), prescribed for temple building in the *Bṛhatsaṁhitā* (Bhatt 1981) and later texts (Kramrisch 1946). This grid is used to generate the ground plan and control measure in the configuration of stone temples (Meister 1976). Working from an understanding of temple construction sequence as well as the ritual underpinnings of temple composition, Meister found the sixty-four square mandala's dimensions correlate closely to the constructed dimensions at the level of the vedībandha, which corresponds with the level of the sanctuary threshold.

After testing this premise on a number of examples, Meister concluded that the horizontal dimensions of the *vedībandha* provide for a set of proportional relationships that relate to śāstra prescriptions. Furthermore, he shows how the horizontal profile of the *cella* depends on the number of offsets and the proportional relationships between each offset based on the proportional subdivision of the 8 x 8 grid (Meister 1979, p. 206). In addition to the ground plans, the profile geometry of the superstructures exhibits an intricate mathematical and geometric expression attributable to canonical precepts (Kramrisch 1946; Meister 1979). Our work applies digital techniques to Meister's method.

Visualisation methods

Utilising the different methods of data analysis and visualisation available to us, we are able to show different representations of the data that has been collected both from photogrammetric and manual modelling. As noted previously, there is a tendency of viewers to add their own context to the structure. When focusing on the raw structure of the temples, this is undesirable. In addition to this, the point clouds

generated from photogrammetry contain noise that may also add an element of subjectivity to the interpretation.

In order to combat these effects, we have developed a voxelisation strategy that allows visualisation of the abstracted shapes without the viewer needing to comprehend the noise. Using this technique, we can generate a solid representation of a temple once the 'up axis' has been found. In this case, we create a cubic bounding box around the point cloud and recursively divide each cube into eight sub-cubes until we reach a predefined minimum size. We then create a visible cube for each sub-cube if the number of points it contains exceeds some threshold (Datta, Chang, Hollick 2016). This collection of cubes will form a 3D model of the structure that we can include in 3D environments and use to perform further analysis.

One of the effects of this technique is that slightly

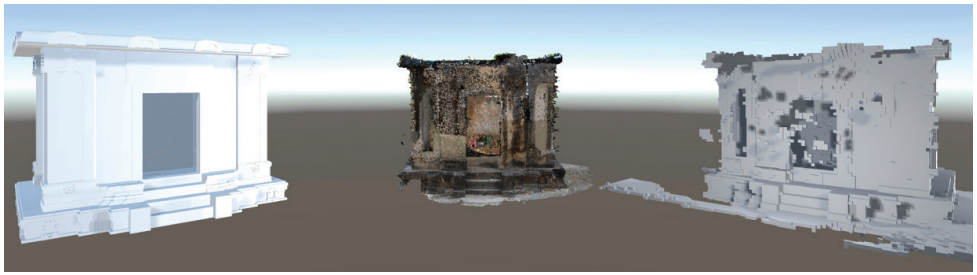

Figure 1. From left to right: manual reconstruction, point cloud, automated voxel reconstruction. (Source: authors).

slanted lines are 'straightened'. Depending on the situation, this may either be a hindrance or a help, as knowledge of the original data is still required. One of the analyses we can perform using voxelisation is to split the model along any of the voxel lines to create a series of 'slices', allowing us to visualise the geometry of the structure and look for symmetry or other familiar structures.

Using the representations shown in Figure 1 (above) we can place the 3D data inside virtual environments, within which the viewer can immerse themselves to

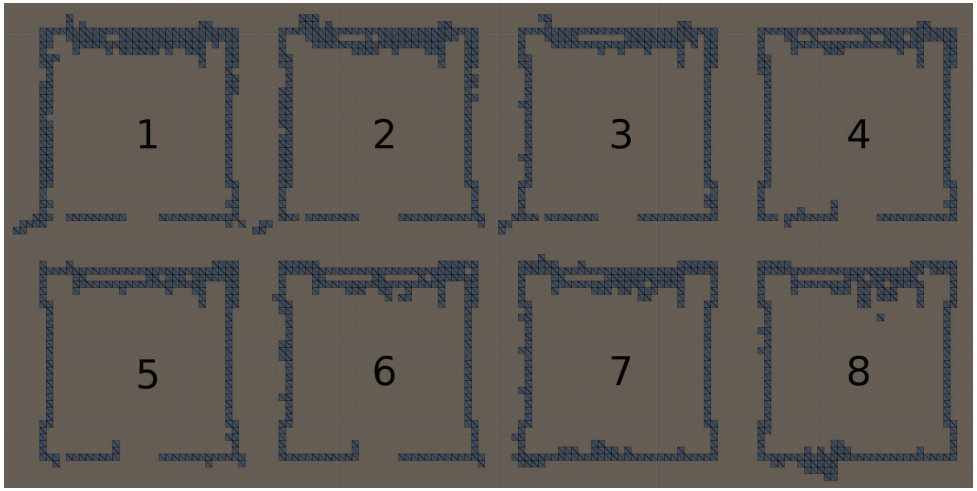

Figure 2. Temple split into voxel slices. Here we have a selection of slices from the centre part of the above temple, numbered 1-8 from top to bottom. This clearly shows the door and structure of the temple, abstracting away some of the noisiness of the point cloud and allowing us to focus on the overarching geometric elements. (Source: authors).

explore the temple structure. This immersion may take the form of large scale displays such as those at the Curtin HIVE (Woods et al. 2017) and at other visualisation facilities, or smaller displays such as those for desktop monitors or various head mounted displays. These display options may allow the viewer to see the scale and layout of the temples in a way that would not be possible on simple paper. Furthermore, the different representations of the temple, revealing otherwise non-obvious features, allow the viewer to focus on different aspects of the structure.

Projection, the visual and the architectural: affordances of digital methods

As the brief summary of visual methods in the previous section shows, reconstruction of temple forms involves using the digital information generated by acquisition methods to create three-dimensional surface and solid models that can be enhanced by textures and materials when necessary. The imagining here still requires some human intervention, whether in the algorithmic manner of machine recognition, or

in the judgement of the individual who manipulates the photogrammetric software until it correlates with their knowledge/recognition of the subject. The image is thus mobilised. What can be recognised here is not only the apparent veracity of the photographic image, but also the indexical nature of a series of photos. This makes them a medium through which it can be possible to go beyond conventions of projection and representation to 'see' the actual object directly. However, this sense of 'looking through' requires a certain predisposition and understanding of context and frame that involves mentally stitching together the 'index' of photographs to more fully see the represented object.

The virtual models created via photogrammetry share with photographs (and sometimes with traditional physical models) a particular state of being. When we look at a photograph we are viewing an image separated from its referent. In a 3D print/virtual model, we are looking at a result of a series of such separations, now also of form from form. However, as we are viewing temples as applied research in themselves – as applications of theory (*sastras*, geometry etc.) to materials, form, composition and aesthetics, then our series of separations are in some way an attempt to simulate a return to these sources (or at least provide clues towards them). In this sense, digital practice has become a useful means for re-construction of reality from multiple sources of partial evidence. Buildings may be represented in apparent three dimensions via drawings but are more directly experienced via models. A 3D model (whether printed or visualised in virtual space) becomes more than a photograph: an object in itself, which, like the original building, can propagate images of itself, these images being once removed from the original building, but still recognisable as such, having, as Robin Evans might put it 'a kind of permanent identity' derived from its multiple images (Evans, 1990). Representation of an overall composition in a model is also provided, in contrast to a drawing, as the viewer is not confined to a fixed position or series of positions in relation to the subject. The ability of the viewer to move around the

model affords a multivalency of experience in relation to it. Unlike the analogue photographic image, the traditional model, whether it is made of simulated 'real' materials (stone, plaster, timber) or deliberately abstracted ones (card, paper, Perspex), is limited in its potential to reveal detail.

Here it needs to be stressed that the modelling process is not a realistic representation of the temple but an ideal 'adaptation' of the rules underlying its architectonic composition. This departure from 'accuracy' and 'authenticity' is a necessary step of abstraction that permits all records to be mapped into an ideal laboratory of digital forms. The rule based model generation can be used to derive, compare and overlay the ground plan and superstructure geometry of related monuments. This rule-based generation of profiles allows us to conjecture on the range of possible measures, based on texts as well as field measurements. The models as 3D prints look deceptively finite and object-like, but their objecthood should be better read as a snapshot of the processes of which they are a part. The models themselves are a kind of language – readily translatable, as people are used to looking at miniature models of buildings (both as designs and as three-dimensional representations of actual buildings). At the moment this language looks deceptively simple, as many of our subject buildings are mostly complete (though many have been restored, some more speculatively than others).

Seeing these models as representative of the 'real' is a little misleading in the same way that viewing photographs used to be (particularly in the pre-digital age). 'In conferring on photography a guarantee of realism, society is merely confirming itself in the tautological certainty that an image of the real which is true to its representation of objectivity is really objective.' (Bourdieu 1990, p.70, quoted in Mitchell 1994, p. 59). In a way that could equally apply to our models: where we have been using the tools, operations, and media of photography to serve our pictorial ends, these instruments and techniques have simultaneously been constructing us as perceiving subjects. The primacy of the visual, of trying to

comprehend a building through consideration of its visual characteristics, needs to be suspended in favour of what Robin Evans might refer to as other means of projection (Evans 1990). In this regard, the digital approach may be compared in a propositional sense to Evans' theories on geometry in architectural making. Evans described a series of translations to track the development of architectural form through projective geometry, the building as an object being cast through a series of drawings to the finished product, a projection informed by the subjective experience of buildings. And so, he developed a proposition about how architecture develops through the translation of drawing into building, of representation into actuality. Our particular challenge is the opposite, the translation of a building through the geometric and proportional clues present in its form, back to its description. Evans also discusses, following art historian Rudolf Wittkower's method of relating architectural characteristics to music theory (Wittkower 1949), the way in which European Renaissance architecture was an architecture of symbolic rather than pure form. Here, the issue of meaning's relation to form is highlighted, in particular the way that forms do not intrinsically have meaning, but are instead *charged* with meaning by their contextualisation within a cultural/philosophical system (Evans 1990, p. 4). Thus, what is important about the geometry of a building is what is held to be important by the cultural/philosophical system that created it, what is *projected* onto it (Evans 1990, p. xxxi). Thus, it is the nature of this projection, and the ability to abstract it by some means, that underlies our processes and methods.

This is, in a sense, a form of 'reverse engineering' or 'reverse architecting' in that it 'concerns all activities for making existing architectures explicit, and the main goal of reverse engineering is to increase comprehensibility of the system' (Krikhaar 1997)– although in the case of our work, we are of course using the term 'architecture' in its traditional and literal sense. It is a process of examination that can be considered, adapting Borches and Bonnema's analysis, to have three phases: information extraction, parametric speculation/application/abstraction and (re)presentation (Borches and Bonnema 2010, p. 356). These three phases are continually repeated. This iterative process is important as the information extracted can be abstracted and (re)presented in multiple ways, with each form of representation offering different insights into the nature of the architectural subject under study. So the models are not so much end products, but vehicles for thoughts. They are both the media and the outcomes of a method, involving physical measurement and photogrammetry. They provide a series of projection procedures that both simulate the form of the subject building, and frame its salient measurements as a series of parameters based on reference to numerical geometries and compositional arrangements as found in ancient texts. As noted by Dumarçay in his construction studies of Southeast Asian temples, parallels between architectural models and architecture as a model provide a theoretical basis for the drift from original geometric sources, where this can be plausibly established, towards variations in form and proportion (Dumarçay 2003). Digital tools for data processing (such as photogrammetry) permit the systematic capture and reconstruction of existing temple remains, and so develop Dumarçay's process of piecing together the genesis and evolution over time of the geometric experimentation within specific schools of temple building. Furthermore, 'ideal' models of temples can be constructed by combining textual descriptions from textual canon (śāstras) with graphic diagrams (rule-based generation, parametric models), supporting the comparative analysis of early temples from related temple building traditions within South and Southeast Asia. The digital models of this architectural diaspora are therefore neither real nor authentic in a traditional sense.

The role of the virtual: visual/conceptual

In summary, virtual representations of temples do not masquerade as replicas of the original object. Instead, they are re-representations that allow hidden elements and aspects of the temple or site

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to be examined. Further, virtual models permit and provide a mode of presence for collections of artefacts and abstractions. Just as close-ups or slow motion in film permits seeing reality in a deeper way, digital models provide such a mode in the case of understanding architecture. Skeletal models of geometry, dissections and sectional renders, allow the viewer to be immersed in the otherwise hidden and unavailable aspects of architecture, which are not experienced through direct perception of the original. However, the processes that we are developing are intended to provide the basis for informed speculation about future subject buildings that are less complete, this basis being grounded in a shared geometric/architectonic compositional schema where measurement is possible (which in some subject buildings, may only be the base of the original structure).

From this codification comes the application of principles that can be applied both to other observable parts (so realigning them according to the same informed assumptions) and by extension, to parts that cannot be observed because they no longer exist, or are in such an eroded state that their original form is no longer recognisable. Such generative methods are useful for describing a class of artefacts with similar characteristics. By observing a family of similar objects, rules and constraint relationships between common elements can be identified. The knowledge embedded in the photographic architectural record can be 'read' through computational means, such as the science of Photogrammetry, to inform, posit or refute positions on their formal derivation and architectural lineage. Using the information we may gain from discovering the evolutionary lineage, preceeding and proceeding objects and family membership of artefacts when geometry is missing or eroded we may be able to fill in this missing information to create a more complete representation.

Our purpose in using digital methods is, therefore, not to challenge or displace the authenticity of the physical object or the faithful accuracy of the

photographic record. Instead, the aim is to develop 'unobtrusive mediations' that permit connections and interpretations that permit scholars and the public to assess and experience the significance of historical architecture. If the evolutionary lineage of a class of artefacts can be captured by identifying similarities and differences in their geometry, this information can be used to aid in the reconstruction of eroded or destroyed artefacts.

Three-dimensional digital and physical models' conjectural reconstructions enable the comparison of temple sites spread over time, geography and culture, which, with the analysis of data recovered from surviving monuments, explain the complex and problematic linkages between canonical prescriptions of ideal form. The data collected, and then analysed via photogrammetric methods, establishes an empirical ground to study the linkages (or lack thereof) in the development of temple architecture across South and Southeast Asia. Using spatial information modelling, the fragmentary evidence from diverse sources can be pieced together first to conjecture and then to establish a comprehensive picture of a whole corpus of temples across space and time.

References

Affleck, J., and T. Kvan. 2005. Reinterpreting Virtual Heritage. *In Proceedings of the Tenth Conference on Computer-Aided Architectural Design Research in Asia,* edited by A. Bhatt, 69-178. New Delhi: TVB School of Habitat Studies.

Bhatt, R. 1981. *Varāhamihira's Bṛhatsaṁhitā*. New Delhi: Motilal Banarsidass (2 Vols).

Bourdieu, P. 1990. *Photography: A Middlebrow Art*. Stanford: Stanford University Press.

Borches, D. P., and M. G. Bonnema. 2010. "Focusing architectural knowledge to support evolution of complex systems." *INCOSE International Symposium*, Vol 20, Chicago, 354-359.

Brown, R. L. 1996. *The Dvaravati Wheels of the Law and the Indianization of South East Asia*. Leiden: E. J. Brill

Chihara, D. 1996. *Hindú-Buddhist Architecture in Southeast Asia*. Leiden: E. J. Brill.

Chandra, P. 1975. *Studies in Indian Temple Architecture*. Varanasi, American Institute of Indian Studies. 1-39.

Coomaraswamy, R. P. 1997. *The Door in the Sky: Coomaraswamy on Myth and Meaning*. Princeton: Princeton University Press.

Datta, S., and D. Beynon. 2005. "A computational approach to the reconstruction of surface geometry from early temple superstructures." *International Journal of Architectural Computing*, 3/4: 471-486.

Datta, S., and D. Beynon. 2014. *Digital Archetypes: Adaptations of Early Temple Architecture in South and Southeast Asia*, Ashgate, Farnham, 2014.

Datta, S., T. W. Chang, and J. Hollick. 2016. "Curating architectural collections: Interaction with immersive stereoscopic visualisation,." In *Proceedings of the 21st International Conference on Computer-Aided Architectural Design Research in Asia (CAADRIA)* 301-310, CumInCAD.

Dumarçay, J. 2003. *Architecture and its Models in South-East Asia*, Bangkok: Orchid.

Dumarçay, J. and Pascal Royère. 2001. *Cambodian Architecture: Eighth to Thirteenth Centuries*. Leiden: E. J. Brill.

Evans, R. 1990. *The Projective Cast: Architecture and Its Three Geometries*. Cambridge: The MIT Press.

Higham, C. 2002. *Early Cultures of Mainland Southeast Asia*. Bangkok: River.

Kramrisch, S. 1946. *The Hindú Temple*, Volumes 1 and 2. (re-published 1976, Delhi: Motilal Banarsidass).

Krikhaar, R. L. 1997. "Reverse architecting approach for complex systems." Paper read at IEEE International Conference on Software Maintenance, at Bari.

Meister, M. 1976. "Construction and Conception: Mandapika shrines in Central India." *East and West*, New Series. 26 (3-4): 409-418.

Meister, M. 1979. "Mandala and practice in Nagara architecture in northern India." *Journal of American Oriental Society*, 99: 204-219.

Meister, M., M. Dhaky, and K. Deva, (eds.) 1983. *Encyclopaedia of Indian Temple Architecture*. 7 vols. New Delhi: American Institute of Indian Studies.

Mitchell, W. J. 1994. *The Reconfigured Eye: Visual Truth in the Post-Photographic Era*, Cambridge: The MIT Press.

Wittkower, R. 1949. *Architectural Principles in the Age of Humanism*, London: Warburg Institute, University of London.

Woods, A., S. Datta, P. Bourke, and J. Hollick,. (under review). "The design, install and operation of a multi-user, multi-display visualisation facility." *Research in Engineering Design*.

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Newcastle Time Machine – a multi-disciplinary approach to digital cultural heritage

Abstract

This article discusses the University of Newcastle's Hunter (Living) Histories initiative (HHI) and the multi-disciplinary heritage model to develop collaborative digital cultural heritage projects. The HHI engages across the university and wider communities to develop heritage projects that are shared globally across various social and digital media platforms. One of the projects undertaken by the group is the 3D Virtual Hunter Project, which created the Newcastle Time Machine, embodying fly-throughs and 3D immersive recreations of the early Aboriginal and Colonial Newcastle, up until 1830. Its creators worked over many years in collaboration with the University's Cultural Collections and used archival written and visual sources to construct the base model for the project, analysing and comparing historic artworks and surveys to assess the most accurate and authentic original sources of the early Newcastle landscape. The methodology to use primary sources as evidence to construct a landscape as accurately as possible was crucial so that the historical past is interpreted with authenticity and integrity. As an educational tool, this project reflects the new digital age and changes in teaching and learning strategies, providing a vision of an historical past in a contemporary present. The Newcastle Time Machine has been further extended by incorporating Virtual Reality (VR) Technology to further enhance this experience. The Newcastle project provides a digital heritage platform that has implications for heritage management. The digital visualisation of the historic environment of Newcastle past is a new way of perceiving the city, and more effective than imagining what Newcastle would have looked like from only studying written sources.

Keywords: Digital heritage; virtual reality, 3D model; computer model; historical analysis; visual sources

Introduction

This article is a case study examining a digital heritage project undertaken by the UON's HHI using a multi-disciplinary approach and brings many participants together around history and heritage (Eklund and Hardy, 2014). The case study explores how the multi-disciplinary approach was also effective in the area of digital heritage to produce the 'Newcastle Time Machine'. This group, previously known as the Coal River Working Party, is a model that facilitates university-community engagement and members of the group include academics, students, and people from the wider community, as well as government and non-government organisations. It must be noted here that the authors of this article are contributors to HHI and the Newcastle Time Machine.

Background – Towards heritage digitisation

The original inspiration to create a virtual experiential repository of historical resources for Newcastle began in the mid-1990s, through involvement with the Mayfield Residents Group, University of Newcastle (UON). Archivist Gionni di Gravio recollects:

> On my way to one of their meetings, which incidentally was being held in the upstairs of the local the Stag and Hunter Hotel, I passed two young men eating their fish and chips in an alcove, and leaving their food scraps and rubbish all over the ground. Upon arrival at the hotel I was very impressed with what I saw; all around the foyer were printed photographs of the Mayfield houses and landscape. As I proceeded up the stairs, the images changed to photographs of the original Hotel when it was originally established as the Amos Hotel. I was so inspired by what the publican had done with the history and historical context of the hotel, I thought to myself: maybe, if those two fellows eating the fish and chips could understand more about the history of the ground beneath their feet, and under the bitumen of the sidewalk, then maybe they wouldn't trash it. So, after the meeting, I rushed home, and upended the contents of my filing cabinets containing historical photographs, notes and documents and began digitising material on the history of Mayfield for eventual uploading to the web.
> (di Gravio 2016)

Di Gravio had been working in the UON's Auchmuty Library for a number of years, and had thrown himself into learning HTML, as well as learning to digitise on rudimentary flatbed scanners. He possessed the technical knowhow to enable the university library to digitise and publish material online to the free Geocities site in 1995 as 'The Mayfield Website' (The Mayfield Website1996), arranging the digitised material including texts, photographs, maps and plans relating to the suburb in chronological order.

The National Library assessed the 'The Mayfield Website' for inclusion in their Pandora archive as one of 'national significance'. The Mayfield website also led to further collaborative projects, with the UON's archivist participation on industrial, business and community committees involved in initiatives utilising historical archival records held in the University. This brought the University and the community closer together.

Meanwhile, a digital revolution was underway during the mid-1990s. Di Gravio recalls playing 3D immersive ground-breaking computer games such as *Myst* and *Riven* and so, after setting up a website for the University Archives in 1996, by 1998 he was trying to find people who could help three dimensionalise the archive's virtual experience. The following email describes his dream:

> I would like our virtual visitors to view a graphic Archives and Special Collections homepage which consists of an image of a rare book room. A table lies in the foreground with manuscripts strewn about, an hourglass etc, and behind lies a bookcase; to the left is the Archivist's office. If they wish to see the Archives collection they walk towards the table and click on the manuscripts; if they want the rare book collections, they click on the bookcase; if they click on the Archivist's door, Denis, (the University Archivist) appears and gives a 2-minute

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> welcome and short introduction as a video piece. What do you think about this sort of thing? I've been trying to convince the forces to not look at the net as a series of word processed documents lying out in space but as a living thing with living minds, as visitors that want to see exciting visual things and wish to interact and "meet" other virtual objects or experiences. I would like to develop this sort of thing because I think there is quite a market out there for Archivists and Rare Book Librarians to make their rare and fragile collections accessible, but at the same time safeguard preservation issues. (di Gravio 1998)

At the end of 2000, Dr Glenn Albrecht, Senior Lecturer in Environmental Studies at the UON, prepared a paper entitled *Rediscovering the Coquun: Towards an Environmental History of the Hunter River* where he attempted, through a series of historical accounts, to provide a view of how things have changed with the River over time, and called for continuing ecological restoration work and the establishment of a native sense of place by restoring the Aboriginal place names with their English equivalents (Albrecht 2000). He greatly appreciated being able to use the online resources made available through the Mayfield Website, and inspired the UON archives to expand the idea of the website to incorporate the entire Hunter River Landscape, and bring together a listing of historic descriptions of the landscape across time. These listings were arranged in chronological order and digitised, and it was at this point that a vision of creating a virtual research landscape was born in an email to interested colleagues (di Gravio 2000). The Virtual Coquun-Hunter River Project was launched two weeks later, expanding historical resources to the entire region.

In August 2002, the UON archives began to work on bringing together all original Aboriginal resources under the 'Virtual Sourcebook for Aboriginal Studies in the Hunter Region' (Cultural Collections 2000). In 2003 the Nobbys Coal River Precinct website was set up to support the work of the newly established Coal River Working Party (CRWP) (Coal River Working

Party 2003). In 2004, CRWP founding member, and Professor of Surveying, Emeritus Professor John Fryer, and his colleague Sabry El-Hakim, painstakingly constructed a 3D representation of the Baiame Cave at Milbrodale Aboriginal Rock Art site in the Hunter Valley (Fryer 2016).

In 2006, di Gravio attended and presented at the eLearning Symposium held at RMIT University (Mapping Historical Resources on the Google Earth Canvas for Teaching and Research, eLearning symposium 2006). To their credit, the teachers had invited a world of outsiders to their symposium, which made it a compelling get together. Among the themes, the hot topic was how to encourage teachers and their classrooms into the 3D game environment, where most of their students currently were, as part of the 'digital native' generation (Iverson and Smith 2012; Prensky 2001).

Di Gravio presented his experiments in mapping archival historical research resources across the three-dimensional landscape of Google Earth and the future possibilities of building virtual teaching environments that we would inhabit. He presented a similar paper *Mapping Historical Resources on the Google Earth Canvas for Teaching and Research* to the Australian Society of Archivists National Conference in Alice Springs in 2007. In 2007 the initial 3D virtual Nobbys was constructed and imported into Google Earth for the New Institute. (di Gravio and Sherlock 2007). In 2008, it was formally announced (with tongue in cheek) that The UON's CRWP would begin construction of a real-time machine (Coal River Working Party 2008). Following the announcement, very little progress in an actual 3D virtual landscape materialised. There was however significant work that established the validity and reliability of the methods being used by the members of the CRWP, and formed the technical foundation for all of the subsequent 3D constructions.

Between 2007 and 2011, surveying students at UON, under the supervision of Peter Sherlock of the CRWP, evaluated the 1830 Armstrong map and 1828 Mitchell field books for their final-year projects (Towers and

Sumner 2009). The students' work showed that the original survey work and mapping was of a very high standard, and readily relatable to the 21st Century cadastre and surveys of Newcastle, with an accuracy in the range 1-3 metres. This increased confidence in using the 19th Century mapping, and also improved the reliability of other early mapping.

In 2010 and 2011, Russell Rigby and John Fryer of the CRWP demonstrated that the original height of Nobbys, recorded as 61 metres (203 feet) in the *Historical Records of Australia* for more than 100 years, was grossly in error. They used a combination of the early 19th Century mapping, a detailed study of the geometric and textural relationships in colonial-era artworks, and contemporary reports to show that the original height was 45 metres, before the reduction to the present height of 30 metres for the erection of the Nobbys Lighthouse in 1857. The consistency of the results obtained from various sources and methods showed that the colonial artworks were much more than just pretty pictures, but contained valuable information that could be used in recovering the shape and detail of the heritage landscape.

It was not until early 2012 when the UON archives engaged Charles Martin that the first 3D historical terrain map for Newcastle was created with the assistance of Russell Rigby. This terrain map made its debut at the November 2012 meeting of the CRWP to an excited audience and community (Coal River Working Party Nov 5 and Nov 29 2012). The *Newcastle Herald* even made it front page news (Ray 2012).

About the 3D Virtual Hunter Project

As already described, the idea of a 3D Virtual Hunter Project was conceived during the 2000s and eventually animated fly-throughs of early Newcastle were created in 2013-2014 as part of work on the 3D Virtual Newcastle Time Machine (Newcastle Time Machine – 1830- Dec 2013).

This virtual model presents historic sources on a digital platform for free public access to tell the Newcastle Story, and engender a much greater understanding of Newcastle's history and heritage, and its unique place in Australia's Aboriginal and European history. The creator worked in collaboration with the UON's Coal River Working Party (renamed Hunter (Living) Histories Initiative in 2016) to produce several digital fly-throughs of early Newcastle in the decades between 1800 and 1830 (Ray 2012). The nominated decades represent the period leading up to the commencement of the construction of the breakwater (Macquarie Pier) in 1818, and the clearing of a major track of coastal dune vegetation at Flagstaff Hill (Fort Scratchley), which later led to the encroachment of the sand dunes.

There were limitations to budget and timing. The work was funded by the Vera Deacon Regional History Fund and supported by the UON's Auchmuty Library (Coal River Working Party 2013). This project was later renamed the 3D Virtual Hunter Project with aims to expand to include the entire Hunter Region, NSW. The creator of the fly-throughs during this phase was an architect, visual designer/artist, and his initial task was to survey the various historical resources and complete a geospatial analysis relating to archaeology and heritage.

Historical analysis and interpretation

The following is an overview of the initial work and methodology used in constructing the 3D model of early Aboriginal and Colonial Newcastle, up until 1830. Research and investigation of historical sources was a significant and essential part of the survey process. It has taken particular skill and expertise to decipher traditional research materials (e.g., historic documents, site maps) and transform them into engaging, immersive, and interactive experiences.

Newcastle's rich and varied history has been documented in primary sources from the time of 'discovery' by Lieutenant Shortland to the subsequent establishment of a settlement and port at the mouth of the Hunter River in the early 1800s. The first attempt to settle this port in 1801 was short lived due to poor management. The area was resettled in 1804 as a place for reoffending convicts after the Castle

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Hill uprising and it remained the centre of secondary punishment in the colony until 1823. At the time of early settlement Newcastle played host to some fine artists and map makers.

Survey Process

The advent of computers and the ability to re-interpret primary sources in a contemporary way allows a completely new appraisal and understanding

Figure 1. Comparative view using various visual sources (1807 to 1829) are analysed to gain a better understanding of changing landscape and built environment of early Newcastle. (Source: Cultural Collections, University of Newcastle. Creator Charles Martin).

of the physical nature of the early settlement. Early visual sources such as artworks and maps were cross referenced and data collated and incorporated into 3D technology. What became evident in the interpretation stage of this project, was that over a short period, changes to the landscape were considerable: not only was the built environment developed, but the topographical nature of the environment underwent much change, largely with the construction of the breakwater out to Nobbys Island. Many of the primary drawings executed on site in Newcastle are more reliable in terms of accuracy than

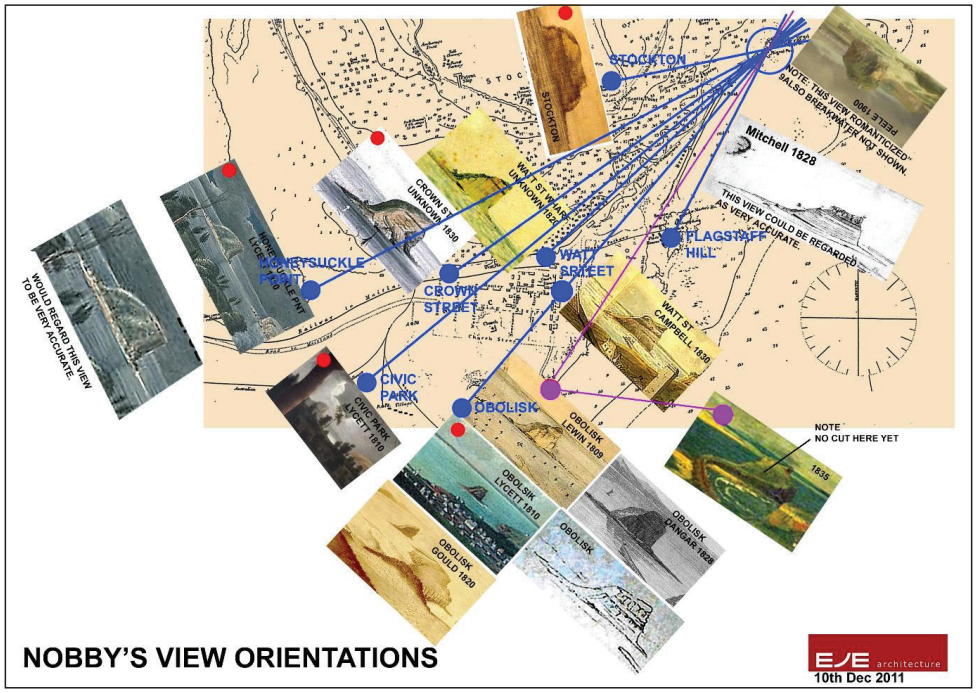

Figure 2. Comparative view using various visual sources of Nobbys Headland (1807 to 1829) are analysed to gain a better understanding of changing landscape and built environment. (Source: Cultural Collections, University of Newcastle, EJE Architecture (in kind support). Creator Charles Martin).

visual sources copied from sketches and other works; whereas, secondary sources are more suspect in terms of accuracy because detail could easily have been

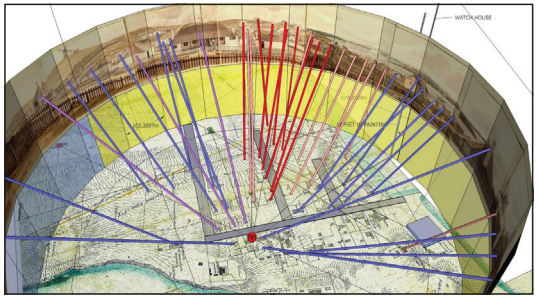

Figure 3. Locating built environment shown in Panorama of Newcastle by Edwards Close in 1818 (Edward Close, 1820) in the landscape as per Armstrong Map 1830 (John Armstrong 1830) (Source: Cultural Collections, University of Newcastle. Creator Charles Martin).

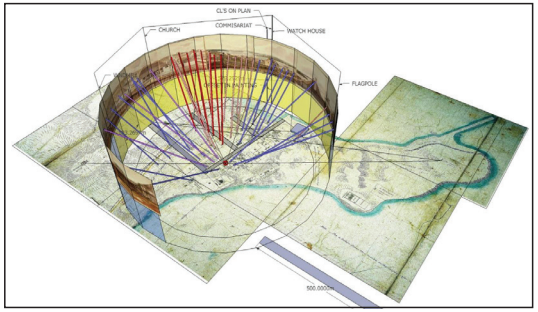

Figure 4. Locating built environment shown in Panorama of Newcastle by Edward Close in 1818 in the landscape as per the Armstrong Map 1830. (Source: Cultural Collections, University of Newcastle. Creator Charles Martin).

changed by the creator who may not have visited the place which they were depicting, nor been interested in documenting the exactness of the topography and built environment.

By constructing initial test models (Figures 3 and 4) on the computer and checking against the reference material (historic sources), it became evident that some of the early impressions were inaccurate. Some of the visual sources exhibit great attention to detail and accuracy, whilst others less so. However, all of the sources did provide invaluable interpretative information and were useful in assembling the final 3D model.

Sketchup software was used to create the computer model of the Newcastle Time Machine. This is a simple modelling program. For rendering of the model, the software *Photoshop* was used to create a painted over effect and artistic overlay.

Figure 5. Comparative Computer Model showing from the Windmill (now Obelisk Hill). (Source: Cultural Collections, University of Newcastle. Creator Charles Martin).

Maps were also used in a comparative analysis to gain as accurate as possible a delineation of the landscape and built structures. The Meehan (1818) and Armstrong (1830) maps were the best contemporary references available, and by creating composites each map shows how Newcastle's early streets were laid out and it was not long after this that a grid street layout was adopted (referred to as the Dangar Plan), which remains in Newcastle's present street layout.

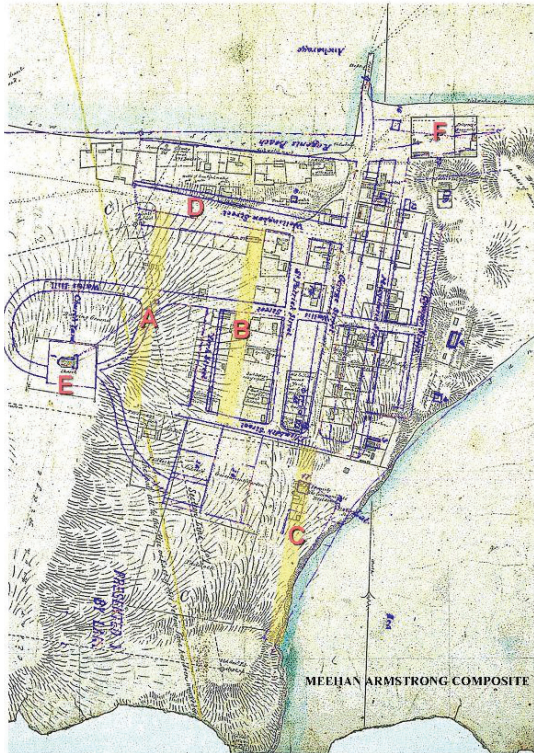

Figure 6. Overlays of the Meehan map (1818) and Armstrong map (1830). (Source: Cultural Collections, University of Newcastle. Creator Charles Martin).

Figure 6 shows the former Commandant's Residence (C) situated on what later became the extension of Watt Street to Ordnance Street. Hunter Street (D), then Wellington Street, was a simple track leading to the west. Christ Church (E) commanded the most prominent positions of Newcastle, and was by far the tallest structure in the settlement in 1830. By the time Armstrong had compiled his map, the Lumber Yard (F) had been formalised into a rectilinear enclosure. The boundaries of this remain evident in 2017. Of particular interest is that the harbour foreshore was still in its original pristine state with a sandy beach (Regent's Beach) and had deep channels.

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Collaboration and consultation

As the models continued to be worked up, with ongoing consultation with historians and members of the CRWP to identify buildings taking place. Where possible, inhabitants identified bringing a human perspective to the project. Members of the CRWP come from the disciplines of history, engineering, geology, surveying, archaeology, creative arts, education, digital/ IT, and have adopted an approach that engages the UON and the community (Hardy and Eklund 2014). It is a wide disciplinary membership. The methodology of the Newcastle Time Machine was well suited to a multidisciplinary model because it meant historical, archival, surveying and geological knowledge and expertise was always available.

During this phase, the creator gained considerable knowledge of the landscape and environment of early Newcastle. However, inaccuracies in the primary sources raised new questions about the early Newcastle environment. Questions were posed to historians and others in specialist fields and in some cases discrepancies were resolved, while other questions remained unresolved. Often an 'educated' guess was made to locate as best as possible, the position of buildings and landmarks.

The project was a 'work in progress' and under regular review with further research and development required. The plan was for the model to be transferred to a more sophisticated program and to seek partners and benefactors to progress the digital experience.

Conversion of the Newcastle Time Machine to a virtual reality experience

In 2014 the Newcastle Time Machine was further extended by incorporating Virtual Reality (VR) Technology. The 3D model, renders and flythrough of early Newcastle and other files were provided to a virtual reality and augmented reality development studio under the direction of Tim Davidson. The earlier model was converted to an interactive 360 degree virtual reality experience using the Oculus Rift VR

headset. Using the Oculus Rift meant our VR platform viewers could experience a truly immersive tour of early Newcastle.

The conversion process imported models into Unity 3D, a real-time render and game development engine. The original models were very high in detail and resolution and although these were ideal for flythrough animations and 3D images, for interactive experiences, and virtual reality much of this detail was removed. This is called 'mesh cleaning'. Once the mesh cleaning and conversion were complete, a build of the virtual environment surrounding the Newcastle Model began. During the conversion process the landscape model was unable to correctly migrate across to the new software, and a new model was built and a replica of the original model file. The landscape was then populated with flora, textures and materials, as well as roads, paths and tracks, retraced in accordance with the original files and maps provided by Charles Martin. With the redevelopment of the landscape complete, additional environmental aspects were included in the scene, such as water and lighting. The 'mesh cleaned' model was added, and this included lower resolution models of the buildings, structures, ships, fences, and people that were added into the scene.

The interactive Virtual Newcastle was starting to take shape. With the virtual environment complete, capabilities were incorporated enabling the viewer to freely navigate around the landscape using a game control pad. A Virtual Reality component was added, which allowed the Newcastle Time Machine experience to be viewed using the Oculus Rift virtual reality headset. This created a new and truly immersive experience in which users were able to feel as if they were actually there. Unfortunately, after considerable user testing, it was discovered that a number of users started to feel nauseous when navigating within the Virtual Reality experience. This is a relatively common phenomenon, known as 'VR sickness', caused by the mind expecting to receive feedback from the body when moving, and when it doesn't receive this, the user at times feels unwell. After extensive testing, 'VR Sickness' was overcome

by making two simple additions to the experience. The first was to place the user on a 'tour' path. This meant that the user could no longer freely roam, but was taken on a pre-defined tour of the township. Whilst this limited the level of interactivity, the user could still have a similar immersive experience and the likelihood of VR sickness was significantly reduced. The second element used to prevent VR Sickness was to place the user inside a virtual 'Horse and buggy'; this saw lingering nausea subside almost completely.

Digital heritage perspective

The heritage discourse in Australia has changed significantly over the decades, and is gradually shifting away from a dominance of 'heritage professionals' and 'old buildings', but has multiple definitions (Australian Government, Dept. of the Environment and Energy 2016). Although digital heritage is not explicitly mentioned in the National Heritage Strategy (2016), it is relevant in heritage circles because digital technologies are used in cultural heritage practices, thus expanding and challenging the definition of 'heritage'. Digital heritage has broad use (Wu and Din 2015, p. xli), referring to digital technologies, archaeology, virtual world environments, video games, and other online methods for exploring the past; it therefore makes sense that contributors to digital heritage also come from many diverse fields. The idea of multiple digital heritage players is legitimised by the status given as stated in *UNESCO Charter on the Preservation of Digital Heritage*: "[digital heritage] embraces cultural, educational, scientific and administrative resources, as technical, legal, medical and other kinds of information created digitally, or converted into digital form from existing analogue resources." (UNESCO 2003b). As Cameron and Kenderine suggest, digital innovation is opening up discussions about current heritage practices and the future direction of heritage (2010, p. 3). This new shift of the heritage sector into the digital realm could be further strengthened by using multi-disciplinary

approaches, particularly information technology and digital specialists.

Digital heritage projects can be tailor made depending on the locality, expertise and technological support available. Digital platforms are becoming a normalised part of contemporary society and digital heritage will continue to take many forms and be applied to diverse heritage and histories. Diversity of digital heritage is outlined in Cultural Heritage in a Changing World (Borowiecki, Forbes and Fresa 2006) and the work around digital dance and performance by Whatley and Sabiescu (2006, pp. 17-36.) shows just how distinct and unique digital heritage projects can be.

Digital technologies are increasingly being used in the heritage industry and the digital revolution will provide collaborative opportunities. 'Heritage' is becoming very technical due to digital implementation and therefore it is increasingly necessary for heritage professions to learn new digital techniques. The diversity of these skills is described in *Digital Heritage: Applying Digital Imaging to Cultural Heritage* (MacDonald 2006). It is, therefore, essential to support shareholders in the realm of digital heritage, including bodies such as ICOMOS, National Trust of Australia (NSW), the education sector, GLAM organisations, and the tourism sector. It is also important that digital heritage as a concept is incorporated in the Burra Charter, as 'digital heritage' incorporated in the *UNESCO Charter on the Preservation of Digital Heritage*. Similarly, efforts to reach out to the digital humanities professions and other associated bodies are needed, as there seems to be a digital revolution in the area of humanities. As Combi (Combi 2016, p. 4) points out, technical revolutions often turn out to be cultural revolutions.

In other parts of the world, digital archiving is usually used to safeguard buildings and monuments (see work by Cyark) from natural disasters, whereas the Newcastle project impresses the historic city of the early 1800s onto a contemporary digital platform. It does not document the modern city in 2017. Nevertheless, the Newcastle 3D model can be used to read the modern landscape and understand impacts

from proposed change, such as urban revitalisation and development, a pressing threat to the cultural heritage of the city.

An advantage of digital heritage and 3D modelling is that audiences can experience history visually rather than via the often-limited written sources (as was the case in Newcastle) by the recreation using 3D models. Digital heritage can be used by heritage professionals and others. Digital preservation and heritage conservation are aided by the practice of 3D technology. Virtual digital models that use relatively reliable primary sources (as described in this Newcastle project) are effective heritage management tools that assist in the better understanding of historic landscapes. The lack of historical secondary sources has meant historical evidence is not always there–evidence that is usually crucial to heritage conservation practice underpinning conservation documents (such as Conservation Management Plans).

Digital technology has many applications in cultural heritage management and protection, and digital heritage can be effective in embedding cultural understanding into planning instruments. Newcastle is undergoing revitalisation since the closure of BHP in 1999, and in 2017 major new development is taking place, or planned, such as major transport infrastructure including light rail (Farquhar 2016). The digital heritage 3D project provides knowledge about the city landscape to better understand the topography and features such as water courses, shorelines and sites of early human occupation by indigenising the city and embodying Aboriginal knowledge and wisdom into planning frameworks to create sustainable cities of the future (Hardy, di Gravio and Robertson 2015). The layout of the built environment as it was in the early 1800s is valuable information that can inform urban planners of the potential of archaeological sites. This is particularly pertinent to Aboriginal and European historical archaeology scattered across the Newcastle landscape. It is not unusual for significant relics to be discovered or rediscovered during development in the inner city, and 3D virtual projects are effective

heritage conservation management tools that can inform planning.

This project has made good use of the primary sources available and has embedded historical evidence into digital platforms to produce a relatively accurate 3D model, and is an educational, professional and academic research tool.

Conclusion

The 'Newcastle Time Team' project has had many contributors actively involved at particular phases of the project, from locating and digitally repatriating historic sources, to researching and re-interpreting sources in digital forms. As discussed, the project is not about digitising Newcastle as a heritage city in 3D representations, but it interprets the historic landscape of the past. The process has required particular expertise to analyse research material, and has taken considerable period to create (mid-1990s to 2017), to formulate ideas, procure relevant documents, analyse sources and apply cultural sources to digital imaging to create a model that is as reliable as can be. At the heart of this project has been time, and documentary evidence.

We acknowledge that a single case study is not a broadly-based review of the effectiveness of the multi-disciplinary approach; however, qualitative statistics related to this digital project have come after an article, 'Turning Back Time', was published on the front page of the *Newcastle Herald* and received over 1K 'likes' and 432 'shares' on the *Herald*'s Facebook page within a month (Owen 2017).

Finally, the collaborative aspects of this digital heritage project can significantly enrich outcomes because of the multidisciplinary approach that was taken. The multidisciplinary model used by HHI could be used by other tertiary institutions to develop digital heritage projects associated with an individual university. It is an approach not typically used in the tertiary setting, but has come about due to the shift towards innovative ways to digitise and interpret archival sources. The multidisciplinary approach is an appropriate mechanism that provides a forum where many voices are heard and recognises the value of collaboration, particularly with those in the digital and creative industries.

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References

Australian Government, Department of the Environment and Energy. 2016. Definition of Heritage. Accessed 13 January 2017. https://www.environment.gov.au/heritage/about/national

Albrecht, G. 2000. "Rediscovering the Coquun: Towards an Environmental History of the Hunter River." Address given at the River Forum 2000 at Wyndham Estate, Hunter River. Accessed 13 January 2017. http://libguides.newcastle.edu.au/chrp/albrecht#s-lg-box-wrapper-5982476

Armstrong, J. 1830. "The Town of Newcastle, New South Wales." Map showing its present actual state, with part of the adjoining Country, and The Coal Works of The Australian Agricultural Company, from a Careful Survey in 1830 by Jno. Armstrong. Wellington: Alexander Turnbull Library, The National Library of New Zealand.

Borowiecki, K. J., N. Forbes, and A. Fresa, eds., 2006. *Cultural Heritage in a Changing World.* New York: Springer Press.

Cameron, F. and S. Kenderine, eds., 2010. *Theorizing Digital Cultural Heritage: A Critical Discourse.* Cambridge: MIT Press.

Close, E. 1820. "Barracks with Christ Church in the Distance, Newcastle, New South Wales." Artwork. National Library of Australia. Catalogue number 4564445.

Coal River Working Party blog. 2003. *"ABOUT".* Assessed 13 January 2017. https://hunterlivinghistories.com/about/

Coal River Working Party blog. 2008. "The Coal River Time Machine", March 13. Accessed 13 January 2017. https://hunterlivinghistories.com/2008/03/13/the-coal-river-time-machine/

Coal River Working Party blog. November 29, 2012. "Virtual Newcastle circa 1800", March 13. Accessed 13 January 2017. https://hunterlivinghistories.com/2012/11/29/virtual-newcastle-circa-1800-1830-ad/

Coal River Working Party blog. February 16, 2014. "3D Virtual Newcastle – What Charles and Vera achieved in 34 days of 2013", March 13. Accessed 13 January 2017. https://hunterlivinghistories.com/2014/02/16/34-days/

Combi, M. 2016. "Cultures and Technology: An Analysis of Some of the Changes in Progress- Digital, Global and Local Culture." In *Cultural Heritage in a Changing World*, edited by K. Borowiecki, N. Forbes, and A. Fresa, 3-16. New York: Springer Press.

Cultural Collections, UON Library WordPress. (2007) "Coal River Surveying Students win Excellence in Surveying Awards." Accessed 13 January 2017. https://uoncc.wordpress.com/2007/10/04/coal-river-surveying-students-win-excellence-in-surveying-awards/

Cultural Collections, University of Newcastle. 2000. "Virtual Coquun-Hunter River Project Guide". Virtual guide produced by the University of Newcastle, Australia. Accessed 13 January 2017. http://libguides.newcastle.edu.au/chrp

Cyark. 2014. Accessed 13 January 2017. http://cyark.org/

Di Gravio, G., and P. Sherlock. 2007. "The Coal River Project – from Convicts and the Dreamtime to Google Earth". Presentation (Monteath's 3D programmers Andrew Baker, David Wallace and landscape mapper) at the UON Coal River Working Party meeting, Callaghan Campus, Newcastle, 29 March.

Di Gravio, G. 2012. "Virtual Newcastle circa 1800-183AD" Hunter Living Histories blog on 29 November 2012. https://hunterlivinghistories.com/2012/11/29/virtual-newcastle-circa-1800-1830-ad/

Di Gravio, G., e-mail to Greg Preston, 11 September 1998.

Di Gravio, G., e-mail to research colleagues, 1 December 2000.

Di Gravio, G., 10 January 2016. Personal reflection of association between 'heritage' and 'digital'.

Din, H. and S. Wu, eds., 2015 *Digital Heritage and Culture: Strategy and Implementation.* Singapore: World Scientific Publishing.

Farquhar, L. 2016. "NSW Government releases further details of Newcastle's new light rail." *1233 ABC News.* April 11. Accessed 13 January 2017. http://www.abc.net.au/news/2016-04-05/nsw-government-releases-further-details-of-new-light-rail/7300302

Fryer, J. 2016. "The Past Matters: Rock art and Indigenous Heritage Workshop." YouTube video recording at *Past Matters Rock Art and Indigenous Heritage Workshop*, May 20, 2016 at University of Newcastle's Auchmuty Library. Accessed 13 January 2016. https://www.youtube.com/watch?v=GbHtRNw2fUg

Hardy, A. and E. Eklund. 2014. "Multidisciplinary Approach to University – Community Engagement." *The Australasian Journal of University-Community Engagement* 9: 77-99.

Hardy, A., G. di Gravio and B.Robertson, 2015. WordPress post "Indigenising the City: Embodying Aboriginal knowledge and wisdom into planning frameworks to create sustainable cities of the future." Paper presented at the Spaces and Flows: Sixth International Conference.

University Center Chicago. Accessed 13 January 2017. https://hunterlivinghistories.com/2015/11/03/indigenising-the-city/

Iverson, O. S. and R. C. Smith. 2012. "Connecting to Everyday Practices: Experiences from the Digital Natives Exhibition." In *Heritage and Social Media: Understanding Heritage in a Participatory Culture*, edited by E. Giaccardi, 130. London: Routledge.

Kelly, M.. 2011. "6500-year-old heritage junked." *Newcastle Herald*, May 20.

MacDonald, L. ed., 2006. *Digital Heritage: Applying Digital Imaging to Cultural Heritage.* Oxford: Butterworth-Heinemann.

Owen, B. 2017. "Turning Back Time". *Newcastle Herald,* April 20. Accessed 17 May 2017.

Prensky, M. 2001. Digital Natives, Digital Immigrants. *Horizon* 9 (5): 1-6.

Ray, G. 2012. "VIDEO: Fly through 3D history of Newcastle." *Newcastle Herald*, November 30. Accessed 13 January 2017. http://www.theherald.com.au/story/1157494/video-fly-through-3d-history-of-newcastle/

Royal Commission of Inquiry into the Coal Industry (New South Wales). Accessed 13 January 2017. http://search.records.nsw.gov.au/agencies/4978

The Mayfield Website. 1996. Accessed 13 January 2017. http://pandora.nla.gov.au/nph-wb/20000720130000/http://www.library.newcastle.edu.au/archives/mayfield.html

Thomson, J. Letter from Mr John Thomson to Captain Schanck, H.R.N.S.W., Vol. III (September 8, 1799): 716-718.

Towers, C., and T. Sumner. 2009. "Sir Thomas Mitchell 1828 Newcastle Survey Report – Full Report and Summary" Accessed 13 January 2017.

Sir Thomas Mitchell's Angular Observations and Field-Note Sketches of Newcastle.

UNESCO. 2003b. "Charter on the Preservation of Digital Heritage". Paris, UNESCO Website. Accessed 13 January 2017. http://portal.unesco.org/en/ev.php-URL_ID=17721andURL_DO=DO_TOPICandURL_SECTION=201.html

University of Newcastle, Coal River Working Party Minutes 5 November 2012. Accessed 13 January 2017. https://coalriver.files.wordpress.com/2014/01/crwp-minutes-2012-november.pdf

Whatley, S. and A. G. Sabiescu. 2006. "Interdisciplinary Collaborations in the Creation of Digital Dance and Performance: A critical Examination." In *Cultural Heritage in a Changing World*, edited by K. Borowiecki, N. Forbes, and A. Fresa, 17-36. New York: Springer Press.

Wilson, J., and A.Widgery. 2007. "Fort Scratchley DTM and Coal River Working Party Surveying Project Report." University of Newcastle Students. Accessed 13 January 2017. https://downloads.newcastle.edu.au/library/cultural%20collections/pdf/johnwilson_coalriver%20report_full.pdf

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Capturing spatial patterns of traditional rural landscapes with 3D point cloud – case studies of Tunpu Villages in Guizhou Province, China

Abstract

Tunpu villages are traditional rural landscapes located in the Karst environment in Guizhou Province, China. The spatial patterns of these villages are the result of continuing human-nature interactions over 600 years, which are of both historical and contemporary significance. During the past decades, however, Tunpu villages have been changing with increasing speed and important spatial patterns have quickly faded away. The aim of this paper is to explore an innovative approach to capture the spatial patterns of Tunpu villages for heritage conservation purposes. Aerial and terrestrial photogrammetry and hand-held laser scanning tools were used to collect point cloud data from two case study villages, which can quantitatively represent the spatial patterns of these villages at different scales. This paper confirms that, with 3D point cloud data and the related technologies, a Tunpu Village of approximately 3 km^2 was surveyed in 4.5 hours and digital models at three different scales were generated in 23.5 hours. This multi-scale approach was able to accurately capture the spatial patterns of Tunpu villages. The outcome is comparable in accuracy to manual measurement techniques, and at a greatly increased level of efficiency and scope.

Keywords: Traditional rural landscape; spatial pattern; photogrammetry; laser scanning; Tunpu village

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Evaluating the rationality of Boullée through the chasm between conception and perception using digital modelling as a method of analysis: a case study on the Cenotaph of Turenne

Abstract

Between 1780 and 1797 French architect Etienne-Louis Boullée began projecting a vision of the architectural monuments during his twilight years through the use of ink-wash drawings on hot-pressed straw paper. The visionary projects embrace both formal simplicity and expressivity simultaneously. While simplicity of form was believed to be the key for ease of apprehending the work, expressivity was seen as necessary to convey the meaning of the form itself. This research presents a study of one particular project produced during this period: the Cenotaph of Turenne 1782, by reconstructing and analysing the unbuilt paper architecture through physical and digital modelling. It seeks to provide an alternative frame of reference to the discourse that evaluates the metaphoric or the iconographic aspects of Boullée's project. The goal of this study is to unfold the stereometric forms and examine the reciprocal relationship between the project's conceptual intention as conceived by Boullée with the effect of the spaces as perceived by the viewer. The paper proposes to investigate Boullée's Cenotaph through the chasm between the concept of the work and its representative images, the apparent and the literal solidity of structure, and the idealized form and the perceived form by the viewer. The research is organized in two parts. The first part aim to forensically deconstruct the guiding principles of Boullée's Cenotaph in order to reveal how the Cenotaph is conceived, while second part enable the reading of how the work is perceived. Although the project is well-publicized in books on Boullée through the five known orthographic drawings, very little has been written about it.

Keywords: Visionary architecture; computational modelling; conception and perception; architectural representation

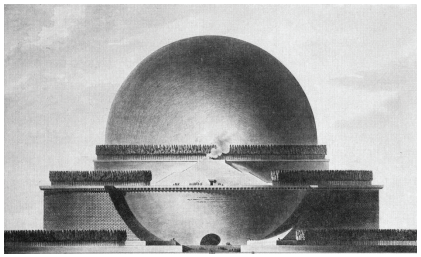

Figure 1. Cenotaph for Newton elevation, HA 57, No.7, ink wash on paper (1784) courtesy of Bibliothèque nationale de France.

Scholarship on Boullée

There are three significant research directions in the literature and scholarship on Boullée:

1) study characterises a strand of research by a group of specialists that focuses on translations and editions such as Helen Rosenau (Rosenau 1953);
2) the historically significant scholarships that attempt to reveal ideas behind his sombre imageries and 'shadow architecture' in Emil Kaufmann (Kaufmann 1939);
3) those that deal with his theoretical contributions reflected in *Architecture, Essai Sur L'Art* (1790) and relate them to a context, for example Antoine Picon has situated the work of Boullée within the sibling discipline of engineering (Picon 1992).

Writings by Boullée and subsequent scholars have addressed his ideas from the *metaphoric* point of view – by associating Boullée's use of stereometric forms as a way to represent the concept of regularity that is found in the laws of nature; and from the *iconographic* point of view – through projecting meaning associated with nature behind Boullée's painterly architectural images rather than substantiate its claim through evidence-based arguments (Rosenau 1953). These reflections are largely formulated upon an overarching argument that Boullée had dedicated a cenotaph specifically for Newton (Figure 1), thus there must be a rational design methodology connected with his works. While his admiration of Newton and reason might be true, it does not prevent us from forming a hypothesis questioning the rationality and perception of his work.

Boullée's treatise: Architecture, Essai sur l'art

Despite the limited amount of his writing, Boullée's *Essai* is undoubtedly influential and is often cited alongside other referenced essays from Vitruvius and Alberti. One important contribution of the *Essai* is that it advocated his views on the *a priori* nature of thinking and picturesque representation over materialization. The stance of prioritising the pictorial image ahead of its technical concern marked a stark difference to the Vitruvian triad (Venustas, Utilitas and Firmitas). Boullée emphatically announced this position in the first paragraph of the *Essai*. 'What is architecture? Shall I join Vitruvius in defining it as the art of building? Vitruvius mistakes effect for the cause' (Boullée 1976, 83).

Nature as the source

Prior to the 18th century, architectural reference to nature is understood to be 'an amalgam in which *imitation* of nature, proportion, beauty and orders were all blended' (Madrazo 1995, 151). In lieu of such 'application', Boullée embraces nature as the source of architecture and order, which is to bring a direct connection between them without mimicking through forms of decoration. Boullée distinguishes himself from Piranesi's arbitrary and whimsical principles of design. He considers Piranesi's engravings to be the work of a dreamer composed of disconnected and scattered ideas with no particular order (Boullée 1976, 86).

Form of nature

When articulating how nature would govern architectural principles, Boullée describes the use of symmetry as a means of generating the image of order and rationality that conveys a sense of beauty and perfection. It allows the mind—which seeks understanding—to comprehend its form. The simple, symmetrical, perfect and regular form for Boullée is the best *iconographic representation* of this understanding. It is clear that Boullée acts upon the hypothesis that there is a rational correlation between simple geometry, nature and the human's perception (Figure 2). The autonomy of architecture through drawing helped to create a distance and independence from its projected building. In this instance, the conceptual project becomes the totality of the work itself.

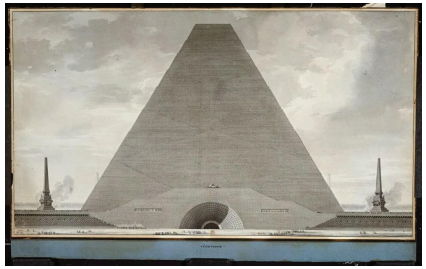

Figure 2. Cenotaph of Turenne elevation, HA 57, No.13, ink wash on paper (1782) courtesy of Bibliothèque nationale de France.

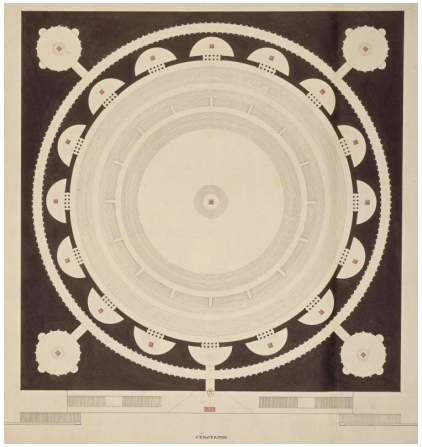

Figure 3. Cenotaph of Turenne Floor plan, HA 57, No.11, ink wash on paper (1782) courtesy of Bibliothèque nationale de France.

Assertion on Boullée's rationality

Boullée's work has been described by Pier Vittorio Aureli as having dealt with the technical requirements of the building as opposed to mere fantasy that embraces the monumental sublime. In *Architecture as a state of exception,* Aureli warns of misreading Boullée's drawings as simply visionary, and calls for a wider acceptance of the view that Boullée has in fact articulated the 'specific conditions' of each project through adopting 'technically inventive and individual approaches to functional, programmatic, and even contextual problems (which) demonstrate a concern for public welfare with its unprecedented provisions for egress in the event of a fire'(Aureli 2011, 142-143). But exactly how did Boullée accomplish that? In the case of the cenotaph, there is certainly no evidence to support such assertion, where the giant spherical space with a span of 160 meters covering some 80,000 square metres of area offers only one means of egress for the entire monument (Figure 3).

Similarly, in Rosenau's *Boullée's Treatise on Architecture*, she notes that 'It would be erroneous, to classify Boullée as a Romantic, since his individualism was based on a reasoned appreciation of function, and ruled by the recognition of the laws of nature' (Rosenau 1953, 12). Rosenau argued that the cypress tree in Boullée's elevation is a good example for his 'endeavor to include the effects and the products of nature in his composition' (Rosenau 1953, 19). Critique and assertion as such addresses the issue of 'nature' through oblique remark and selective examples. As my analysis reveals, the tendency to rely upon the drawings to confirm Boullée's intellectual assertions remains highly problematic.

Tracing the conception of the idealized form

The setting-out of the geometry in 2D section can be read as a composed geometric relationship between the triangle and the circle for extrapolating and synthesising the overall stereometric massing. The diameter (Ø) of the dome is half of the circumference (Cir.) that defines the outer extent of the triangle

(Figure 4). Three-dimensionally it is the interplay of composition between four primitives: pyramid, cone, spheres and cylinders, resulting in forms of subliminal spaces.

Stereometric translation

The first nuanced finding is an apparent 'oversight' between Boullée's theoretical text and its mirroring image. When describing the design for the Cenotaph, Boullée writes, 'I have given the Pyramid the proportion of an equilateral triangle because it is perfect regularity that gives a form its beauty' (Boullée 1976, 106). However, when examined closely, only half of the statement is true. Due to his training as a painter, Boullée was perhaps more interested in the iconographic image rather than the exactitude of geometry. The pictorial representation of the idealized pyramidal body is neither *literal* nor *perceptual*, literal in the sense that the appearance of the 'equilateral triangle' pyramid is in fact an isosceles triangle. The perfect equilateral occurs only in projection (Figure 5). Perceptually, the magnitude and scale of the project prevents a total and inclusive reading of the form when viewing normally.

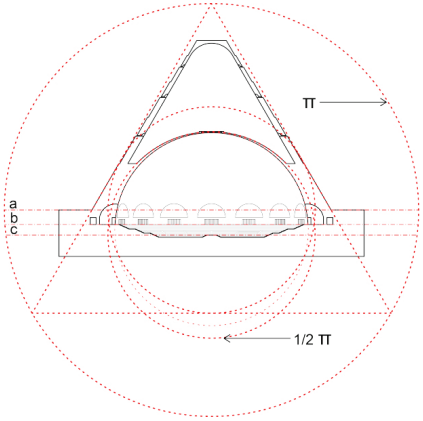

Figure 4. Geometric principles of the Cenotaph of Turenne (drawn by the author).

$$tan\,60° = \frac{h}{a}$$

$$a = \frac{h}{\text{Tan } 60°}$$

$$\frac{\sqrt{(\frac{h}{\text{Tan } 60°})^2 + h^2}}{(\frac{h}{\text{Tan } 60°})^2} = \tan \alpha$$

$$tan\,\alpha = \frac{\sqrt{(\frac{h}{\text{Tan } 60°})^2 + h^2}}{\frac{h}{\text{Tan } 60°}}$$

$$tan\,\alpha = \frac{\sqrt{\frac{h^2}{\text{Tan } 60°} + h^2}}{\frac{h}{\text{Tan } 60°}}$$

$$tan^2\alpha = \frac{\frac{h^2}{\text{Tan } 60°} + h^2}{\frac{h^2}{\text{Tan } 60°}}$$

$$tan^2\alpha = 1 + tan^2 \text{ Tan } 60°$$

$$\boldsymbol{\alpha = 63.435°}$$

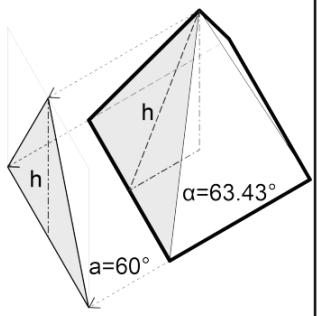

Figure 5. Equilateral pyramidal geometry as established through graphic and mathematical method (drawn by the author).

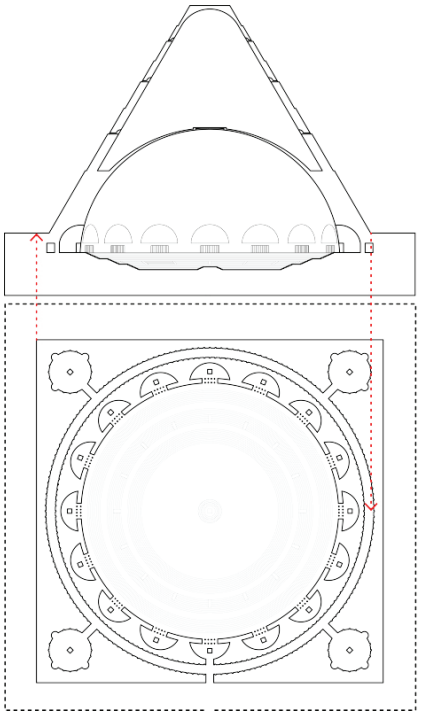

Figure 6. Drawing incongruence between plan and section (drawn by the author).

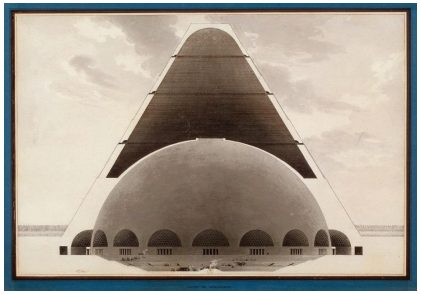

Figure 7. Cenotaph of Turenne section, HA 57, No.14, ink wash on paper (1782), courtesy of Bibliothèque nationale de France.

The figurative poche

It is impossible to match the plan with the section as the perfect alignment between the square boundary of the pyramid and the circular ambulatory does not actually exist. Therefore, the placement of poche is used when different geometries come together (Figure 6). The figurative poche serves as surplus strategy deployed by Boullée as a necessary mediator between the boolean interior form and the primitive exterior shape. Through the manipulation of the poche and augmentation of the massing, the scale of the Cenotaph is further exaggerated.

This manipulation and augmentation is also used to differentiate the construction principles between the inside and outside (Figure 7).

The ambulatories at the base of the pyramid as shown in the section drawing indicate an impossibly thin wall, where the poche's thinning is taken to the maximum extremity. The fact that it appears to support the coffered dome above is defying any structural and material logic—a condition contravening basic gravitational laws of nature (Figure 8). In this instance, the *literal* solidity of structure is disregarded. Incoherence is also evident in the ways the dome is represented. One could read this articulation of the dome as either a section or an oblique elevation, but not simultaneously.

The shadow spaces

A digital model containing geometric traits of the Cenotaph was created in Rhinoceros 3d and rendered in 3ds Max to offer an index for determining the theoretical lighting conditions within the Cenotaph (Figure 9). The simulated model of the Cenotaph was positioned at the latitude and longitude coordinates of Paris (48.864716, 2.349014). It was set up as if the Cenotaph were constructed in half section, therefore allowing natural light to penetrate into the interior space. Given the hermetic composition of the forms, the purpose of the oculus remained unclear. It is more likely that the oculus holds an iconographic reference to nature, e.g. in connection to the environment

and atmosphere, as opposed to serving any literal function.

(re)Forming of an idea

Images in the following section are produced through the *method* of digital modelling to offer a *means* to perceive and to compare the five drawings presented to us by Boullée. In addition to offering alternative point of views of the Cenotaph, the images of digital modelling also differentiate themselves from Boullée's hand drawings by minimizing the sublime dramatization, to offer a neutral depiction of the spaces (Figures 10-13).

What the images reveal refutes the notion of regularity and beauty, since it is perceptually impossible to consume the totality of the space at once. The idea of order resulting from the composition of volumes – which forms a part of Boullée's argumentation – could not be contained within the human perception like the 'picture frame' of a drawing. Therefore, the statement 'The arrangement should be such that we can absorb at a glance the multiplicity of the separate elements that constitute the whole', as stated by Boullée can only be understood *notionally* rather than as something that could be experientially perceived (Boullée 1976, 89).

Perceiving the space

Each image frame is rendered in two focal-length settings: 10mm and 24mm positioned at the eye-level. The first set offers a more inclusive view, the near panoramic vision. However, it presents the target (Cenotaph) in a way that is impossible to perceive due to its expansiveness, similar to those orthographic sections and elevations drawn by Boullée. Instead, it is the second set of renditions, which are the equivalent to the perception of human eye that needs elaboration. In the realm of visual perception, we may consider two contributions affecting one's perception: *objective* and *experiential*. Experiential contribution is understood as relating the perceiver's own-self through *memory*, *experience* and *expectation to* the

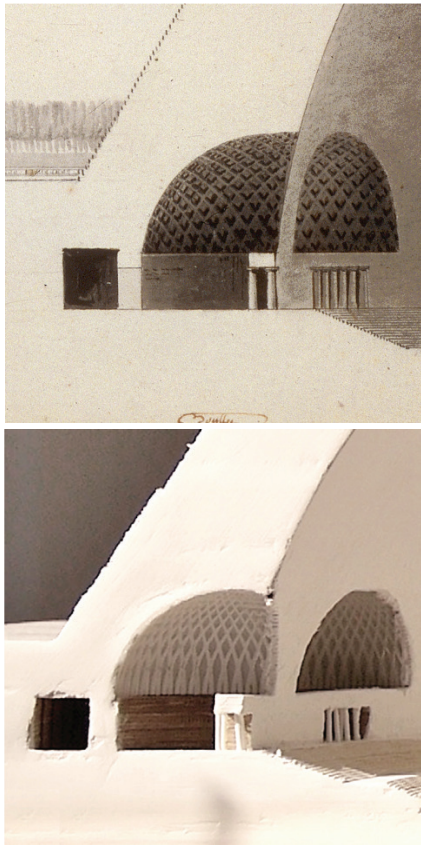

Figure 8. Discrepancy between the partial section of cenotaph ambulatory as drawn by Boullée (left) and the reconstruction of the physical model (right).

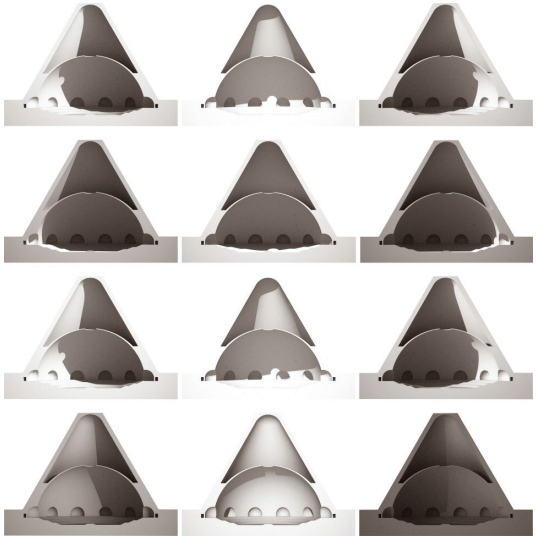

Figure 9. Daylighting study of the reconstructed cenotaph model, images were created in four seasons from top to bottom: vernal equinox, summer solstice, autumn equinox and winter solstice. Three time frames were rendered for each season, from left to right: 9am, noon, 3pm. (images by the author).

Figure 10. View toward the triumphal arch entry shown in the perceptually natural focal –length of 24mm (above) compared with the expansive and inclusive view of 10mm (right).

target being viewed; whereas objective contribution is the literal observation of the thing one perceives. It means perceiving all that is presented before the awareness, it is a matter of seeing things as they are, rather than through tangential experience.

Most people oscillate between these two contributions and are never quite fixate in one mode. I would argue that these contributions may be used to interpret Boullée's work and it is his desire to draw attention from the beholders to perceive the drawings through an *objective* lens: objective in the sense that the presence of the geometric body, whether spheric, pyramidal or conic to fit within the picture as a projected image, was a matter of greater concern than the literal purity of the geometry or the perception of it or within it. He expects the viewers to take the *literal* readings across his drawings by consuming the emotional expression and *apparent* clarity of form and structure it emanates. In fact, the literal reading of the drawing is affirmed by Boullée in the *Essai,* suggesting

his reader consult his plans in place of all possible explanations, for he is persuaded that what should be required of an *artist* above all is not that he explain well, but he execute well (Boullée 1976, 90).

Materializing the space

In addition to the images generated digitally, a physical model was constructed through *sectioning* by layering multiple laser-cut sheets of cards, a process best reflective of the construction logic of the Cenotaph (Figures 14-16). The differentiation between inside and outside is further exacerbated through the use of colour that magnifies the reading of the poche. While the staggered exterior implies a system of unitary construction, the austere, unembellished interior suggests a smooth plaster finish, enhancing the scaleless reading of the surface, and to receive a play of light.

Conclusion

This research project began with the premise to search for an alternative frame of reference for reading and evaluating Boullée's project by investigating the split between the intellectual motivations for how the work is conceived versus how the work is perceived via the idealized form represented through the drawings. The evidence produced and articulated in the analysis—including the challenge of spanning significant distances by the dome, or painting the interior spherical wall with daylighting as if it is a canvas, or the lack of passage for air within the funerary, or an imprecise reference to the use of perfect geometry for the pyramid, or the many inconsistencies and phenomenological impossibilities that lies within the Cenotaph – all points to the fact that Boullée was more invested in the notion of *objective perception* of form in drawing rather than its *experiential perception* in space. In Boullée's attempt to establish a structured-relationship between the concept of his idealised project with an *objective perception* by the viewer, he has largely overlooked the influence of the *experiential perception* (Figure 17) as I have argued for

Figure 11. Rendition within the cenotaph ambulatory with coffer-ceiling, represented by focal –length of 24mm (above) and the expansive and inclusive view of 10mm (right).

Figure 12. View of the cenotaph ambulatory looking toward the rhythmic and alcove-formed circular corridor as represented by focal –length of 24mm view (above) and the 10mm view (right).

Figure 13. Rendition within the cenotaph of the sunken funerary hall as represented by focal –length of 24mm (above) and the expansive and inclusive view of 10mm (right).

in this paper. An analysis made possible through the use of digital modelling tools.

Since the use of computing software became an integral part in the research of architectural heritage beginning in the late 20th century, there are two ways in which the tools have played a role: First, those whom use the software to study and survey architectural heritage sites. Using the collected data file as a way to archive the relics of the city. On another stream, there are those in the likes of Kent Larson, who calls attention to the use of computer-graphic images through the unbuilt work of Louis Kahn with the aim to 'create new imagery that communicates Kahn's unbuilt space as it might have been experienced' (Larson, 2000). What this investigation revealed is, within the two spectra, there lies a third approach where one sees the realization of the rendered images and the models not as an end to itself, but rather, as an alternative perspective to transgress the unchallenged assertion. By all means, Boullée's architectural drawings and treatise should never be studied independently; they support and complement each other and the reader would fail to grasp the intended meaning without oscillating back and forth in these two modes of signification and it would be erroneous to draw a definitive conclusion discrediting the rational basis of Boullée. Asserting the disclaimer is not to render this part of the research trivial or peripheral. Rather, it highlights the importance of defining the lens for evaluating his work. Finally, the long-term research motivation is to build up a catalogue of analysis on Boullée's unbuilt architecture to advance the knowledge of this brilliant 18th century master.

Figure 14. A reconstructed section model exposes the atmospheric effect and daylighting qualities of the cenotaph (Image by the author).

Figure 15. View of the physical model from the sunken funerary ground towards the ambulatories on the left. The enormity of the unornamented surface contrasts distinctively with the textured surfaces of the inner conic geometry on the right (images by the author).

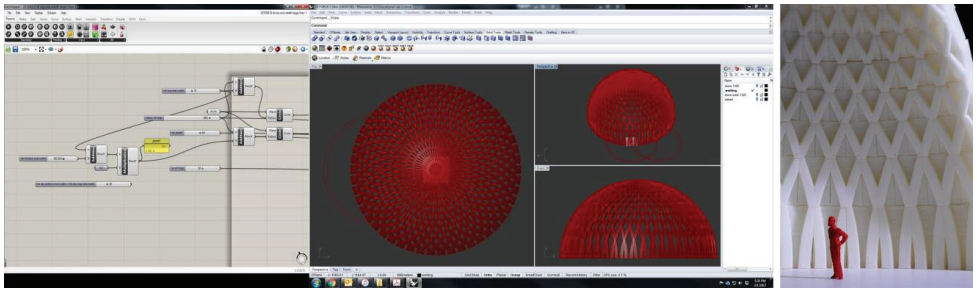

Figure 16. Tracing the geometric origins of the coffer ceiling pattern through parameters established and assisted by Grasshopper (images by the author).

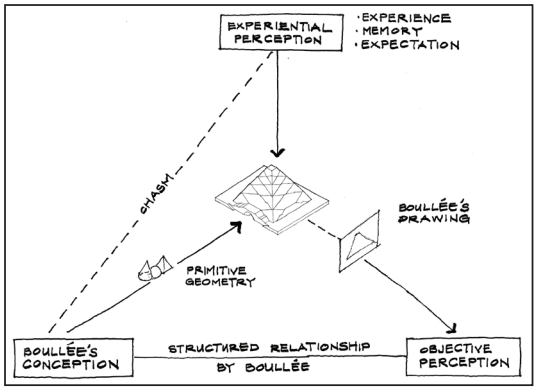

Figure 17. The multiple trails to understanding the conception and perception of the idealised project by Boullée (drawn by the author).

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References

Madrazo, L. 1995. "The Concept of Type in Architecture: *An Inquiry into the Nature of Architectural Form*." PhD diss., Swiss Federal Institute of Technology.

Aureli, P. Vittorio. 2011. *The Possibility of an Absolute Architecture*. Cambridge, Mass.: MIT Press.

von Falkenhausen, S. 1997. "The Sphere: Reading a Gender Metaphor in the Architecture of Modern Cults of Identity." *Art History: Journal of the Association of Art Historians 20* (June): 238-267.

Iwamoto, L. 2009. *Digital Fabrications: Architectural and Material Techniques*. New York: Princeton Architectural Press.

Kaufmann, E. 1939. "Étienne-Louis Boullée." *The Art Bulletin* 21 (3): 213-227.

Patterson, R. 1995. "Three Revolutionary Architects, Boullée, Ledoux, Lequeu". In *Architecture and the Sites of History: Interpretations of Buildings and Cities,* edited by I. Borden, 149-62. Boston: Butterworth Architecture.

Larson, K. 2000. *Louis I. Kahn: unbuilt masterworks*. New York: The Monacelli Press.

Picon, A. 1992. *French Architects and Engineers in the Age of Enlightenment*. Cambridge: Cambridge Press.

Rosenau, H. 1953. *Boullée's Treatise on Architecture*. London: Alec Tiranti LTD.

Rosenau, H. 1976. "Etienne-Louis Boullée 1728-1799." In *Boullée & Visionary Architecture*, edited by H. Rosenau, 7-13. New York: Academy Editions.

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Google Keyword Planner, Google Trends and Google Images: digital methods for investigating the social value of heritage

Abstract

Many World Heritage monuments stand as symbols for their cities. In Sydney, the Opera House is an icon, in Paris the Eiffel Tower, in Agra, the Taj Mahal. This concurrence suggests that such iconic sites are deeply rooted within their communities. However, in Guadalajara, Mexico, this does not seem to be the case. Hospicio Cabañas is a World Heritage property located in the centre of Guadalajara. The Neoclassical architectural complex is a unique example of an architecture for public assistance and houses frescos by Jose Clemente Orozco, one of the great Mexican muralists. While this place is of international significance, our observation was that neither the architecture nor the art, both iconic in their own right, appears to be prominently associated with its city as an icon. Instead, it is the twin spires of the Catedral Basílica de la Asunción de María Santísima, the main cathedral located a kilometre away, that perform this role. Every day we search for information online; searching has become a cultural phenomenon, much of it mediated by Google. In this paper, we explore how the data collected as part of our culture of search can offer an emergent methodology for a broad assessment of the social value of heritage. Prompted by an anecdotal observation about the value of two heritage sites in Guadalajara, we investigate how each is publicly perceived, using Google's free analytical tools, Google Keyword Planner, Google Trends and its image based service, Google Images. The paper adopts the theoretical stance proposed by Richard Rogers, which conceptualises Google as a socio-technical phenomenon driven by society and algorithms. In this way, it speculates and makes an initial investigation and comparison between the social connections with World Heritage and National Heritage, with a view to future development.

Keywords: Google; search culture; World Heritage; National Heritage; Guadalajara; cities; images; methodologies.

Introduction

The focus of this paper arose out joint observations about the social value of heritage sites in Guadalajara, Mexico and the proliferation of contemporary online communication technologies. We were familiar with Guadalajara's significant buildings and their prominence in everyday culture and were interested in how Google's search data and free analytics tools could validate our observations about two particular buildings.

Hospicio Cabañas is one of largest and oldest historic hospital complexes in the Americas. The property was

Figure 1. Photograph of Hospicio Cabañas by Flickr member fcastellanos. (Source: Creative Commons Licence: Attribution-NonCommercial-NoDerivs 2.0 Generic (CC BY-NC-ND 2.0).

the first site of modern heritage in Mexico; inscribed as World Heritage in 1997. Designed by Spanish architect Manuel Tolsá, the hospice was founded in early 19th century to provide shelter for the needy, including orphans, the elderly, disabled and chronic invalids. In addition, the architectural complex houses murals by José Clemente Orozco that were added in 1937. The murals are considered masterpieces of Mexican art and depict a fusion of Spanish and indigenous Mexican culture. Today, Hospicio Cabañas operates as a cultural institute and museum and while an important place in the City of Guadalajara, is infrequently depicted in its visual culture (Figure 1).

In contrast, Guadalajara's main cathedral, La Catedral Basílica de la Asunción de María Santísima

Figure 2. Photograph of La Catedral by Flickr member Alex Torres. (Source: Creative Commons Licence: Attribution-NonCommercial-NoDerivs 2.0 Generic (CC BY-NC-ND 2.0)).

(La Catedral), has a strong and prominent cultural presence as an urban icon in the city. La Catedral is an important tourist destination and is both a local landmark and an image frequently represented in the city's visual culture (Figure 2). While La Catedral is not a World Heritage site, it is recognised at federal and state level as an immovable historic monument within Mexico's heritage protection system.

Many factors may underpin the perceived differences in the cultural prominence of these two heritage places in Guadalajara: La Catedral is an older building that has always been used for religious practice, while Hospicio Cabañas was a hospice and is now a museum. La Catedral is associated with spiritual devotion, while Hospicio Cabañas with the needy and destitute. Yet, we were interested in exploring how the social values of such distinct places might be compared when one is a World Heritage property and the other is of national significance and an important tourist icon.

In this paper, we explore an emergent methodology for assessing social value at a broad scale using Google Keyword Planner, Google Trends and Google Images. Previous research explored the role of online representations of heritage sites as evidence of social significance and participatory culture (Garduño Freeman 2010, 2013, 2016), and the implications of encounters in virtual worlds for heritage significance (Chavez Aguayo 2009, 2016a, 2016b). We were interested to see whether the perceived disparity between the inscribed significance of Hospicio Cabañas that of La Catedral would be evidenced in Google's readily available search data and analytic tools. Such a methodology, while preliminary, has the potential to offer a means of assessment of social value and public perception of heritage sites at a global level.

Google search culture

> Searching is instrumental to the way the web works. (Hillis, Petit and Jarret 2013, xi)

Google mediates our access to online information. Most of us, when looking for information, enter

keywords into Google's search engine which currently has the largest global market share (Armstrong 2016; Netmarketshare 2017b, 2017a). Accustomed to having information at our finger tips (Sparrow, Liu, and Wegner 2011), we Google in all manner of social situations; so much so, that 'googling' has become an everyday activity generating masses of data encapsulating our interests, concerns and needs.

Google's mission has become 'to organize the world's information and make it universally accessible and useful' (Google 2016) which has enabled the evolution of a search culture, where 'googling' has become an embedded but inconspicuous practice (Hillis, Petit and Jarret 2013). We search on mobile devices in casual conversation, to answer questions, to find places, satisfy boredom or quench curiosity. Hillis, Petit and Jarret observe that, 'to search has become such a natural and obvious condition of using the web, and the web such a natural and obvious feature of the internet, that the specific contingency of these everyday practices has become obscured' (2013, 2). They emphasize that it is crucial to reflect on the way in which searching through Google, structures knowledge and information as part of a growing search culture curated through computational algorithms.

Google is powered by a closely guarded algorithm known as 'PageRank™'(Lee 2016, 4). The search service enables users to find webpages, images videos and other forms of information by sorting millions of pages and returning relevant results. Google (now owned by parent company Alphabet Inc) is also a corporate behemoth; by 2016, Google, had overtaken Apple to become the most valuable company worldwide (La Monica 2016). Since incorporation in 1998, Google has tailored its search engine service to multiple languages and cultural settings and to specific types of content (Google Scholar, Google Books, Google Image) and developed game changing services (Google Street View, Google Translate). However, keywords are essential to the way that Google's search algorithm crawls and indexes webpages. These webpages are then ranked by the

algorithm dependent on the quantity and quality links pointing to the webpage. (Google 2017). While not neutral, Google can be loosely conceived of as an 'echo of our online conversations' (Rupiah 2016) as it is dependent on the interplay of all the elements of the system: the algorithm; the information on each webpage; the search queries and keywords entered by people. Google is a dynamic and complex socio-technical phenomenon structured on one hand by the searches performed by a 'community' of global users and on the other by a constantly evolving engineered algorithm.

Google collects indexing and search query data and offers several free analytical tools: Google Trends; Google Keyword Planner; and Google Display. These, along with more tailored services such as Google Analytics, help users to refine website keywords, advertising and search engine optimization to increase search rankings. Stephens-Davidowitz proposes that search data can reflect people's true opinions more accurately than other social science methods (2017). Search data is a valuable resource for understanding human perception because of two key factors: first, simply because of its size and reach (human beings produce approx. 2.5 million trillion bytes of data every day); and second because search queries are (usually) anonymous and therefore offer a sense of privacy to express oneself without judgment. Google search data has been used to predict the likelihood of diseases, or the relationship between mood and weather (Stephens-Davidowitz 2017). Here, we explore how Google's data and tools can offer quantitative and qualitative ways to evidence social value around heritage places.

Social value

The concept of social value is well established in Australia and is part of legislation and best practice guides for natural and built forms of heritage (Australian Government 1999; ICOMOS Australia 2013). In contrast, social values for buildings are not considered in the Mexican context; heritage remains defined as monuments and zones designated

for their archaeological, artistic or historic value (Mexican Government 1972). Nonetheless, there is increasing international interest in recognising social and community values evidenced in the inclusion of communication and communities within World Heritage Convention's strategic objectives (UNESCO 2017). Mexico has been part of this shift, at least at an academic level (Johnston 2016), but also at an international level through their ratification of UNESCO's *Convention for the Safeguarding of the Intangible Cultural Heritage* (2003). Broadly, social values acknowledge the associations communities have with significant places and their role in providing a sense of identity and belonging. But conceptions of well-defined and geographically co-located communities are being challenged by internet and communication technologies in an increasingly networked world (Garduño Freeman 2016; Waterton 2010; Lewi et al. 2010). Harnessing Google's search data to assess the social value of places can contribute a great deal to an area of assessment that is complex and often resource intensive. Social values are dynamic, fluid and subjective (Johnston 1992; Johnston et al. 2003; Johnston 2012, 2016; Byrne, Brayshaw and Ireland 2003; Byrne 2013; Smith 2006) and are therefore distinct from more stable values such as aesthetic, historic or scientific kinds of significance. Using real-time data has the potential to offer methods to understand how social values change over time or in response to specific events. At the same time, we acknowledge that such an approach is not without its limitations: access to online services is not uniform and such a methodology relies on data currently controlled by a global corporation. Recognising these conditions, the paper's approach is speculative and the discussion here recognises such limitations and acknowledges that reliability on such a method requires further in-depth research.

Google Keyword Planner and Google Trends

Our comparison of the social value of Hospicio Cabañas and La Catedral using Google's search data uses three tools: Google Keyword Planner, Google

Trends and Google Images. First, we make a direct quantitative comparison of the volume of search data for keywords for each place, and a qualitative analysis of associated keywords using Google Keyword Planner. We then consider these results over time and in terms of their geographic origin using Google Trends. Second, we exploit keywords in relation to photographs using Google Images where what is represented in the image can be distinct from its text-based filename.

Google's analytic tools are intended to assist in the development of advertising campaigns and search engine optimization. The goal is increasing website audiences and traffic. While there are many factors that affect the way Google's algorithm ranks pages, one of the central variables is keywords. Both Google Keyword Planner and Google Trends analyse search volume in relation to specific keywords.[1] Google Keyword planner focuses on the average monthly search volume[2] over the past 12 months and provides a list of associated keywords, while Google Trends provides a longitudinal analysis of search volume from 2004. Google Trends also allows for comparisons between search terms. Because the analysis is dependent on keywords, language must also be accounted for.

Our Google Keyword Planner search was centred on place names in both English and Spanish: Hospicio Cabañas (same in both languages), Catedral (Spanish) and Cathedral (English). To differentiate from other similar named places, we added Guadalajara to our search terms. The results confirmed our initial observation that La Catedral was more prominent by tenfold than Hospicio Cabanãs, but only when the search is carried out in Spanish (Table 1), which suggests that La Catedral is far more significant within the Spanish speaking (and presumably Mexican) communities. In English, the results were the same between the two places. Other searches were performed using other keywords including 'heritage', 'heritage guadalajara' and 'heritage mexico' in both languages to contextualise these results (Table 2). The search volume for 'heritage' was one thousand

times greater than the search volumes of Hospicio Cabañas, while one tenth the volume for 'heritage guadalajara' and 'heritage mexico'. Such differences could indicate that Guadalajara is not perceived as an important location for heritage in Mexico or indeed internationally. Further, the volume of searches for 'heritage' was tenfold that of its Spanish translation 'patrimonio'. Again, this could be indicative of the dominance of Western English-speaking nations in the conceptualisation and use of the term. This could also offer insights into Mexico's slower adoption of such all-encompassing terms, reflected within their heritage legislation that is still founded on terms such as 'monuments' and 'zones' (Mexican Government 1972).

Table 1: Results for average monthly search volume for place keywords over the period from May 2016 to May 2017; retrieved from Google Keyword Planner.

Keywords	Search Volume	Factor
Hospicio Cabañas Guadalajara (English)	100-1000	1
Hospicio Cabañas Guadalajara (Spanish)	100-1000	1
Cathedral Guadalajara (English)	100-1000	1
Catedral Guadalajara (Spanish)	1000-10,000	10

Table 2: Results for average monthly search volume for broad keywords over the period from May 2016 to May 2017; retrieved from Google Keyword Planner.

Keywords	Search Volume	Factor
Heritage Guadalajara (English)	10-100	0.1
Patrimonio Guadalajara (Spanish)	10-100	0.1
Heritage Mexico (English)	10-100	0.1
Patrimonio Mexico (Spanish)	10-100	0.1
Heritage (English)	100,000-1,000,000	1000
Patrimonio (Spanish)	10,000-100,000	100

Google Keyword Planner also returns a list of keywords associated with the primary keyword entered. These associated keywords are retrieved in order of relevance alongside monthly search volumes. These keywords can be analysed using word frequency analysis using Wordle.com, (a website that creates word clouds, where font size indicates higher

frequency) to reveal overall associated themes. We found that the associated keywords in Spanish for Hospicio Cabañas were dominated by its identity as a cultural institute and its role in housing the murals of Jose Clemente Orozco (Figure 3). In English, the associated keywords recognised Orozco's mural, but

Figure 3. Wordle diagram of associated keywords from Google Keyword Planner results for 'hospicio cabanas guadalajara' in English.

Figure 4. Wordle diagram of associated keywords from Google Keyword Planner results for 'hospicio cabañas guadalajara' in Spanish.

Figure 5. Wordle diagram of associated keywords from Google Keyword Planner results for 'cathedral guadalajara' in English.

Figure 6. Wordle diagram of associated keywords from Google Keyword Planner results for 'catedral guadalajara' in Spanish.

also included references to other World Heritage sites in Mexico such as the archaeological ruins of Monte Albán, Uxmal and Chichén Itzá (Figure 4). Interpreting these themes, frames Hospicio Cabañas as a significant site of heritage in English, but in Spanish its value is as a cultural institute. In contrast, the associated keywords in Spanish for La Catedral indicated its role in the historic centre of the city, with references to tourism and places of accommodation (Figure 5). In English, La Catedral was clearly associated with Mexico, with the state of Jalisco, and with attractions and places to visit (Figure 6).

The results from Google Keyword Planner are interesting: because while La Catedral has a higher search volume, the associated keywords indicate it is for its value as an urban icon within the historic centre of Guadalajara rather than as a religious space or as a place of heritage significance. In contrast, Hospicio Cabañas, while having a lower search volume, seems to be a significant heritage site for English language audiences. For Spanish language audiences, its value is as a cultural institute and museum. Insight into the longitudinal patterns of the search volumes and their predominant country of origin was gathered using Google Trends (Figure 7).[3] The relationship observed between the prominent position of La Catedral in relation to that of Hospicio Cabañas, is longstanding.[4]

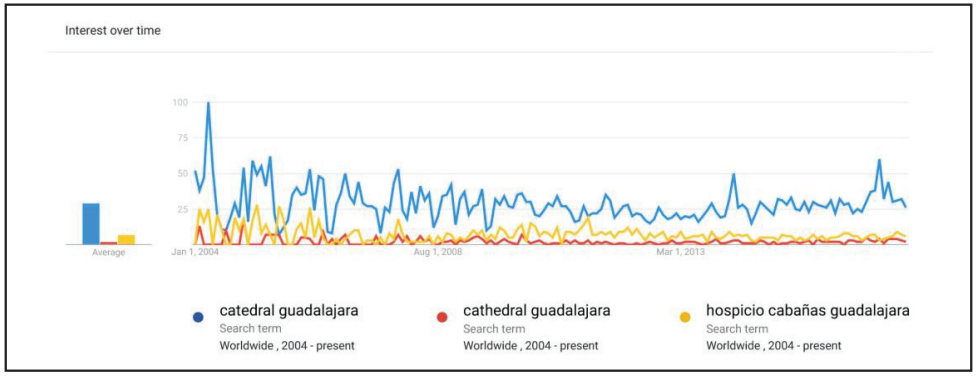

Figure 7. Google Trends graph of keywords in Spanish and English.

Google Trends also reveals that most of the searches for La Catedral originate from Mexico and the USA, reinforcing our observations that this building was more locally significant than Guadalajara's World Heritage site, Hospicio Cabañas.

This longstanding differentiation is significant because both La Catedral and Hospicio Cabañas could be urban icons; they are located less than one kilometre away from each other. The two buildings are part of an urban cruciform arrangement and form an axis from west to east through the historic urban centre of the city. Both have heritage significance, albeit within different contexts and of different levels of significance. The results appear to offer some preliminary confirmation of our observation that La Catedral is an urban icon for Guadalajara that far surpasses the perceived importance of a World Heritage site from a global perspective.

Google Images

Images are one of the most popular types of content being searched for on Google (Smith and Google 2010). Google Images, as the name indicates, retrieves images sourced from websites, social media platforms and archives. Like the standard text based web search, Google Images uses over 200 parameters to rank results within its algorithms (Lee 2016, 197). In 2001 when it launched, the service gave access to the first 250 million images indexed (Google 2014); by 2005 this had increased to 1 billion, and by 2010 it had reached 10 billion (Smith and Google 2010). Like Google Search, keywords is one of the key variables used to index and rank images. Title tags, size, textual richness and the content of the webpage also contribute to Google's ranking (Rose 2016, 301). However, unlike text based searches where the data being indexed is the actual content, with images, the data being indexed is the file name and its alternative text rather than the visual content of the image itself.[5]

The second exploration using Google was through its image search service, Google Images. Searches using the same keywords from the first part of our investigation were carried out. When the keywords

based on the names of the places were used (in English and Spanish), Google Images returned an accurate series of photographs of each site (Figure 8). This confirmed that the keywords used were sufficiently accurate. However, the value of the Google Images search is the ability to use broader search terms that are common to both places based on the intentional association created between the filename and the content of the image. For example, broader searches using the English and Spanish variations of 'heritage guadalajara', 'heritage mexico' and then even

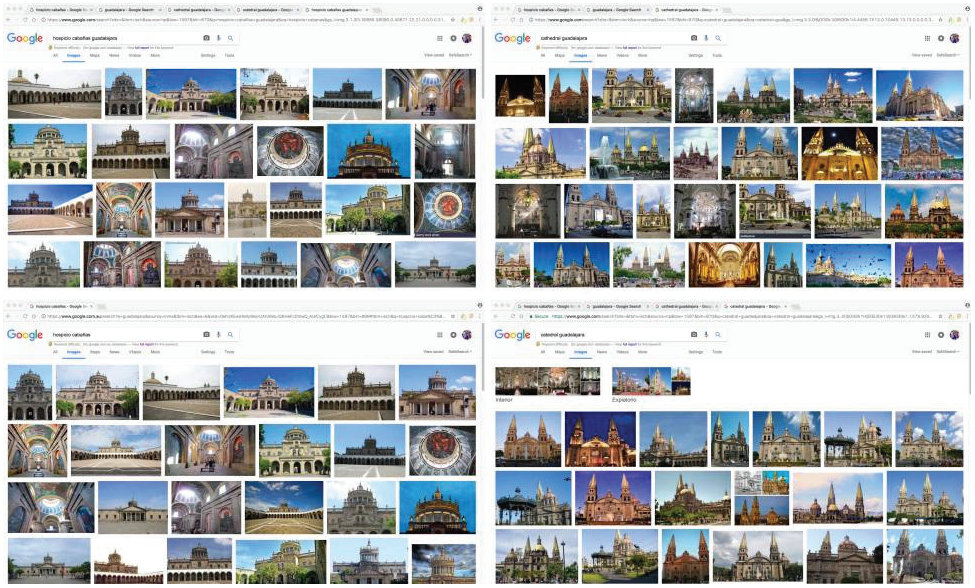

Figure 8. Google Images results for 'hospicio cabanas guadalajara' (English above left and Spanish below left) and 'catedral guadalajara' (English above right and Spanish below right).

more broadly 'guadalajara' can reveal how Hospicio Cabañas and La Catedral rank against each other in terms of the number of times featured and their order of appearance on the page.

Taking the keyword 'heritage' as an example, Google Images' results feature several images of Stonehenge and other 'old' buildings as well as logos containing this word (Figure 9). Notably, no images of modern,

intangible or digital heritage were returned. This reinforces the traditional heritage perspective as 'old, grand, monumental and aesthetically pleasing', and as evidencing part of the 'authorised heritage discourse' (Smith 2006, 11). While these results may simply confirm accepted notions within the field at present, over time such results could track changing perceptions of how heritage is understood.

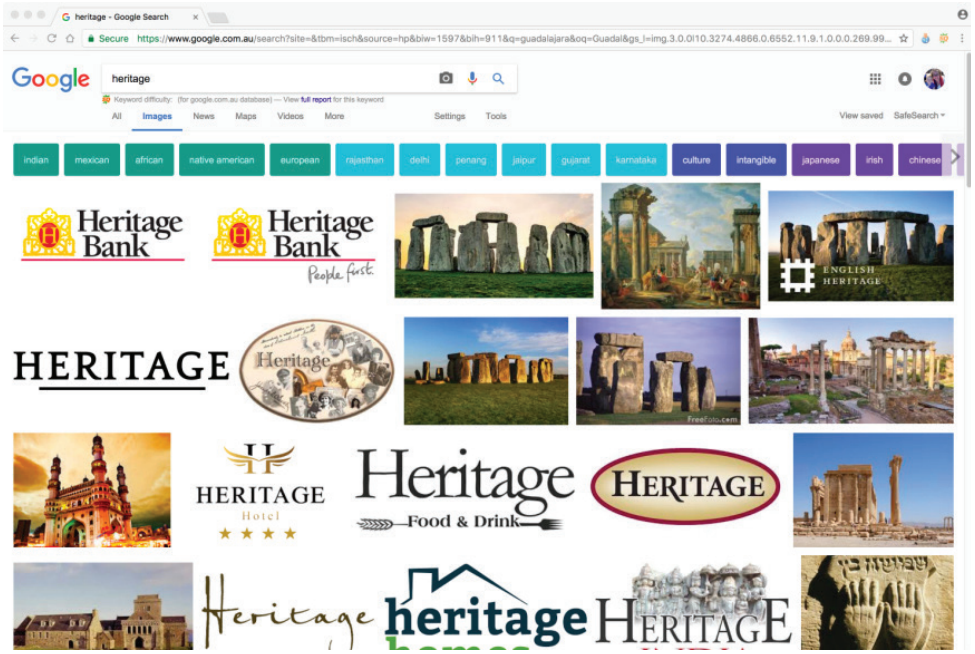

Figure 9. Google Images results for 'heritage' in English.

The Google Image search using the keywords 'heritage guadalajara' returned images of both Hospicio Cabañas and La Catedral, as well as of other local monuments such as the former gate to the city known as Los Arcos (Figure 10). Yet, only Hospicio Cabañas appears in the search for 'patrimonio mexico'; it appears as the twenty-fifth image in the Spanish search, which was dominated by images of several

of Mexico's World Heritage sites (Figure 11). The English search, 'heritage mexico' returned images of archaeological sites, such as Chichén Itzá, traditional costumes, local cuisine and icons of Mexico City. Such results suggest that the term 'patrimonio' in Spanish is more readily associated with World Heritage rather than with national or local examples, and that while both places feature as heritage in relation to Guadalajara, only Hospicio Cabañas is significant at a national or international level, regardless of their actual legal inscriptions.

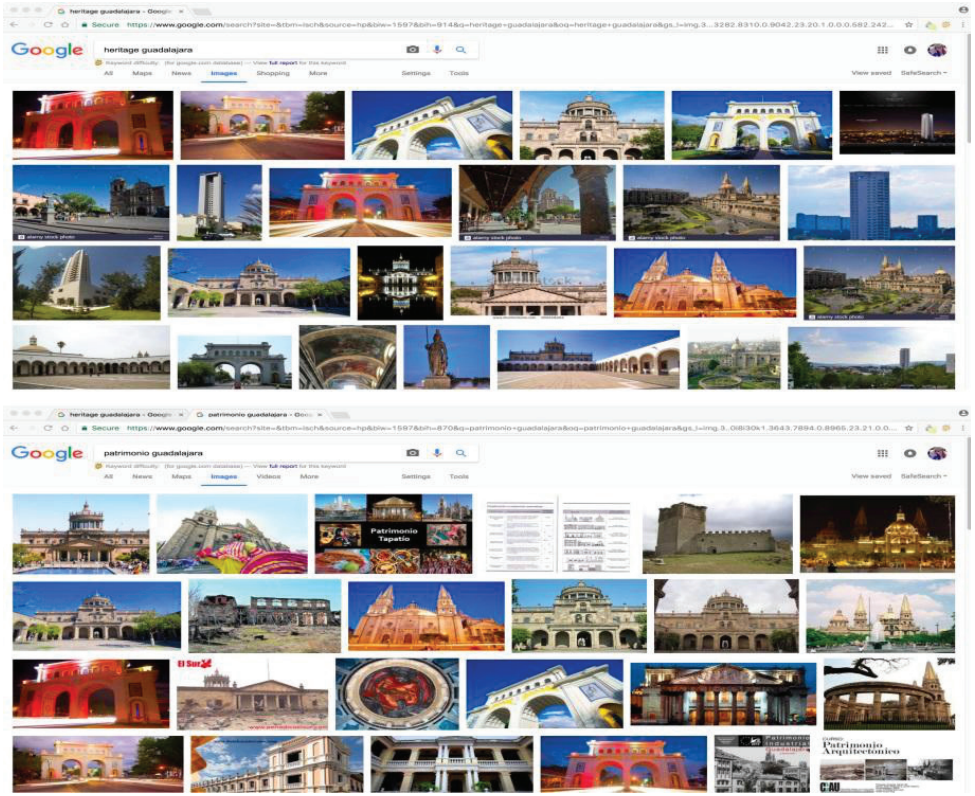

Figure 10. Google Images results for 'heritage guadalajara' in English (above) and 'patrimonio guadalajara' in Spanish (below).

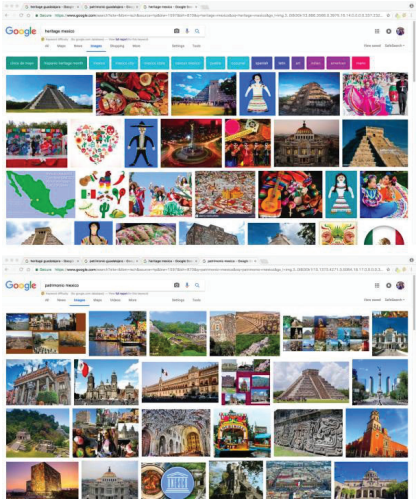

Figure 11. Google Images results for 'heritage mexico' in English (above) and 'patrimonio mexico' in Spanish (below).

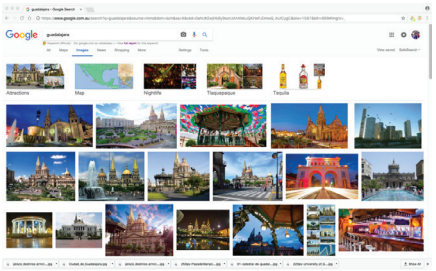

Figure 12. Google Images results for 'guadalajara'.

When we performed one final search, using 'guadalajara', our observations about La Catedral's iconic role in Guadalajara's city-image were also confirmed (Figure 12). The results from the search, like those from the analysis of the associated keywords, indicated that La Catedral is an urban icon for the city; of the images returned, ten of the first eighteen were of La Catedral. In contrast, Hospicio Cabañas appears in eleventh place, just after Los Arcos. These results were dependent on the term 'guadalajara' being present in most of the file names of the images, providing some evidence of the strong association of these buildings with the city (Figure 13).

Discussion on the potential use of Google as a methodology

> The issue no longer is how much of society and culture is online, but rather how to diagnose cultural change and societal conditions by means of the Internet.
>
> (Rogers 2013, 21)

The formal inscription of heritage is not neutral; rather it is now accepted that it is a political and subjective act, situated within a larger social and dynamic cultural processes. Monuments and heritage sites are 'a potent resource for place branding. They accentuate the history of a place, and thus assert the place's uniqueness' (Lai and Ooi 2015, 276). World Heritage inscriptions have also been implicated in economic results associated with place branding such as tourism, city rankings and global status (Kirshenblatt-Gimblett 1998, 2006; Di Giovine 2009; Hall and Piggin 2003). Place branding is connected with place identity and sense of place; it is implicated in the narratives, representations and popular discourses that circulate and draw together citizens and visitors alike (Mayes 2008). In Guadalajara, the inscription of Hospicio Cabañas as a site of World Heritage has not enabled it to contribute greatly to the city's branding at a global level. The local icon of La Catedral is an urban icon and plays this role.

Richard Rogers argues for a more integrated definition of digital methods for research, where methodologies must incorporate both qualitative and quantitative aspects in order to understand the circulation of information online in its fullest sense. Google's search data and tools open up new ways to explore both dimensions. Google also allows for the analysis of visual data; at the same time visual and digitally mediated participation methods for understanding heritage is gaining interest in the field. Waterton and Watson's edited collection *Culture, Heritage and Representation*, positions representations and visuality as significant components of heritage (2010). Giaccardi's *Heritage and Social Media: Understanding Heritage in a Participatory Culture* recognizes participatory forms of communication as evidence of the connection between people and heritage expressed in their everyday experiences (2012). Investigating the interrelationship between people and culturally significant places positions search data and tools as artefacts that actively mediate the past, present and future. It also assumes that such data and tools have social agency as they contribute to, and build upon, their social and cultural use (Giaccardi and Plate 2017). But search data and tools are not separate artefacts. Rogers conceptualises data and images (or any other artefact for that matter) as one element within a system and focuses on the way that internet research can investigate 'digitally native objects and the methods that routinely make use of them' (Rogers 2013, 19). Rogers proposes that digital methods need to take account of the entangled relationship that emerges between the data collected in search engines and media platforms, as well as the content in circulation, the connections (forward and back links) between websites as a socio-cultural technological system. Online images can be studied in terms of their 'circulation' as well as their 'production, content and audiencing', they can exist in multiple places at once, driven by user participation and the set of algorithms (Rose 2016, 35). Search data, tools, social media and other platforms that underpin experiences of the internet can be conceived of as elements within a 'connective eco-system' (van Dijck 2013) where inputs,

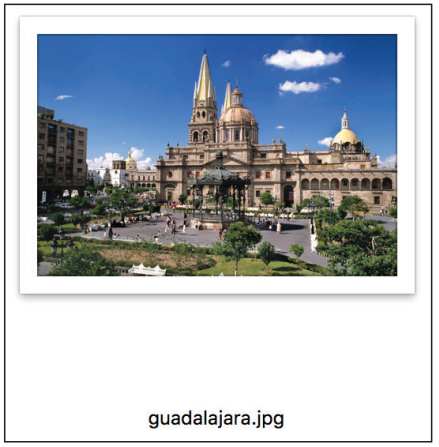

Figure 13. One image from the Google Image search for 'guadalajara' showing how an image of the building has to be associated through its filename.

associations and results are seen as negotiations between people on a mass scale and technological algorithms seeking to understand accurately what we are looking for. Rogers argues that digital methods should embrace the entangled nature of results alongside computational components.

Conclusion

In a world where information is embedded as a cultural phenomenon in our everyday experiences, understanding its implications is crucial. At present, Google is the primary search engine platform. It is simultaneously structuring knowledge through its algorithm as well as being structured by the inputs of society. Google is a real-time representation and a way to track changing perceptions over time. In analysing sites of heritage using Google's free tools, we seek to develop methods that could be adopted by professionals and heritage managers. There are other services in Google's suite which could also add further information: Google Display Planner gives demographic information; Google Maps is a site for digitally mediated experiences. While emergent, further research is needed to comprehend the full potential for heritage of Google's data. Our methodology, explored here, suggests that Google search data and Google Images can evidence broad perceptions and associations, confirm well-grounded observations and therefore enable new ways to compare the social value of a range of heritage places.

Notes

1. For this analysis keyword means one or more words.
2. Google Keywords gives results in broad bands unless there is an advertising campaign running.
3. Note: Google collects data from searches, maps, YouTube and other services unless users block or opt out of this.
4. We acknowledge that the data only goes back as far as 2004.
5. In 2009 Google added a feature to its image search service to browse similar images (Murphy-Chutorian, Rosenberg, and Google 2009). This developed into a new service called Search by Image, rolled out in 2011, which harnesses image recognition technologies and allows users to perform a search by uploading or providing the url of a specific image rather than a keyword (Wright and Google 2011). Interestingly, Search by Image was (apparently) instigated to enable users to take a picture of a famous landmark and access information about it (Wright and Google 2011).

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References

Armstrong, M. "Google Rules The West, Baidu Top In China." https://www.statista.com/chart/5472/google-rules-the-west-baidu-top-in-china/.

Australian Government. 1999. "Environment Protection and Biodiversity Conservation Act 1999."

Byrne, D. 2013. "Love & Loss in the 1960s." *International Journal of Heritage Studies* 19 (6): 596–609. doi: 10.1080/13527258.2012.686446.

Byrne, D., H. Brayshaw, and T. Ireland. 2003. "Social Significance: A Discussion Paper." Sydney, Australia: Research Unit, Cultural Heritage Division, NSW National Parks and Wildlife Service.

Chavez Aguayo, M. A. 2009. "Democratization of Creativity and Cultural Production in Virtual Worlds: A New Challenge for Regulation and Cultural Management." Paper presented at the 3rd European Conference on Game Based Learning, Graz, Austria, 12-13 October 2009.

—. 2016a. "La mediación de los mundos virtuales en la difusión del patrimonio cultural." In *Patrimonio inmaterial, identidad y educación: formar para el porvenir, una visión desde América Latina y el Caribe*, edited by F.J. López Morales and E. Quiroz. Mexico: Instituto Nacional de Antropología e Historia.

—. 2016b. "Una mirada social sobre el concepto de patrimonio cultural y su evolución." In *Gestionar en clave de interculturalidad*, edited by J.L Mariscal Orozco. México: Consejo Nacional para la Cultura y las Artes.

Di Giovine, M. A. 2009. *The Heritage-Scape: UNESCO, World Heritage, and Tourism*, *Things that Move: The Material Worlds of Tourism and Travel (2007)*. Lanham, MD: Lexington Books.

Garduño Freeman, C. 2010. "Photosharing on Flickr: Intangible Heritage and Emergent Publics." *International Journal of Heritage Studies* 16 (4):352-68. doi: 10.1080/13527251003775695.

—. 2013. "Participatory Culture as a Site for the Reception of Architecture: Making a Giant Sydney Opera House Cake." *Architecture Theory Review* 18 (3):325-39. doi: 10.1080/13264826.2013.890008.

—. 2016. "Sydney Opera House on eBay: Enabling Technologies, Community and Social Value." *Historic Environment* 28 (2):44-55.

Giaccardi, E. ed.2012. *Heritage and Social Media: Understanding Heritage in a Participatory Culture*. London: Routledge.

Giaccardi, E., and L. Plate. 2017. "How Memory Comes to Matter: From Social Media to the Internet of Things." In *Things to Remember: Materializing Memories in Art and Popular Culture*, edited by Lázló Munteán, Liedeke Plate and Anneke. Smelik. NY: Routledge.

Google. 2016. "Our history in depth." Accessed January 16 . http://www.google.com/intl/en/about/company/history/.

—. "Google Company." 2016. Accessed January 16.

https://www.google.com/about/company/.

—. "How Search Works: From Algorithms to Answers." 2017. Accessed January 18 https://www.google.com/insidesearch/howsearchworks/thestory/.

Hall, C. Michael, and Rachel Piggin. 2003. "World heritage sites: Managing the brand." In *Managing Visitor Attractions, New Directions*, edited by A. Fyall, B. Garrod and A.Leask, 203–19. Oxford: Butterworth-Heinemann.

Hillis, K., M. Petit, and K. Jarret. 2013. *Google and the Culture of Search*. NY: Routledge.

ICOMOS Australia. 2013. *The Burra Charter: The Australia ICOMOS Charter for Places of Cultural Significance 2013*. Accessed December 31, 2015. http://australia.icomos.org/publications/charters/.

Johnston, C. 1992. *What is Social Value?: A Discussion Paper*. Canberra: Australian Government Publishing Service.

—. 2012. "Swimming Upstream, with Crocodiles: Social Value and the Prevailing Heritage Discourse." Paper presented at the ACT and Region Annual Australian Heritage Partnership Symposium. Valuing Heritage: Advocating for Community Attachment in Planning, Canberra, 28 July.

—. 2016. "Reconociendo el vínculo entre la significación social y las prácticas en torno al patrimonio cultural." *Corima: Revista de Investigación en Gestion Cultural* 2 (2).

Johnston, C., L. Riches, A. McGregor, and K. Buckley. 2003. "Inspirational Landscapes." Canberra, ACT: Australian Heritage Commission.

Kirshenblatt-Gimblett, B. 1998. *Destination Culture: Tourism, Museums, and Heritage*. Berkeley, CA: University of California Press.

—. 2006. "World Heritage and Cultural Economics." In *Museum Frictions: Public Cultures/Global Transformations*, edited by I. Karp, C. A. Kratz, L. Szwaja and T. Ybara-Frausto, 161-202. Durham, NC: Duke University Press.

La Monica, P. R. 2016. "Google is worth more than Apple again." In *CNN Money*.

Lai, S., and C S. Ooi. 2015. "Branded as a World Heritage City: The Politics Afterwards." *Place Branding and Public Diplomacy* 11 (4):276–92.

Lee, N. 2016. *Google It: Total Information Awareness*. NY: Springer.

Lewi, H., D. Nichols, P. Goad, J. Willis, and K. Darian-Smith. 2010. "Making the Modern Community." In *Community: Building Modern Australia*, edited by H. Lewi and D Nichols. Sydney: UNSW Press.

Mayes, R. 2008. "A Place in the Sun: The Politics of Place, Identity and Branding." *Place Branding and Public Diplomacy* 4 (2):124–35.

Mexican Government. 1972. *Ley Federal sobre Monumentos y Zonas Arqueológicos, Artísticos e Históricos*. Accessed October 7, 2017. http://www.diputados.gob.mx/LeyesBiblio/pdf/131_280115.pdf

Murphy-Chutorian, E., C.Rosenberg, and Google. "Similar Images Graduates from Google Labs." Accessed January 18,2017. https://googleblog.blogspot.com.au/2009/10/similar-images-graduates-from-google.html.

Netmarketshare. "Desktop Search Engine Market Share." Accessed May31, 2017. https://www.netmarketshare.com/search-engine-market-share.aspx?qprid=4&qpcustomd=0.

—. "Mobile/Tablet Search Engine Market Share." Accessed May 31, 2017. https://www.netmarketshare.com/search-engine-market-share.aspx?qprid=4&qpcustomd=1.

Rogers, R. 2013. *Digital Methods*. Cambridge, MA: MIT Press.

Rose, G. 2016. *Visual Methodologies: An Introduction to Researching with Visual Materials*. London: Sage.

Rupiah, K. 2016. "How does the Google Image search algorithm work - and is it racist?" In *Mail & Guardian. Africa's Best Read*.

Smith, L. 2006. *Uses of Heritage*. London: Routledge.

Smith, N. and Google. "Ooh! Ahh! Google Images presents a nicer way to surf the visual web." Accessed 18/01/2017. https://googleblog.blogspot.com.au/2010/07/ooh-ahh-google-images-presents-nicer.html.

Sparrow, B., J. Liu, and D.M. Wegner. 2011. "Google Effects on Memory: Cognitive Consequences of Having Information at Our Fingertips." *Science* 333 (August).

Stephens-Davidowitz, S. 2017. *Everybody Lies: Big Data, New Data, and What the Internet Can Tell Us About Who We Really Are*. New York: Harper Collins, Dey Street Books.

UNESCO. 2003. "Convention for the Safeguarding of the Intangible cultural heritage." In *32nd Session: The General Conference of the United Nations Educational, Scientific and Cultural Organization*. Paris.

—. "World Heritage Convention: Strategic Objectives." Accessed May 15,2017. http://whc.unesco.org/en/convention/.

van Dijck, J. 2013. *The Culture of Connectivity: A Critical History of Social Media, Cultural Memory in the Present*. Oxford: Oxford University Press.

Waterton, E. 2010. "The Advent of Digital Technologies and the Idea of Community." *Museum Management and Curatorship* 25 (1):5-11. doi: 10.1080/09647770903529038.

Waterton, E., and S. Watson. 2010. *Culture, Heritage and Representation: Perspectives on Visuality and the Past*. Surrey, England: Ashgate.

Wright, J., and Google. "Search by text, voice or image." Accessed 18/01/2017. https://search.googleblog.com/2011/06/search-by-text-voice-or-image.html.

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Heritage as an asset. How to involve local communities in the protection of cultural heritage

Abstract

The 'Framework Convention on the Value of Cultural Heritage for Society' can be considered a turning point in the role of communities in the protection of Cultural Heritage. It emphasises the value of cultural heritage and its potential for wide use as a resource for sustainable development and quality of life in a permanently evolving society; and it also reinforces social cohesion by fostering a sense of shared responsibility for the places in which people live. Technologies have improved citizens' networks and mobility and offered the possibility of actively engaging communities in public policies from the beginning. Anyway, their use in Cultural Heritage processes has not been widely explored. The paper, built on a handful of critical observations and literature reviews, first looks at several rehabilitation experiences in Spain where community participation has not been taken into account. Another group of international experiences where community participation has been promoted through the use of digital tools based on social networks, suggests that new imaginative solutions can be found. They demonstrate not only how easy it could be to engage communities in safeguarding cultural heritage at risk, but also how disruptive lack of involvement could be. Heritage is definitely more than the sum of recognised objects and has to be approached as a territorial system where the relationship between the physical heritage and human actions constitutes an integral whole. The use of digital tools such as social networks in the case studies presented, made it possible for these projects to obtain wide participation of individuals not active in heritage conservation and not always related with the stakeholders involved. When it is given the opportunity, community engagement is fast and proactive with important payback towards an increased sense of place and a strong sense of belonging, which rebounds on built heritage. Finally these latter experiences offer several key points worth taking into account for similar implementations in other contexts.

Keywords: Cultural heritage; common; community participation; digital heritage

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The rhetoric of reproduction: built heritage in a digital age

Abstract

In recent years, digital heritage has emerged as an important new field of research and practice, with an implicit ambition to record, conserve and even reconstruct culturally significant sites and artefacts threatened by war, climate change, natural disasters, development and neglect. Digital heritage initiatives have been enthusiastically promoted and adopted by government bodies, institutions and philanthropic organisations from around the world. Despite its allure, the application and utility of preserving, managing and reproducing built heritage via digital technology remains largely untested, and carries with it risks that may ultimately undermine the practice altogether. Drawing from recent examples such as the Institute of Digital Archaeology (IDA)'s replica Palmyra Arch, and Factum Arte's facsimile of Tutankhamen's Tomb, this paper identifies some of the particular challenges raised by the physical replication of heritage using digital technologies. Issues such as the quality of reproduction, the motivations for such projects, and unintended outcomes (e.g. neglect, complacency) are considered, as are more philosophical questions such as the revision of history. As such, the paper takes on a critical and provocative future vision of digital heritage technology and its use in replication, by highlighting some of the threats such practices may pose to the very cultural heritage it aims to protect.

Keywords: Digital heritage replication; Palmyra; Tutankhamen

Introduction

The past decade has seen a proliferation of digital heritage organisations and initiatives gaining media coverage and industry acclaim for their efforts. When news cycles are filled with reports of war, unchecked climate change, conflict, and unstable economic systems, the use of digital documentation and reproduction to 'protect' cultural heritage offers a glimmer of hope for increasingly dark times. The fear of slow, incremental loss that propelled heritage conservation over past centuries has evolved into a paralysing mix of desperation and resignation: we are more aware than ever that heritage can—and will—be destroyed more rapidly today by natural and manmade forces, regardless of diplomatic and industry protests to the contrary. Digital documentation and 3D printing technologies have flourished in this anxious atmosphere; the optimistic rhetoric that surrounds these programmes offers reassurance that heritage will be 'saved' for all humankind, present and future. For precisely this reason, digital documentation, archiving and replication have been launched into with altruistic aplomb by government bodies, heritage institutions and philanthropic organisations. However, their application and utility in preserving, protecting or reconstructing built heritage remains largely untested, and carries with it risks that may ultimately undermine the practice altogether.

After a decade or so of activity, it is now possible to reflect on the limitations of this technology and the problems of its accompanying rhetoric. While some critical debates are beginning to grapple with the socio-political issues of gathering digital information (including its ownership, accessibility and control, often by foreign organisations and government bodies) as well as the technical problem of its long-term storage, less attention has been paid to is application. This includes questions regarding the quality, and quantity, of digitally-facilitated reproductions, not to mention the unintended consequences of such practices on the experience, maintenance and protection of our cultural heritage.

Certainly, as the technology that enables increasingly accurate documentation and reproduction has forged ahead, heritage conventions and standards of practice have failed to keep pace. Emerging philosophical questions also warrant greater attention: should the decay and destruction of a heritage site be the final chapter in its story, or are reproductions acceptable in certain circumstances and, if so, which ones? As public criticism of the Institute of Digital Archaeology (IDA)'s Palmyra Arch project has recently demonstrated, some of these issues have begun to surface, revealing a seam of discord within the apparently universal optimism with which digital heritage programmes have been championed. It has also made manifest the gaps that exist between the promotion of digital heritage as a kind of insurance policy for international built heritage, and the practical challenges of attempts at physical reconstruction. This rhetoric will undoubtedly unravel further as applications of digital heritage technologies are expanded.

The issue of rhetoric will be returned to at the end of this paper. First, however, the discussion will take a polemical view on current digital heritage practices, to speculate on several known and potential pitfalls in their application, drawing on the recent efforts of two internationally recognised organisations, IDA and Factum Arte. While the issue of copies and replicas has long been a subject of fascination for historians and conservation practitioners, in this paper we focus specifically on some of the philosophical questions that digital reproduction raises and indeed, that will need to be addressed in the near future. Accordingly, three recent examples of digitally-assisted reproduction by IDA and Factum Arte will be briefly analysed, along with the accompanying rhetoric and public criticisms of these projects. It is our intention to use these examples to raise broader questions about conservation in the digital age (rather than to provide answers). While critical in approach, the paper recognises that the discipline of digital heritage is only at the beginning of a highly ambitious project intended to record and safeguard data for millennia to come. It also acknowledges that many within the industry, including the two subject

organisations of this paper, are involved in ongoing research to advance both technical practices and disciplinary standards. Nevertheless, the relative longevity of IDA and Factum Arte within this young industry has provided some of the first demonstrated applications of developing technology, and hence an opportunity to discuss some of the critical issues at stake in heritage reconstruction. In particular, IDA has attracted mixed reviews for its 'activist' Palmyra Arch 3D printing project and has plans to continue this service in the future, raising practical concerns about quality, but also motivation. Factum Arte, on the other hand, has established a reputation for intricately detailed replications but, in achieving such quality, its work prompts broader philosophical reflection. The respective challenges that each presents is examined below.

To print or not to print: Institute for Digital Archaeology (IDA) and the Palmyra Arch

It is perhaps not surprising that a number of digital heritage organisations are currently focusing their documentation efforts on the conflict-stricken Middle East. IDA, however, has taken the further step of making a physical reconstruction: namely, a one-third-scale replica of Palmyra's Triumphal Arch (Figure 1), which was destroyed by ISIS militants in 2015. Made using digital cutting and printing technology, the replica Arch was displayed in London (Figure 2), New York and Dubai in 2016, and plans for its future installation in Syria have circulated (IDA 2016a & 2016c). While it is likely that we will witness more such reconstructions in coming years, there is little international regulation at present to set the criteria for their quality, quantity or context. Moreover, there is ongoing debate in the heritage sector on the appropriateness of manufacturing reproductions at all, fuelled by conflicting interpretations of international instruments, including the 1964 *Venice Charter* (Stanley-Price 2009, 32). While IDA's high profile project makes an important contribution to this debate, it is the confusion and controversy that has surrounded the reconstruction of the Palmyra

Arch that is of interest to this paper. In particular, the project highlights two interconnected issues: the quality of the replication, and the motive for its undertaking.

Figure 1. Palmyra's Triumphal Arch in 2007. (Source: Jerzy Strzelecki, Wikimedia Creative Commons 3.0).

Founded in 2012 by Roger Michel, IDA has connections with Harvard and Oxford Universities, the Dubai Future Foundation and UNESCO's World Heritage office, amongst others (IDA 2016b), and describes one of its key focuses as 'On-Site Reconstructions'. Despite this, global press coverage of the Palmyra Arch project has revealed much uncertainty about the scope of the project and the materials and processes used. Unable to document the Arch with laser scanning technology, IDA relied instead on a large number of photos to create what it claimed was an 'accurate' digital model of the structure (Leigh 2016, D5), complete with features that would be 'completely indistinguishable

Figure 2. IDA's replica Palmyra Arch in London, 2016. (Source: Garry Knight, Flickr Creative Commons 2.0).

from the original' (Roger Michel, quoted in Jenkins 2016, 31). On its website, IDA describes the Arch as being a one-third-scale reproduction that was 'produced using state-of-the-art 3D technology,' including a 'seven axis mechanical arm which carved the arch out of pure Egyptian marble' (IDA 2016a). It had previously been reported that the Arch would be assembled from 3D printed parts made of powderstone (Dunn 2015). There was also uncertainty over the design and number of arches being replicated: it was first announced that two replicas of the entrance archway of the Temple of Bel would be simultaneously installed in Trafalgar Square and Times

Square, and that smaller replicas might be made for display in museums (Basulto 2016; Richardson 2016). IDA's Director of Technology, Alexy Karenowska, was also quoted explaining that once the data was put online it would be open-access so people could print their own models (Basulto 2016). As of December 2016, this has yet to come to fruition.

Some of the confusion that has surrounded the form and scope of IDA's Palmyra Arch is understandable: the use of new technology on such an ambitious project is bound to involve some trial and error. The project was also carried out in the public eye, and without detailed laser-scan data from the original. Yet, for some, such as Adam Lowe of Factum Arte (a competitor of IDA), these limitations were not enough to justify the Arch's final appearance. In a 2016 'review' of the London installation, Lowe described the replica Arch as being 'a uniform yellowish material and roughly modelled from photographs.' He added later that 'A cursory comparison between the original and the replica confirms that it is an approximate copy and not a facsimile or replica. […T]he copy doesn't match the original in terms of detail, decoration and colour let alone scale' (Lowe 2016). Others were more blunt. Kay Kohlmeyer, an archaeologist familiar with the Arch, asserted that the model looked more like 'a Disney World display' than the original (quoted in Garaev, 2016). Such criticism demonstrates that even for IDA, an organisation with connections to institutions like Harvard and Oxford, one of the major challenges in the 3D printing of heritage is quality. The problem is unnecessarily exacerbated when paired with rhetoric that encourages an expectation that the outcome will be accurate, authentic or, as Michel claimed of the Arch, 'completely indistinguishable from the original' (quoted in Jenkins 2016, 31). Though such goals are admirable, the reproduction Palmyra Arch and its criticisms highlight the need for more clear and measured rhetoric in relation to the current possibilities and limitations of replication.

IDA's motivations for the project have also been brought under some scrutiny. When first announced, the reproduction of the Arch was promoted as a 'call

to action' (Dunn 2015), intended 'to draw international attention to the global crisis surrounding the looting and despoliation of cultural heritage objects and architecture' (Lidguard 2015). IDA's Michel claimed, 'We are saying to them if you destroy something we can rebuild it again. The symbolic value of these sites is enormous, we are restoring dignity to people' (quoted in Dunn 2015). Some applauded the defiant, activist nature of the Arch project: Boris Johnson, then Lord Mayor of London, championed the replication as giving 'two fingers to Daesh' (quoted in Clammer 2016). Other commentators were less convinced of the purpose and efficacy of the Arch. Archaeologist Tim Schadla-Hall remarked: 'It seems to me it's a bizarre expenditure of money, possibly with worthy but misinformed aims, to promote something which isn't a real past, in an entirely reproduced form' (quoted in Richardson 2016). By contrast, the potential of the project to detract attention from Syria's humanitarian crisis was central to Joseph Willits' critique: 'I cannot help but feel this project plays a role in cementing the idea that Syria's monuments and heritage are far more important than its people' (quoted in Taylor 2016).

Collectively, these criticisms point to a bigger issue: that digital documentation and replication may be used, or at least be seen to be used, for any number of personal, political, institutional or financial gains, all the while obscuring other more important issues. And if, as Lowe and Kohlmeyer have alleged, the replica Arch was significantly different from the original, what purpose does this replica serve in promoting an inaccurate and incorrectly scaled image of the lost structure to international audiences? While the Arch project has successfully brought attention to the destruction of built heritage in Syria, it has yet to achieve tangible outcomes like heritage site protection or humanitarian assistance for the Syrian people. Moreover, ongoing conflict has so far prevented IDA from installing the Arch near Palmyra as promised (Richardson 2016); and as Emma Cunliffe (2016) has noted, there is conjecture as to whether any reproductions should be allowed at Palmyra at all. What is certain is that the project has succeeded in publicising the products and services of IDA, an

outcome that Michel openly acknowledged when he suggested that the Arch would be 'proof of [IDA's] competency to do these things' (Richardson 2016). This leaves the Institute, and indeed any other organisations that engage in similarly high-profile reproductions, vulnerable to the perception of ulterior motives behind such altruistic, activist endeavours.

Blurring the boundaries between fake and real: Factum Arte, The Wedding at Cana and Tutankhamen's Tomb

These debates over issues of quality and motivation for reproduction are not easily settled. Certainly, with regard to the former, it is not simply a matter of waiting for enhanced technical capacities—quality will often be constrained by available skills, materials, time and cost, requiring judgements to be made on the necessary verisimilitude of a given reproduction, and its similarity to an original artefact. Besides, copies with an exceptionally high degree of accuracy are already achievable—albeit at a price—and open up a further suite of difficult questions concerning the authenticity of people's experiences in the presence of such replicas, as well as issues of complacency and neglect in heritage conservation. Acknowledging that these are deeply philosophical and largely hypothetical questions, here the paper shifts focus to ground the final part of the discussion in two examples of 3D replication undertaken by Factum Arte (and its partner Factum Foundation) in an effort to explore these concerns. The replicas—a copy of Paolo Veronese's painting *The Wedding at Cana* (1563, replica installed 2007) and a facsimile of Tutankhamen's Tomb (c. 1323 BCE, replica installed 2014)—have been generally well-received by heritage professionals and commentators and, interestingly, both exist simultaneously with the original works.

Factum Arte was formed in the early 2000s under the direction of Adam Lowe (Factum Arte 2016a), while its not-for-profit sister organisation, Factum Foundation, was founded in 2009 (Factum Foundation 2016a). Factum Arte undertakes commercial commissions and charitable projects, with much of

the funding for the latter coming from the coffers of its Foundation and public donations (Factum Arte 2016d; Factum Foundation 2016e). Like IDA, Factum Arte has collaborated with a range of heritage organisations and authorities including the British Museum, Musée du Louvre and the government of Egypt (Factum Arte 2016a); its services include software and hardware design, documentation using laser scanning and photogrammetry, reproduction (3D printing and casting) and installation (Factum Arte 2016c). The replications of *The Wedding at Cana* and Tutankhamen's Tomb were some of the organisation's earliest projects; more recent work includes the Theban Necropolis Preservation Initiative in Egypt and the Cross-River Monoliths Project in Nigeria (Factum Foundation 2016c).

Originally displayed in a monastery on the island of San Giorgio Maggiore in Venice, *The Wedding at Cana* was looted by Napoleon's army in the late eighteenth century and taken to Paris. It is now one of the Louvre's many prized attractions. With the Louvre's permission, Factum Arte began digitally documenting Paolo Veronese's almost 70 square metre painting (Figure 3) in late 2006 (Factum Arte 2016b). In 2007 an intricately detailed replica was printed and installed back in the artwork's original position in the Venetian monastery (Caliari 2016). The result, at least in the eyes of the commissioning foundation's director, Pasquale Gagliardi, was a replica with 'all the lines, colour gradations, and even the flaws and signs of wear of the original canvas' (quoted in Owen 2007, 49). As with IDA's Palmyra Arch project, *The Wedding at Cana* replica was not without its critics, but in this case the concerns raised were largely of a philosophical nature. In a piece for the *New York Times*, Povoledo (2007, B7) opened with the question, 'Can – and should – technology right a historical wrong?' Cesare De Michelis, of the University of Padua, suggested such work was 'devastating and "immoral" if it claims to substitute the original, just like cloning human life' (quoted in Povoledo 2007, B7). Lowe's response to these concerns was to argue that the work was 'not a clone but a deep and detailed study' (quoted in Povoledo 2007, B7)—a view shared by art critic Corriere della Sera who described the replica as 'a turning point in art' (quoted in Jobey 2013, 30).

While Factum Arte's success with *The Wedding at Cana* replica may be applauded, its criticisms should not be dismissed. And, even though the subject in discussion here is a painting, these criticisms reveal some of the challenges for digital heritage replication more generally. Perhaps the most difficult question is whether the placement of a replica in its original context following theft, damage or destruction, effectively erases or corrects complex political, social and cultural histories. At the very least, we should consider whether the replacement of works like *The Wedding at Cana* obscure these important parts of the object's own story. Additionally, the act of duplication places two (or more) iterations of the same artefact in opposition to one another: why bother visiting an original in the wrong context when a high-quality replica in the 'right' context can provide a more

Figure 3. Paolo Veronese's The Wedding at Cana on display in the Louvre, 2014. (Source: Nathanael Burton, Wikimedia Creative Commons 2.0).

fulfilling experience? Factum Arte's Lowe claimed that when *The Wedding at Cana* replica was unveiled, 'about 30 per cent of the people there just burst into tears. Here were a lot of cultured people who knew their history, who knew what they were looking at, and who felt a strong emotional reaction at something which they knew to be a copy' (quoted in Aspden 2014). And what, might it be asked, would happen to this highly effective replica if the Louvre eventually returned the original artwork to the Venetian monastery? Would the replica, which has itself become an emotionally charged and historically significant cultural artefact—a new original in its own right—be forgotten or destroyed? As 3D heritage replication expands, we must be mindful that this technology has the potential to instigate multiple histories of a single heritage structure or artefact. These histories may even compete with, and contradict, one another until, as Umberto Eco once imagined, notions of 'real' and 'fake' are effectively meaningless (1998, 7).

These are not the only philosophical conundrums unearthed by 3D heritage replication. Factum Arte's 1:1 scale replica of Tutankhamen's Tomb, installed in Luxor near the original (Figure 4) in 2014 (Factum Foundation 2016b), highlights some of the ethical problems that can arise from well-intentioned and highly accurate reproductions. The project was initiated in 2009 with the support of the Egyptian authorities, the University of Basel, and the Friends of the Royal Tombs of Egypt organisation (Factum Foundation 2016d). It was completed in 2011, but conflict in Egypt delayed the installation for three years (Factum Foundation 2016b & 2016d). While the project has since been expanded to include replications of other tombs nearby (Factum Foundation 2016f), the initial focus on Tutankhamen's Tomb was triggered by a growing consensus that it would need to be closed permanently in the near future: temperature and humidity variations caused by large groups of visitors, as well as high levels of atmospheric dust, air-borne pollutants and micro-organisms generated by the tomb's daily exposure, have led to the worrying separation of the plaster from the tomb surface (Factum Foundation 2016f).

Figure 4. The original Tomb of Tutankhamen, Egypt, 2007. (Source: Nasser Nouri, Flikr Creative Commons 2.0).

The existing global profile of Tutankhamen's Tomb may explain some of the publicity that Factum Arte's replica attracted when it was announced and then installed. Commentators have noted that the original Tomb will remain open for the foreseeable future, albeit with short visiting times enforced, while the highly-detailed replica nearby charges a lower admission and allows visitors to spend much longer in the Tomb space (Kingsley 2013, p. 23; Aspden 2014). This raises an interesting question for tourists: enter the 'real' tomb, but in doing so be a contributing factor in its decline? Or visit the 'fake' tomb, a replica that some have suggested is so convincing people may not be able to discern its 'real' age (Aspden 2014; Burrell 2014, 14)? What is most powerful about this situation

is that the moral decision on preservation rests with the tourists themselves—the replica tomb thereby forces a very personal confrontation with the broader conservation dilemmas commonly faced by heritage authorities and governments.

Another curious aspect of this situation is that the replica represents the Tomb as it was in 2009—a very different state to that on its discovery in 1922. Doubtless it will also wear and evolve differently to the original, and we must therefore consider whether its existence might inadvertently change or skew people's perceptions of the 'real' Tomb over time. Indeed, it seems unlikely that such replicas will be allowed to age at all. Instead, they can be more aggressively cleaned and repaired than any original, effectively freezing the experience of the artefact in time. A further concern in the case of the replica of Tutankhamen's Tomb is whether there is any need, or desire, to maintain conservation and repairs to the original once it closes to visitors. Without wanting to detract from the highly effective and undoubtedly useful replica created by Factum Arte, it nevertheless occasions the discussion of a potential flaw in the rhetoric of digital heritage practice: the very act of documenting and replicating, carried out in the name of heritage protection, may one day provide the excuse needed for some governments and authorities to neglect the original artefact. Worse still, for other sites, a digital backup may itself be deemed an adequate substitute that permits passive or wilful destruction of cultural objects that are expensive or simply inconvenient to maintain.

Discussion and conclusion

As 3D heritage replication progresses and its use inevitably grows, we must be mindful that it has the potential to instigate a wide range of problems, some of which are new to the heritage sector, and others that are new iterations of old or ongoing debates. In this discussion, attention has been drawn to just a few of the most pressing issues: the need to regulate digital heritage replication practices; the risk that heritage replications might be poorly executed or used for ulterior motives; and the potentially negative consequences that even the most well-meaning and high-quality digital replication projects might incur. Some of these challenges will undoubtedly be addressed by the digital heritage sector in the short- and medium-term, while others may be harder to resolve.

Additionally, the paper has argued that over the technology's short history, the general public has been encouraged to see it as a sophisticated solution to an otherwise dangerous or costly problem. This attitude has been reinforced by magnanimous yet vague rhetoric expressed by industry leaders and organisations (doubtless with good intentions) and has been further hyped by simplistic or sensationalised press coverage. These are not processes that can 'save' or 'protect' built heritage, in any of the most basic senses of these words. While it is tempting to dismiss this as pedantry, when the press reports that digital heritage technology will 'save Syria's history from ISIS' (Greenberg 2015), facilitate Palmyra's 'rise' or 'rebuilding' from the rubble (Coghlan 2016; Jenkins 2016, 31), or 'defeat the wreckers' who engage in heritage terrorism (Macintyre 2016), it is arguable that a large portion of the public, as well as those in government making decisions on heritage matters, will take such claims at face value. In reality, digital technology can record, store and help us to interpret massive amounts of data, and we can use this data to make reproductions or inform decisions about conservation. This technology will not prevent vandalism or destruction, however, nor can it halt climate change or dissuade tourists who desperately want to experience the real thing. A 3D scan or physical replica, no matter how detailed, is not the same as—nor is it equivalent or adequate to—the heritage site or structure that it represents, and it is misleading to encourage a belief to the contrary. It is also deceptive, therefore, to foster a sense of boundless optimism and confidence in the existing systems, as this may only lead to complacency, adding to the risk of neglect faced by so much of our built heritage.

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This technology is also in its infancy and, while it is making great leaps and bounds, many aspects of its practice still need development. It is not unreasonable, therefore, to suggest that an industry-wide convention or regulatory body is necessary to oversee, standardise and stabilise the booming digital heritage sector. An added level of governance may also address the need for more caution and transparency. The *Venice Charter* (1964) has proven inadequate to address the nuances of digital heritage practice, and the scope of the *Nara Document on Authenticity* (1994) is broad to the point of ambiguity. The *London Charter for the Computer-Based Visualisation of Cultural Heritage* (Version 2.1; London Charter 2009) may offer some provisions but does not fully encompass physical replication. These instruments of international heritage rely on governments and heritage agencies to ratify and enforce their content at the national level and, even then, they only operate as 'best practice' guidelines rather than legally-binding acts. In this vacuum, it falls to heritage practitioners, digital technology professionals and academics to engage in critical, theoretical dialogue that can inform global standards.

In a similar light, it is important that the efforts of organisations like IDA and Factum Arte be recognised and encouraged, as it is through such pioneering projects and experimentation that our understanding of the challenges and limitations of digital heritage technology and its application can strengthen and grow. Indeed, in order to answer many of the questions posed in this paper, it will be necessary for more of these types of projects to take place, for mistakes to be made, and errors addressed. Certainly, the expansion of the digital heritage sector needs to be accepted and supported by policy writers and academics, and, in return, the industry needs to acknowledge the long-term benefits to be gained from open engagement with critical issues such as those identified here.

References

Aspden, P. 2014. "Fit for a King: Tutankhamen's Replica Burial Chamber." *Financial Times (Online)*, April 17. https://www.ft.com/content/2613b3e2-c5df-11e3-a7d4-00144feabdc0.

Basulto, D. 2016. "How 3D Printers Can Help Undo the Destruction of ISIS." *Washington Post*, January 7. https://www.washingtonpost.com/news/innovations/wp/2016/01/07/how-3d-printers-can-help-undo-the-destruction-of-isis/?utm_term=.a9d4aed2359c.

Burrell, I. 2014. "New Tomb for Tutankhamen Emerges From 3D Printer." *Independent (London)*, May 1, 14.

Caliari, P. 2016. "Returning 'Les Noces de Cana' and Some Issues Concerning Repatriation and Originality." *Factum Arte*. http://www.factum-arte.com/pag/537/Returning--quot-Les-Noces-de--span-Cana--span--quot--by-Paolo-Caliari.

Clammer, P. 2016. "Erasing ISIS: How 3D Technology Now Lets Us Copy and Rebuild Entire Cities." *Guardian (London)*, June 1. https://www.theguardian.com/cities/2016/may/27/isis-palmyra-3d-technology-copy-rebuild-city-venice-biennale.

Coghlan, T. 2016. "Palmyra Could Rise Again From Rubble." *Times (London)*, 17 May. http://www.thetimes.co.uk/article/tc-palmyra-tdwt2lrh2.

Cunliffe, E. 2016. "Should we 3D Print a New Palmyra?" *The Conversation*, March 31, https://theconversation.com/should-we-3d-print-a-new-palmyra-57014.

Dunn, J. 2015. "Ancient Arch of Palmyra Which was Destroyed by ISIS Will be Recreated in Trafalgar Square and Times Square Using the World's Largest Printer." *Daily Mail (London)*, December 28. http://www.dailymail.co.uk/news/article-3376093/Ancient-arch-Palmyra-site-destroyed-Isis-recreated-Trafalgar-Square-world-s-largest-3D-printer-call-action.html.

Eco, U. 1998. *Faith in Fakes: Travels in Hyperreality*. London: Vintage.

Factum Arte. 2016a. "Art." *Factum Arte*. http://www.factum-arte.com/ind/4/Art.

--- ---. 2016b. "A Facsimile of the Wedding at Cana by Paolo Veronese." *Factum Arte*. http://www.factum-arte.com/pag/38/A-facsimile-of-the-Wedding-at-Cana-by-Paolo-Veronese.

--- ---. 2016c. "Technology." *Factum Arte*. http://www.factum-arte.com/ind/1/Technology.

--- ---. 2016d. "What is Factum Arte?" *Factum Arte*. http://www.factum-arte.com/aboutus.

Factum Foundation. 2016a. "About Us." *Factum Foundation*. http://www.factumfoundation.org/pag/198/About-us.

--- ---. 2016b. "Installation in Luxor." *Factum Foundation*. http://www.factumfoundation.org/pag/226/Installation-in-Luxor.

--- ---. 2016c. "Projects." *Factum Foundation*. http://www.factumfoundation.org/ind/38/Projects.

--- ---. 2016d. "Recording the Tomb." *Factum Foundation*. http://www.factumfoundation.org/pag/207/Recording-the-Tomb.

--- ---. 2016e. "Support the Foundation." *Factum Foundation*. http://www.factumfoundation.org/giving.

--- ---. 2016f. "The Theban Necropolis Preservation Initiative Summary." *Factum Foundation*. http://www.factumfoundation.org/pag/238/The-Theban-Necropolis-Preservation-Initiative-Summary.

Garaev, P. 2016. "3D Imaging Won't Save Syrian Cultural Heritage." *I24 News*, October 16. http://www.i24news.tv/en/news/international/middle-east/127765-161015-3d-imaging-won-t-save-syrian-cultural-heritage.

Greenberg, A. 2015. "A Jailed Activist's 3-D Models Could Save Syria's History From ISIS." *Wired*, 21 October. https://www.wired.com/2015/10/jailed-activist-bassel-khartabil-3d-models-could-save-syrian-history-from-isis/.

IDA (Institute of Digital Archaeology). 2016a. "Building the Arch." *Institute for Digital Archaeology*. http://digitalarchaeology.org.uk/building-the-arch/.

--- ---. 2016b. "Partners." *Institute for Digital Archaeology*. http://digitalarchaeology.org.uk/partners/.

--- ---. 2016c. "Triumphal Arch." *Institute for Digital Archaeology*. http://digitalarchaeology.org.uk/building-the-arch/.

Jenkins, S. 2016. "After Palmyra, the Message to ISIS: What You Destroy, We Will Rebuild." *Guardian (London)*, May 27: 31.

Jobey, L. 2013. "Remaking History: Art – Conservation." *Financial Times (London)*, July 27, 30.

Kingsley, P. 2013. "Tut-Tut… Replica of Pharaoh's Tomb Hailed a Landmark in Conservation." *Guardian (London)*, October 4, 23.

Leigh, K. 2016. "Hope for Palmyra's Future." *Wall Street Journal*, April 5: D5.

Lidguard, C. J. 2015. "Syrian Monument to be Recreated in London in Defiant Gesture Against ISIS." *Express (London)*, December 30. http://www.express.co.uk/travel/articles/630065/A-Syrian-monument-to-be-recreated-in-London-in-defiant-gesture-against-ISIS.

London Charter. 2009. *The London Charter for the Computer-Based Visualisation of Cultural Heritage (Version 2.1)*. http://www.londoncharter.org.

Lowe, A. 2016. "IDA Palmyra Arch Copy." *Factum Foundation*. http://www.factumfoundation.org/pag/236/Reports.

Macintyre, B. 2016. "Technology Can Defeat the Wreckers of ISIS." *Times (London)*, March 18. http://www.thetimes.co.uk/tto/opinion/columnists/article4715942.ece.

Owen, R. 2007. "Digital Miracle Restores Water and Wine Masterpiece to Monastery." *Times (London)*, September 15, 49.

Povoledo, E. 2007. "A Painting Comes Home (Or At Least a Facsimile)." *New York Times*, September 29, B7.

Richardson, N. 2016. "The Arch of Triumph of Palmyra is Recreated in London – 1,800 Years After It Was Built." *Telegraph (London)*, April 19. http://www.telegraph.co.uk/news/2016/04/08/why-the-arch-of-triumph-of-palmyra-is-being-recreated-in-london/.

Stanley-Price, N. 2009. "The Reconstruction of Ruins: Principles and Practice." In *Conservation: Principles, Dilemmas and Uncomfortable Truths*, edited by A. Richmond and A. Bracker, 32-46. London: Elsevier.

Taylor, A. 2016. "The Problem with Rebuilding a Palmyra Ruin Destroyed by ISIS – Does it Simply Help Assad?" *Washington Post*, April 20. https://www.washingtonpost.com/news/worldviews/wp/2016/04/20/the-problem-with-rebuilding-a-roman-ruin-destroyed-by-isis-does-it-simply-help-assad/?utm_term=.dec0c1626ff0.

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Revitalising Ethiopia's Africa Hall: using new digital technologies in heritage practice to conserve Africa's heritage

Abstract

Africa Hall is highly significant to Ethiopia, the African Union member states (52 countries) and the UN as the founding building for the UN in Africa. It played a key role during the formation of the African Union and the UN mission, which oversaw the decolonisation of Africa. A modernist architectural work (1958-1961), designed by Italian Architect Arturo Mezzedimi, it was built to be a symbol for contemporary Africa moving forward. The building is now in dire need of upgrade to remain relevant and functional. In 2014 Conrad Gargett was commissioned to lead a multidisciplinary project team. The mandate of the project was to renovate and upgrade Africa Hall's facilities to achieve modern conference standards and provide a UN visitor centre for the public and conference delegates. The project's scope included conservation works, major upgrades to conference functionality, along with technology-rich interpretative displays and experiences presenting the building's place and its role in African history to visitors. Conrad Gargett used multiple emergent digital technologies, including 3D laser scanning to generate a point cloud and video recordings, to record the building and site. The 3D BIM drafting software and presentation software were used to produce existing drawings, then design and document the project. With the project in Africa, the client and project team in four continents, various contemporary technologies enabled day-to-day communication. This paper critically examines the challenges and opportunities experienced by Conrad Gargett's team applying emergent digital technologies in heritage practice - using Africa Hall as a case study, a major heritage conservation project in Addis Ababa, Ethiopia for the United Nations (UN). Throughout this remote project's development, the team adapted to use multiple emergent technologies and with agility they upskilled quickly. This paper posits that projects such as this offer a chance to close the inventor-practitioner gap.

Keywords: Africa Hall; Arturo Mezzedimi; Conrad Gargett; digital technologies; heritage practice; modern architecture.

Introduction

This paper critically examines the challenges and opportunities experienced by Conrad Gargett's architectural team applying emergent digital technologies in heritage practice - using Africa Hall, a major heritage conservation project in Addis Ababa, Ethiopia for the United Nations (UN)[1] as a practice case study. The multiple emerging and evolving technology platforms used during this project have required education and commitment from the client, user groups and wider consultant team to develop a shared understanding of the benefits to the project, ahead of each technology's application and use. The Conrad Gargett team's adaption to multiple emergent technology use and their agility to upskill quickly, became both a necessity and an opportunity for what can arguably be described as a 'risky venture' due to the project's remote location, high profile and complexity.[2]

During the project, Conrad Gargett used Zebedee 3D laser scanning to generate a point cloud and GoPro video recordings to record the building and site. 3D BIM (building information modelling software – Autodesk Revit) drafting software and presentation software (Lumion 3d fly-throughs) were used to produce existing drawings, then design and document the project. With the project in Africa, the client and project team in four continents,[3] video conferencing (client lead technology) and information management software (Newforma) have enabled day-to-day communication.

Drawing from the research undertaken by the project team, reviewing the documentation produced, and interviewing project team members - this paper shares the team's experiences, highlights opportunities, identifies the current challenges of these emergent and evolving digital technologies to demonstrate how this high profile, remote project afforded Conrad Gargett the ability to close the inventor-practitioner gap.[4] The paper is divided into five parts: the first two sections briefly describe Africa Hall's cultural heritage significance and the project Conrad Gargett has been commissioned for. The latter three sections will critically examine the use of technology to record the existing building, to document the proposed project and lastly to facilitate the team's communication.

Africa Hall's history

Africa Hall (Figure 1, 3 & 4) is highly significant to Ethiopia, the African Union member states (55 countries) and the UN as the founding building for the UN in Africa, a place that assumed a key role in the forming of the African Union and the UN mission, and saw the decolonisation of Africa. A modernist architectural work (1958-1961), designed by Italian Architect Arturo Mezzedimi (1922-2010),[5] it was built to be a symbol of contemporary Africa moving forward. As a venue for the African Union (the first African Parliament Building), Africa Hall's design facilitates international, political, economic

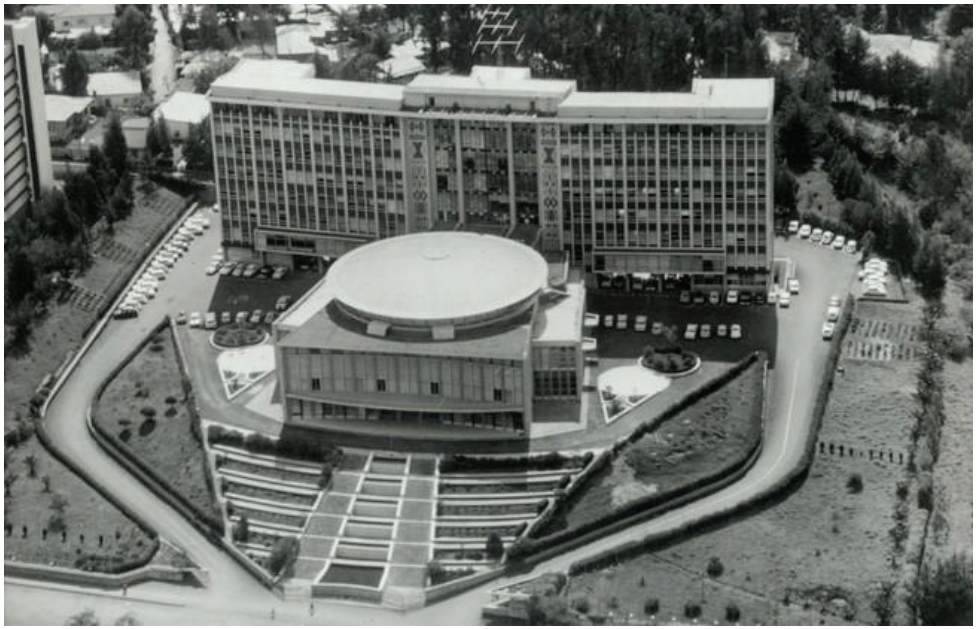

Figure 1. Africa Hall and the Office Building soon after completion. (Source: UNECA collection).

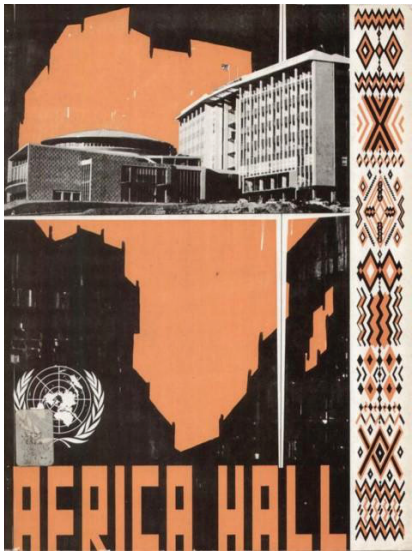

Figure 2. Front cover Commemorative booklet, 1961. (Source: UNECA collection).

and social conferences; public meetings; permanent and temporary exhibitions; and is the permanent headquarters of United Nations Economic Commission for Africa (UNECA).

UNECA was established by the Economic and Social Council (ECOSOC) of the UN in 1958. Its mandate is to promote the economic and social development of its member states, foster intra-regional integration, and promote international cooperation for Africa's development. Following the choice of Addis Ababa as the headquarters of the newly created UNECA, Ethiopia's (then) Emperor Haile Selassie 'ordered the construction of a modern and imposing building' not only to accommodate UNECA, but also to provide a 'venue for future African and international conferences' (Commemorative booklet, 1961, 58). Formally opened on 6 February 1961, the Africa Hall complex was constructed as a gift from the Ethiopian Government to UNECA (Commemorative booklet, 1961 – Figure 2).

As one of the Emperor's favourite architects (Ayala 2016), Mezzedimi planned that the project be based on the 'modernity of functional and aesthetic conceptions, with a parallel attempt to give character', (Commemorative booklet, 1961, 16) and 'symbolic representation, with the inclusion of formal elements, of the willingness of Africa Hall to receive new ideas and all peoples' (Commemorative booklet, 1961, 16). The choice of site and the location of the buildings

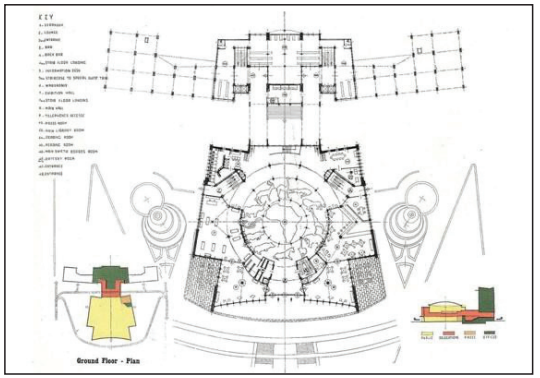

Figure 3. Drawing for the ground floor reproduced in the Commemorative booklet 1960s (Source: UNECA collection).

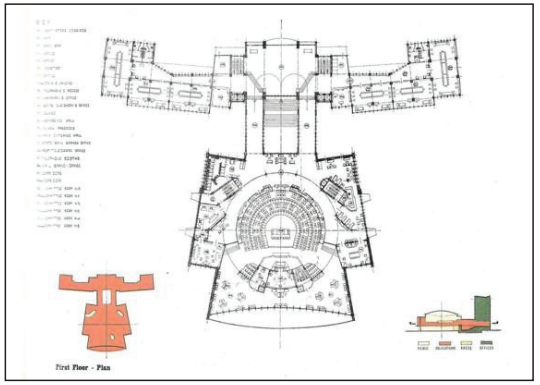

Figure 4. Drawings for the first floor reproduced in the Commemorative booklet 1960s (Source: UNECA collection).

on the site were key components in establishing the symbolic importance of the building, providing the landscape atmosphere Mezzedimi sought (Commemorative booklet 1961, 17). Unfortunately, Africa Hall is now in dire need of conservation and upgrade to remain relevant and usable.

To mark its fiftieth anniversary, UNECA, in collaboration with the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the African Union Commission (AUC), launched the current project to renovate Africa Hall in recognition of its role as a 'monument to modern African history' (UN General Assembly resolution 65/259 2011).

Seeking to conserve and revitalise history

The mandate of the current project is to renovate and upgrade the facilities to achieve modern conference standards and a UN visitor centre for the public and conference delegates. The project's scope includes building fabric conservation and repair works, and both renovation and major upgrades to the conference facilities. The proposed project for Africa Hall – for it to continue functioning as a UN conference venue (and public conference venue) and as a major visitor centre utilising contemporary digital media

– will ensure its on-going use as a highly functional conference venue, able to tell the story of the place, and maintain links with the wider UN community (CGRAMW 2014). Without the proposed works, the building risks becoming too out-dated (with aging building/conference technologies) to continue to fulfil its intended function (Gole 2016).

The renovated and upgraded conferencing facilities will include: new conferencing fitout and infrastructure; new security infrastructure (as expected for a building used by heads of state and

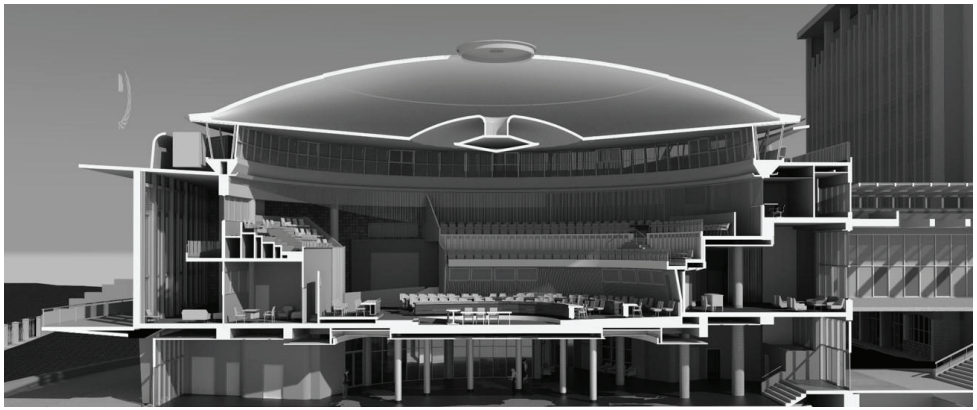

Figure 5. Perspective Section - Proposed BIM Model B & W Render (Source: CGAMW 2017).

diplomats); new digital displays for conference programmes and information; new interpretive elements throughout the building; new audio and video displays for visitors highlighting key and defining moments in the life of the building; and a new permanent exhibition using a range of media (including technology-rich interpretative displays and experiences) to present the place and its role in African History (CGRAMW 2014).

To ensure international best practice conservation methodology is undertaken, the project team has employed UNESCO and ICOMOS international protocols, including the ICOMOS Burra Charter. The

project team produced a Conservation Management Plan, measured drawings, and undertook a condition survey, to inform the design and construction documentation (Figure 5). However, different from its work in past projects, the team has utilised multiple emergent technologies as tools to do so.

Creating the dots: using emergent technology to record the existent

Given the organic form and size of the building and its surrounding site, the complexity of the project was well recognised from the outset. Furthermore, the global nature of this project meant that the time the architects could spend onsite measuring (and the ability to return to the site frequently to 'fill in' gaps in the measurements) was limited. The use of emergent digital technology was thus seen as a necessity by Conrad Gargett to achieve a time-effective means of collecting accurate data for Africa Hall's measured drawings.

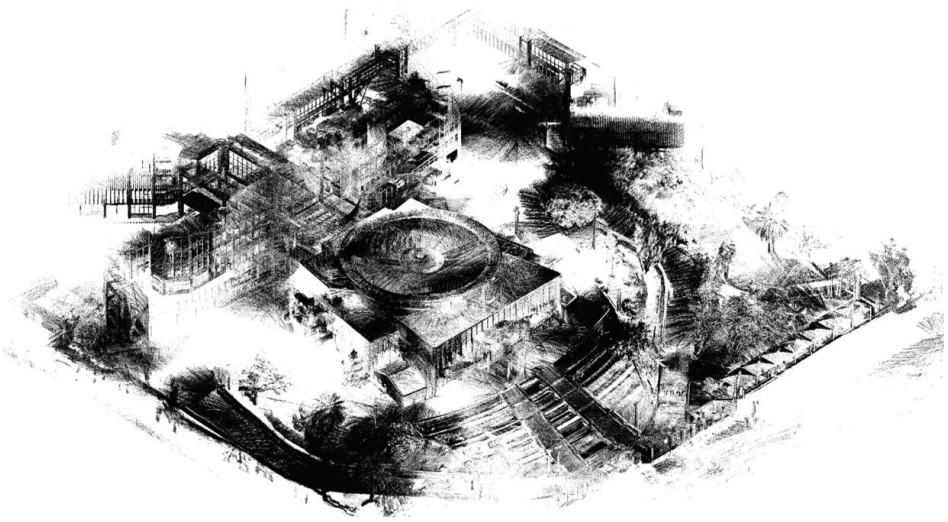

Figure 6. External Isometric–Point cloud of merged scans (Source: Conrad Gargett 2016).

Handheld 3D laser scanning equipment (Zebedee Zeb1) was used to generate a point cloud digital model of the existing buildings and site (Figure 6 & 7).[6] The scanner achieved highly efficient data capture, which meant that less checking and re-checking was required later on. The flow-on effect of early accurate information provided reassurance that the cascade of human measuring errors would not be an issue. GoPro video recordings provided at-desk vision to the design and drafting team, and enabled the whole team to 'walk through the building' remotely and as needed, expediting the whole team's detailed understanding

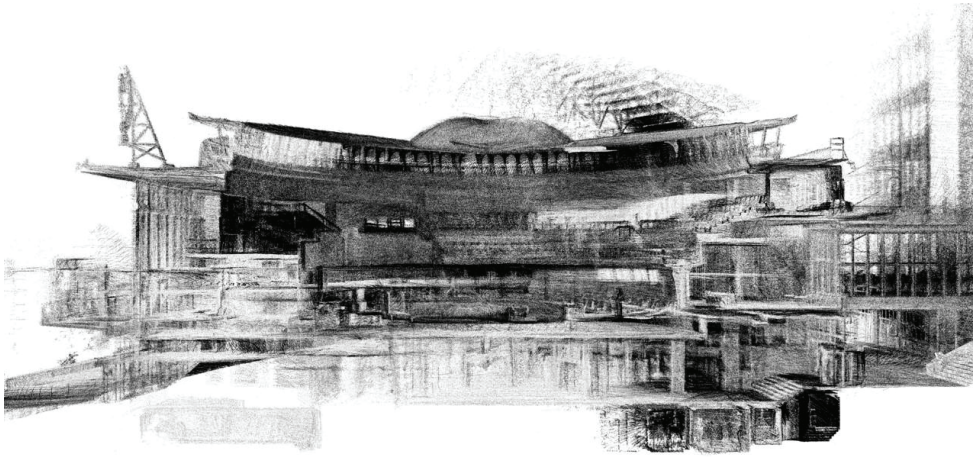

Figure 7. Perspective Section – Point cloud of merged scans (Source: Conrad Gargett 2016).

of the building[7] – a significant improvement when compared to the use of still photographic shots, which were commonplace before (Gole 2016). Because it was a complex geometric building, the combination of hand held technologies enabled the team to create 3D BIM record drawings efficiently, with greater accuracy, and to incorporate increased detail, compared with the less technology-rich project deliveries of past heritage projects.[8] The geographic reach of heritage projects that Conrad Gargett can now take on has expanded with the adoption of these new technologies.

The Zebedee scanner enabled access into areas of this building previously not recordable (heights, confined spaces) including voids, ducts and risers.[9] No ladders or scaffolding were needed. The point cloud achieved accuracy of +/- 10mm,[10] suiting 1:50 scale drawings and was considered reliable when used up to a maximum of 15 metres from scanner to building element. Hand measures were completed for detailed and significant joinery to be conserved and/or altered in the project's scope (Boundy 2016).

A 30-minute tutorial and then some practice was all the training that is required prior to using a Zebedee scanner for project work. However, being a hand-held device, it is pertinent that time is invested to map out the walking route and to think through level transitions, extent of single scan, inform building security, advise all occupants onsite on the day(s) and ensure that all doors are open in advance.[11] The person scanning then needs to be mindful of how they move and their extent of movement to ensure the required detail is obtained. 'It is interesting to watch Simon walk as he scans – there is a Zebedee walk.' (Gole 2016) When interviewed for this paper, Simon described his walk:

> You need to walk slow and deliberately, oscillate the scanner with your wrist, walk backward through door openings…corrupts if you are too fast. The scanner triangulates as you move around, so walking straight can lead to dimension errors. I have found walking in closed loops enables the software to correct itself and remove running errors. Putting an object in a featureless space, a plain corridor, provides a reference object for the scanner to triangulate.
> (Boundy 2016)[12]

Further learnings to date, from this project and others, include: the need to occasionally scan a space two or three times and then merge these scans together to have enough dots to draft from; to be mindful of reflective/mirrored surfaces that the laser cannot map; to take more scans than perceived to be needed[13] (Boundy 2016). Other hand-held technologies used onsite furthered the paperless, straight-into-

Figure 8. Main conference space – As built. (Source: Commemorative booklet 1960s. UNECA collection).

Figure 9. Main conference space – Photo (Source: Conrad Gargett 2014).

technology approach taken by the team. 'Punch lists' (Newforma) using iPads created the draft condition survey. Then there were the unexpected surprises of working overseas, which for this project included: the Zebedee scanner's cord almost being confiscated by Dubai airport security, as they initially perceived it could be used as an on-flight strangulation weapon (Gole 2016). However, 'it feels like early days still with the Zebedee . . . but the inventor feedback loop is refining this' (Gole 2016). Direct feedback from the Zebedee inventors to the team is that they are working on building a GoPro into the Zebedee (Blake, Boundy 2016). The use of the Zebedee and GoPro for Africa Hall might even suggest the team themselves became 'inventors' in the way they combined emergent technologies.

Connecting the dots: technology to design and document

The point cloud is a sea of dots, which needs to be interpolated into building elements to create a 3D BIM model, which in turn generates the architectural drawing set. Knowledge of the building's materiality (Figure 8 & 9) coupled with construction experience is required.[14] However, with this knowledge the dots can be deciphered and traced, a significantly faster task than interpreting hand-scribed site measures.[15] Africa Hall was initially modelled (in Revit) from original drawings[16] and AutoCAD as-built 2D facilities management drawings, then after site scanning of the model was adjusted to the point cloud data.[17] The point cloud data was referenced into the Revit file. Dots were changed to a series of colours to show planes and to identify the data from individual scans, to assist interpretation (Figure 9 & 10). The 'tracing' was largely done using 2D model views. GoPro video recording was concurrently viewed, greatly aiding interpretation of the dots (Boundy & Blake 2016).

The use of point cloud and video technologies significantly reduced the numbers of errors and discrepancies encountered in past projects, including: onsite measure errors and rounding errors, identification of out of plumb and out of square walls (and other building elements), varying wall thicknesses, uneven floor levels, ceiling height variations and void variations, differences between sourced reference drawings by others and the built building (to list just a few examples).[18] Without the point cloud, some measurements are invariably missed, leading to subsequent site visits being required. Reducing these project risks, has the potential to shift inherent project delivery complexities which can frustrate heritage conservation, renovation and adaption projects. The increased ability to identify idiosyncrasies of the construction early on – discrepancies between the as-drawn and the as-built – has, for this project, mitigated some of the issues that might have (previously) arisen when recording a building constructed in the mid-twentieth century in Africa[19] (Boundy, Blake & Pendergast 2016).

3D BIM was utilised as the drafting software from the onset of the project, firstly to create the record drawings for the existent Africa Hall. It was then used to develop design strategies in 3D for approaches to the use of space, furniture arrangements and strategies for upgrades for fire and equitable access.[20] It was also used to develop strategies in 3D for the integration of new services – in particular the modelling for new mixed-mode mechanical ventilation systems.[21] Once design development was completed with the broader consultant team, 3D BIM drafting software was used to produce the tender and construction documentation as 2D drawings and detailed schedules.[22] Engineering consultants documented the project and tested their design utilising 3D modelling software.[23]

The use of 3D BIM is now an industry standard for new buildings and many heritage conservation projects led by medium to large Australian architectural practices.[24] Where this project's delivery has varied from standard practice is in the use of emergent technology onsite - testing these technologies' commercial benefits for 'everyday' architectural and heritage conservation practice.[25] The point cloud and the video recording

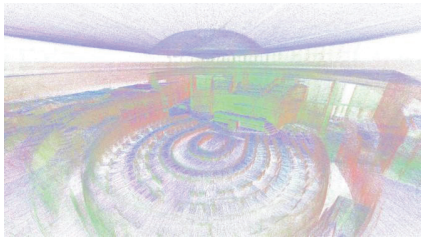

Figure 10. Main conference space – Point cloud of merged scans (Source: Conrad Gargett 2016).

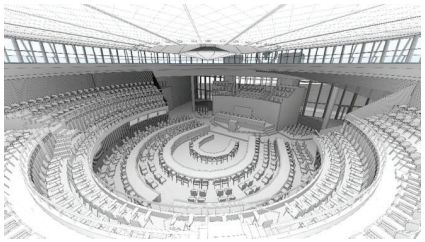

Figure 11. Main conference space – BIM Model perspective view existent space (Source: Conrad Gargett 2016).

records of the existing building have continued to be used almost on a daily basis for the documentation of Africa Hall, providing a readily available reference, resulting in highly accurate documentation, beyond that previously achievable (Gole, Pendergast, Blake & Boundy 2016). With construction scheduled from 2017, it is envisaged that point cloud and the video recordings will be referenced relatively frequently as construction progresses, with further video taken as the works progress (Pendergast 2016).

Technology rich communication for a global project

The emergent digital technology used for this project not only gave the Conrad Gargett team the tools and confidence to do the project, but it is believed they significantly contributed to achieving and maintaining client confidence. The multiple technologies used have required the education and commitment of the architectural team, client groups and the wider consultant team to develop a shared understanding of the benefits to the project ahead of each technology's use. Time upfront was spent by the architectural team leaders explaining what and how technology could be used, how each would help the team and client, and both time and cost implications[26] (Gole 2016).

Day-to-day communication was aided by the use of technology, not emergent technologies, but tried, tested and known to be the best software available of their type. The video conferencing (client lead technology) enabled the client and consultants to get to know each other quickly and easily, compared to what would have otherwise been limited, in-person meetings or meetings with reduced team representation. The client's software choice has enabled greater connectivity than software generally utilised for other Conrad Gargett projects (Gole 2016). Newforma provided a live database for the whole of the team. This technology tracks all correspondence (incoming and outgoing, with automated tracking, thereby avoiding labour intensive transmittals); transfers large file packages of information to the global team;[27] tracks changes or mark-ups, task assignments, requests for information and 'punch lists'/defects lists (Boundy, Pendergast & Blake 2016).

Lumion software was used to prepare 3D fly-through design presentations initially to the core client stakeholders, highlighting the key aspects of the building upgrade and it was also used to secure funding approval from the UN General Assembly. A 3-minute presentation enabled all client stakeholders to understand the project quickly, surpassing 2D presentation formats of past projects.[28] The use of 3D presentation software was considered to be the most compelling way to illustrate a complex project and is believed to have been fundamental to the project's receiving full funding with approval from UN member states (Gole 2016). The presentation was prepared as a single video using fly-throughs of the 3D BIM model combined with sourced early imagery, recent photos and embedded pop-up text to explain the design intent; an architect from Conrad Gargett was not needed to personally present the video, as the text succinctly explained what would have been relayed in person [view video at https://www.youtube.com/watch?time_continue=2&v=clZHiGByEbI]. Lumion is an easy to use and relatively fast 'real time rendering' presentation software package, run by a gaming engine, linked to Revit.[29] The retained link to Revit enables all design updates to be readily viewed in the presentation without the need to re-work the presentation, which is common to other software packages. The graphics are not photorealistic or glammed-up,[30] but this suited the project and still enabled an accessible and considered presentation to the clients, imparting the details of the changes proposed and how these changes were going to be done in a sensitive and sympathetic way (Gole, Pendergast & Blake 2016).

Conclusion

To conclude each interview, we asked the Conrad Gargett heritage team what might be the future for documenting renovation and adaptive-reuse projects.[31] This interview question elicited a return question from interviewees: 'Is there a way of making

2D documentation even easier and quicker for others to read? Maybe the future is documentation by video... using video and point cloud in combination and lessening reliance on the 2D' (Gole 2016). Imagine using video technology to communicate through all project stages - from site recording, design, documentation, construction, visitor interruptive displays and then facilities management – we are currently at three out of six.

Hearing the Conrad Gargett project team share their experiences, it is apparent they hope this project will provide inspiration for the conservation and adaptive re-use of other notable modernist architectural buildings within Australia and abroad. It is with this aspiration, and the team's focus on both best practice heritage conservation methodology and progressive technologies, that they chose to upskill and take up the challenge of using emergent and evolving digital technologies for Africa Hall. The project's remote location and high-profile client, beckoned the use of these emergent digital technologies to reduce a variety of risks (some too often perceived as inherent to heritage conservation projects) and to ensure the confidence of the client was captured, maintained and rewarded.

The project's unique set of circumstances allowed the inventor-practitioner gap to be closed. Conrad Gargett cleverly combined different technologies to work remotely and work on a complex building varying from the original architect's drawings. Through this paper it is hoped the experiences shared might give those developing scanning/drafting/ facilities management technologies increased understanding of what is required in contemporary heritage practice, and might offer ideas for how the digital world can further improve the work process from start to end.

Notes

1. This paper has been prepared as a practice case study. Theoretical case studies and literature reviews of other papers discussing the use of scanning in academic and architectural practice have not been covered in detail. Publication alongside the other *digital cultural heritage: FUTURE VISIONS* papers provides some theoretical context for this paper.
2. 'Remote location' defined as remote to Conrad Gargett in Brisbane.
3. Client facilities management and consultants in Addis Ababa, Ethiopia; Client (leads and funding) in New York, USA; Conrad Gargett and consultants in Brisbane, Sydney and Perth, Australia; and consultants in Valence, France.
4. For this paper, 'gap' is defined as the lag time from invention to use in everyday practice.
5. Mezzedimi was to undertake numerous projects in Addis Ababa, other parts of Ethiopia and in neighbouring Eritrea (Mezzedimi 1992), while working with Emperor Haile Selassie (1892-1975) for approximately 23 years (Magada 2016). 1624 buildings are attributed to this working relationship, with Africa Hall a highlight. (Albrecht, Galli 2014).
6. Zebedee Zeb1 was shown to Conrad Gargett's heritage team by CSIRO and UQ late 2013. Conrad Gargett then hired (from 3d Laser Mapping Rental) a Zebedee, project by project, for about 18 months, before purchasing in 2016 (from Geoslam) after frequent use and the desire to have it on hand to use at short notice (Blake 2016).
7. Conrad Gargett purchased a GoPro in 2013. Africa Hall was the first project it was used for. (Blake, Gole 2016). Long battery life, wide angle, media type, file size, equipment size and cost to achieve a 'good enough' quality made this type of video equipment more suited to project work then older technology video recorders (Boundy, Blake 2016). Videos were taken during the onsite work (including condition survey work and walk throughs, attached on-architect), not as a separate task. Videos were taken in shorter takes, to enable filing by individual spaces etc., making it easier to find later (Pendergast 2016).
8. For this project (13,800m^2 useable floor area) one architect took 6 days onsite to scan. Each scan was transferred to the Brisbane office overnight for back-up and for a Brisbane team member to check the files. Ethiopian internet speed (limited broadband

width) and dropouts did slow this down, unfortunately necessitating regular checking during the night to ensure the connection was still working. Corrupted scans were redone within the same 6 days. This timeframe was tight for the project's size. Prior site measures by Conrad Gargett (and formerly Riddel Architecture) were done using a point to point laser device (Leica) plans annotated/drawn onsite by hand and still photography taken. For Africa Hall the low-tech approach is estimated at 2 staff members for several weeks, plus time to recheck and collect missing measurements (Boundy 2016).

9. Africa Hall has an accessible/walkable roof.

10 It is understood that a fixed scanner is +/- 1mm. This was observed by the team when a fixed scanner was used for a 2011 project.

11. 15 minutes is needed at the beginning of each day to plan walking routes. It then took approximately half the time of a scan to pre-walk the route, opening doors, advising occupants (a third of the time on site).

12. It is understood that the next version needs less human movement – the operator does not have to use their wrists to oscillate the scanner. Objects were placed every 5-metres in featureless corridors (Boundy 2016).

13 The current user interface is limited to 3 LED lights (red, green and yellow) and data needs to be uploaded post-scan to obtain point cloud data, so it is not clear if the data has been corrupted until data is returned. Currently done through the scanner's supplier (Geoslam), as part of their ongoing customer service. This has also been a beneficial feedback loop. Software has recently been made available to do this in house. The ability to see the quality of scan data while scanning would be a welcomed future improvement to the user interface.

14 The construction knowledge and experience of the architect/technician is still important -to know what the dots might represent–for example, to recognise dots as a skirting and draw as a Revit wall sweep–and cannot be replaced by the point cloud.

15 Hard to estimate, as a greater level of details was drawn, but 10 percent faster is thought to be the time improvement (Blake, Boundy 2016). The Revit model took approximately 4 weeks to draw (Boundy 2017)

16 Sourced records include an extensive drawing collection (architectural, structural and service drawings) held by UNECA. A commemorative booklet published by the Ministry of Information of the Imperial Ethiopian Government provides a valuable record of the building including detailed descriptions, drawings, photographs and testimonials (Commemorative booklet, 1961).

17 A detail and contour survey was commissioned and was needed as it picked up information not duplicated by the point cloud (e.g. n ground services).

18. Assumptions that had been made from the original drawings included: column sizes, wall thicknesses and beam locations – the point cloud enabled these to be accurately and quickly picked up and the 3D BIM modelling adjusted.

19. Varying local construction methods, consultant and trade contractor skill base, compared to what the team is more familiar with in Australian buildings.

20. Level of detail 200. (Blake 2016) The consulting engineers model their own existing and new works in line with them, taking responsibility for their own discipline's scope (Gole 2016).

21. Navisworks was used by the team for clash detection and as a design checker/improver (Blake, Boundy 2016).

22. All 2D design and documentation drawings present information contained in the 3D BIM model. The 3D model was used by the Quantity Surveyor The architectural specification was prepared using separate word processing software. Fabric conservation/repair documentation is still largely dependent on 2D drafting.

23. For example, the mechanical engineers tested air flows and the electrical engineers tested lighting levels using 3D modelling - presenting these as 3D imagery in their design reports.

24. Riddel Architecture (merged with Conrad Gargett late 2012) have used this software for heritage conservation and adaptive re-use projects from 2006. The first documented project with the consultants modelling in 3D BIM software was completed by the office in 2009-2010, with the first built project documented with this software completed in 2012 (Boundy, Blake 2016).

25. Conrad Gargett is aware of others using point clouds to record sites, lasers from fixed stations, drones and robots to record the current status of listed sites, and archaeologists using point clouds to forensically investigate change. The team is aware of smaller practices using the consultancy service of the UQ School of Architecture, to obtain point cloud surveys and of

one other local (Brisbane) architectural practice offering point cloud scans as an in-house service.

26. Actual time spent was similar to that for past projects.
27. Postage took up to 8 weeks for one of the mailed documents (Pendergast 2016). Conrad Gargett is one of a number of larger Australian architectural now using this software.
28. A lot of non-construction industry people do not understand 2D drawings and for those that do, significantly more time (than 3-minutes) is typically needed to explain equivalent design content and obtain approval for complex projects with multiple client stakeholders (Gole 2016).
29. Lumion was first used by Conrad Gargett in 2012 (Blake 2016). 'Real time rendering' refers to the retained link to the Revit BIM 3D model. Lumion outputs stills, movie and panorama.
30. Not marketing imagery quality typically now used for selling real-estate or in design completion entries. Lumion does not have shadows and lighting effects, but Conrad Gargett can do all production in-house (Pendergast, Blake 2016).
31. L. Daunt interviewing Blake, Boundy, Gole & Pendergast. Conrad Gargett is currently testing: iPhone Google cardboard to create virtual reality; Oculus to show local clients their project as virtually walk throughs; and a 360-degree camera (Boundy 2016). "Quick and Dirty" design work can be (and is being) done from a point cloud, but this is limited (to concept or preliminary master-planning studies). For costing, coordination with engineers and to enable architectural documentation, a 3D BIM measured drawing set of the existing building is needed (Gole 2016).

References

Albrecht, B. and J. Galli. 2014. "African Modernities." Text from the catalogue of the exhibition *Africa Big Change - Big Chance, Triennale di Milano, 2* https://www.academia.edu/8820024/African_Modernitites

Arturo Mezzedimi Architectetto.Accessed May, 2014. http://www.arturomezzedimi.it/en/home.htm

Australia ICOMOS. 2013. *The Burra Charter: The Australia ICOMOS Charter for Places of Cultural Significance.* http://australia.icomos.org/wp-content/uploads/The-Burra-Charter-2013-Adopted-31.10.2013.pdf

Blake, L. 2016. Interview of L Blake, interview by L. Daunt, November 17, at Conrad Gargett's Brisbane office.

Boundy, S. 2016. Interview of S Boundy, interview by L. Daunt, November 14, at Conrad Gargett's Brisbane office.

Cantone, H. 2016. "Italy-Africa: A Contradictory Inventory of Modernity." *'The Africa-Italy Connection' Critical Interventions, Journal of African Art History and Visual Culture.* 10 (1). http://www.tandfonline.com/doi/full/10.1080/19301944.2016.1180921

Conrad Gargett Riddel Ancher Mortlock Woolley (unpublished) Prepared for The United Nations Economic Commission for Africa: 2014. *Africa Hall refurbishment: Return Brief;* 2014. *Africa Hall: Condition Report*; 2014. *Africa Hall: Concept Design Report*; 2014. *Africa Hall: Conservation Management Strategy; Africa Hall: Developed Design Report.*

CSIRO, 2016. http://www.csiro.au/en/Research/D61/Areas/Robotics-and-autonomous-systems/Sensing-and-mapping-our-environment/Zebedee Accessed October 28, 2016.

Gole, D. 2016. Interview of David Gole, interview by L.Daunt, November 15, transcript, at Conrad Gargett's Brisbane office.

Gole, D, L. Pendergast, and S. Boundy. 2016. interviewed as a group by L. Daunt, November 11, at Conrad Gargett's Brisbane office.

Kerr, J S. 2013.*The Conservation Plan: a guide to the preparation of conservation plans for the places of European cultural significance.* 7th edition. Australia ICOMOS. http://australia.icomos.org/publications/the-conservation-plan/

Levin, A. 2016. "Haile Selassie's Imperial Modernity: Expatriate Architects and the Shaping of Addis Ababa." *Journal of the Society of Architectural Historians* 75, no. 4: 447–468.

Magda, D. 2016. "A Modern Capital in the Making: The 1960s architectural legacy of Addis Ababa." *Selamta: The Magazine of Ethiopian Airlines.* Jan-Feb. http://www.selamtamagazine.com/stories/a-modern-capital-in-the-making

Marquis-Kyle, P. and M. Walker. 2004. *The Illustrated Burra Charter, Good Practice for Heritage Places.* Australia ICOMOS Ltd.

Mezzedimi, A. 1992. *Hailé Selassié: a testimony for reappraisal.* Rome. April. http://www.arturomezzedimi.it/en/pubblicazione_pdf.pdf

"Modern Africa Tropical Architecture". (2013/1). *Docomomo Journal* 48

"Modern Heritage in Africa". (2003/1). *Docomomo Journal* 38

Pendergast, L.2016. Interview of L Pendergast, interviewed by L. Daunt, 11 November , at Conrad Gargett's Brisbane office.

UNECA Commemorative booklet. 1961. *Africa Hall, Addis Ababa.* 1960s. The Ministry of Information of the Imperial Ethiopian Government.

UNECA Commemorative booklet. 2013. *Celebrating Success: Africa's voice over 50 years (1963-2013).*

UN ECOSOC. 1978. *The twenty-first anniversary of the Economic Commission for Africa.* 1 September.

UNESCO. 1972. *Convention concerning the Protection of the World Cultural and Natural Heritage.* http://portal.unesco.org/en/ev.php-URL_ID=13055&URL_DO=DO_TOPIC&URL_SECTION=201.html

UNESCO. 1972. *The General Conference of the United Nations Educational, Scientific and Cultural Organization meeting in Paris from 17 October to 21 November 1972, at its seventeenth session*; adopted 16 November 1972 (ratified by Ethiopia in 1977).

UNESCO. 2011. *Recommendation on the Historic Urban Landscape, including a glossary of definitions.*10 November. http://portal.unesco.org/en/ev.php-URL_ID=48857&URL_ DO=DO_TOPIC&URL_SECTION=201.html

United Nations, Economic Commission of Africa. 2016. www.uneca.org/

World Heritage Convention UNESCO. 2016. ". http://whc.unesco.org/en/criteria

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Practical applications of digital technologies in the conservation, management and education fields by Scotland's national heritage body

Abstract

As early adopters, Historic Environment Scotland continue to pioneer practical applications of digital technologies in conservation management and education. Applications for educational purposes are illustrated via Scotland's new building conservation centre for research and education, and in estate management. An innovative digital national asset management system is outlined.

Keywords: Laser scanning; asset management; conservation; condition monitoring; HES-SIGMA; engine shed; BIM

Introduction

Historic Scotland, the predecessor body to Historic Environment Scotland, showed early interest in the use of digital documentation for cultural heritage. Ben Kacyra *et al* submitted a patent for a laser scanner in 1999[1] and the field quickly developed for industrial applications. The original driver of and intent for the technology, was to capture as-built information in the petrochemical, power and manufacturing industries by using lasers to measure triangulated measured points at rapid intervals to create a 'cloud of points'. This cloud of points provided a line of sight measurement approach to surfaces providing millions of measured points in rapid time compared to traditional survey approaches. In addition to providing spatial information in terms of an XYZ co-ordinate, the laser scanner also provided information on the reflectance value of the surface being measured, which showed some promise in the differentiation of materials.

Figure 1. Pictish carved stones captured with 0.5um using a Leica T Scanner. (Source: courtesy of CDDV).

The cultural heritage sector quickly realised the benefits of a documentation system which could provide highly accurate spatial information. In Scotland, the technology was applied to the documentation of carved stones of the early Christian period, particularly those of Pictish origin (Figure 1). A centuries old tradition of drawn and photographic survey had started to move towards a new era. Early systems around 2000 and 2003 were slow in data capture and could be difficult to use, but the principal challenge was in data manipulation because of the lack of bespoke software, large file sizes and data compatibility with other industry software. Some of these challenges continue today to some extent, but both hardware and software have progressed significantly.

Historic Scotland purchased its first laser scanner in 2003. It subsequently entered into a research partnership with the Digital Design Studio at the Glasgow School of Art in 2005 who had developed expertise in digital modelling and had an interest in using laser scanning and other data capture technologies. Ben Kacyra established CyArk, a US non-profit to promote digital technologies for culture heritage after he saw the destruction of the Buddhas of Bamyan in Afghanistan in 2001. CyArk identified Scotland as a leader in the application of such technology to cultural heritage purposes and established a close relationship. Historic Scotland formed an innovative commercial partnership between the two public bodies to maximise the benefits to Scotland and the Centre for Digital Documentation and Visualisation (CDDV) was created in 2008. This LLP has delivered a wide range of domestic and international projects since inception (Wilson *et al.* 2013).

Cultural diplomacy

In 2008, the Minister for Culture in the Scottish Government agreed that Scotland would digitally document Scotland's five World Heritage Sites to contribute to the digital archive that CyArk were creating, and that a further five international sites would be delivered for the purposes of cultural diplomacy and for extending opportunities for Scotland to develop its expertise further. The project was titled the Scottish Ten, delivered by Historic Scotland, Glasgow School of Art and CyArk. In Scotland, Edinburgh, New Lanark, Neolithic Orkney and the island of St Kilda were digitised by using airborne liar, terrestrial laser scanning and sub-millimetre hand scanning datasets combined with digital photogrammetry (Wilson *et al.* 2011). Mount Rushmore in the United States, Rani Ki Vav Stepwell in India, the Eastern Qing Tombs in China, the Sydney Opera House in Australia and the large cantilever cranes in Japan were documented in partnership with local heritage bodies to encourage technology transfer (Wilson *et al.* 2011). The designation of the Forth Bridge as Scotland's sixth World Heritage Site in 2015 prompted this too to be laser scanned, to date the largest and most complex project of its kind and completed late 2016.

In 2010, the First Minister of Scotland announced that Scotland would deliver the Rae Project, digitally documenting all the historic assets in State Care, comprising 345 of Scotland's most important places.

Figure 2: Forth Bridge point cloud. (Source: courtesy of CDDV).

This project remains live and underpins our approach to asset management in Historic Environment Scotland.

Towards a management tool

In 2011, CDDV was commissioned to look at a 3D asset management system based on the point cloud developed from laser scanning at the World Heritage site of Schonbruun Palace in Vienna. In reality whilst the documentation of the site was a significant success, the software available at this time and the integration of datasets and spatial information proved too complex a challenge to create a workable and useable system. The principal was sound–a three-dimensional database based on unique xyz co-ordinates and tagged as geo-locators seemed logical.

The digital documentation of the Sydney Opera House under the Scottish Ten project is aligned with the building management team pushing forward with the creation of a digital asset management system within a complex and busy historic asset and performance venue. The laser scanning work

completed under the project provided the first 'as built' data for the Opera House since its completion in 1973. Access to every surface of the building proved technically challenging and the experience of rope teams gained at Mount Rushmore proved invaluable. The Opera House continues to be at the forefront of digital management of historic assets, building from the spatial data capture of the Scottish-Australian-American team.

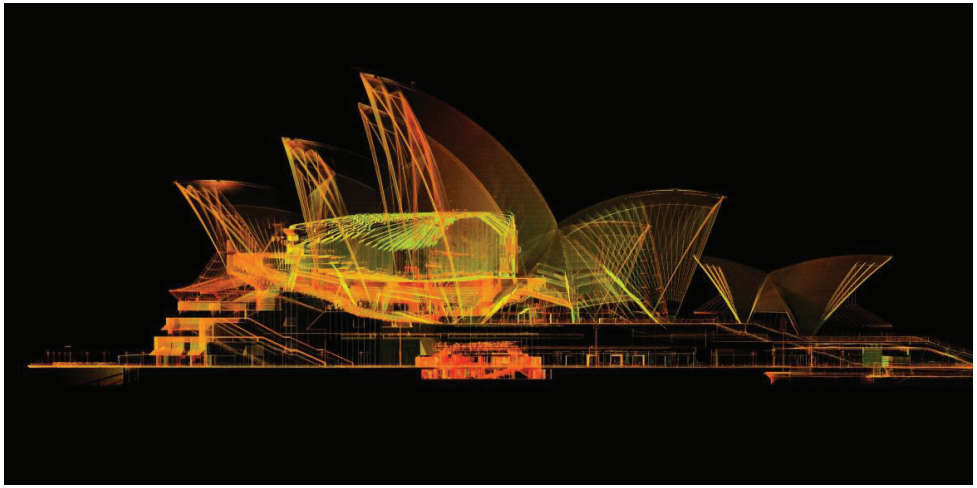

Figure 3: Sydney Opera House. (Source: courtesy of CDDV).

BIM–a tangent to the plot?

Building Information Modelling, or BIM, had its origins in the 1980s but came to prominence in the late 1990s. It came from a different perspective and evolved using architectural CAD type approaches. The US National Building Information Model Standard Project Committee uses the following definition:

> Building Information Modeling (BIM) is a digital representation of physical and functional characteristics of a facility'
> (National BIM Standard – United States 2014)

The UK Government has promoted BIM and its application actively since 2011, with the Scottish

Government following a similar line, stipulating that public capital projects are to be using BIM by April 2017. The UK's BS/PAS 1192 standard is acknowledged as the leading global standard for building information management, and is due to form the basis of an international ISO standard.

The use of BIM and related digital information management processes in the heritage sector is in its infancy. In Scotland, we are currently leading the heritage application of BIM. Whilst Historic Environment Scotland can exclude most of its operations from BIM application, it has chosen not to do so given its strong interest in digital technology. Since 2012 we have explored the opportunities and constraints of the application of BIM in parallel with our digital spatial capture work, developing a Heritage BIM strategy to support the management of the historic environment.

As part of our organisational BIM strategy, we are delivering a pilot HES BIM Project, which aims to investigate the use of BIM processes across four case studies representing a diverse cross section of our portfolio. The principal pilot case study is the Palace Block at Edinburgh Castle where we are using a BIM model to collate the complex asset information of an ancient monument in use, including historic, technical and maintenance information for elements of fabric, infrastructure, mechanical and electrical systems. We are currently exploring how this can be used to assist with operational asset management at one of the key buildings in this, our most visited property, with over 1.5m visitors each year.

Digital data for conservation purposes

At a very simple level the creation of high quality spatial survey data is an important output in itself. We have developed survey standards which extend to performance specifications for fieldwork, processing and data archiving. Early alarmist responses from archival bodies around managing large digital datasets has moved on significantly. Accurate survey and

modelling from physical and archival evidence can provide new perspectives.

The ability to record morphological change in surfaces and structures has been of significant benefit. Historic Environment Scotland has had good success in combining digital documentation expertise with the

Figure 4: James V sculpture at Stirling Castle – meshed scan data to model of existing appearance to interpretation of original presentation in the 16th Century. (Source: courtesy of CDDV).

datasets generated through our thermographic work. Thermography and moisture mapping is a commonly used building pathology tool and combining these datasets with 3D models has created a powerful tool for tracking moisture movement and fabric issues.

Modelling reconstructive or restorative approaches in order to deliver fundraising campaigns for projects has proven successful for a number of projects in Scotland (Wilson *et al.* 2010). This was most notable in the restoration of the Grand Fountain in Paisley, where

an unusual cast iron fountain with a bespoke colour scheme by Cottier was modelled from traditional paint analysis techniques, and scan data used to generate 3D models and printed patterns to re-cast missing elements. Practical benefits were also seen in using point clouds to inform conservation decisions (Wilson *et al.* 2012).

Digital documentation in an emergency situation is perhaps best exemplified by the post fire salvage and recovery operation at the Glasgow School of Art in 2014. Amongst the first people on site were our digital documentation team who were able to document the site as found, and directly prevented the removal of building fabric and so we were able to demonstrate that masonry identified as dangerous, was in fact no different from previous materials, by comparing historic scan data.

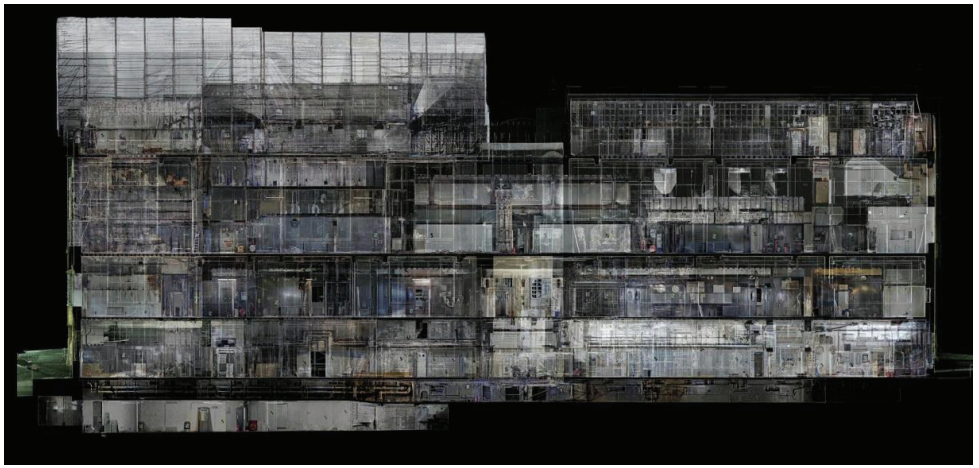

Figure 5: Post fire survey of Glasgow School of Art. (Source: Courtesy of GSA).

Towards a conservation asset management system

Historic Scotland merged with the Royal Commission of Ancient and Historical Monuments to create Historic Environment Scotland in October 2015. RCAHMS had a century old role in documenting the

historic environment in Scotland through a range of approaches and making this information available to the public. The new body would retain a key role to continue to care for the national collection of properties in State Care, an unbroken line of some 700 years to the Kings Works.

The management of the properties and associated collections would be undertaken through a formal Scheme of Delegation through an Act of Parliament. This required a transparent system of asset management which provided assurance to Scottish Ministers on the quality of care being delivered, the ongoing condition of the assets and building in mechanisms to deal with the growing impacts of a changing climate in Scotland. The conservation team saw this as both a challenge and an opportunity to shift the focus, performance and outcomes of our core purpose. It was also considered to be an opportunity to bring together our digital documentation expertise, our asset management requirements and enhance the quality of our decision-making information and prioritization, particularly when resources were tight. The initial Estate Asset Management Project (EAMP) covered:

- Legal basis for ownership of assets and resolution of boundaries.
- Consideration of the impacts of a changing climate.
- Assessment of data assets we and our partners held.
- Assessment of asset management models and systems.
- The development of a condition survey metric.
- Baseline condition assessment of Properties in Care and Associated Collections.
- Development of new Conservation Principles, Standards and Specifications and a peer review model.

These projects were mostly completed during early 2015 ahead of the creation of HES on October 1st 2015. Key findings and outputs included:

- Up to date and spatially accurate GIS and CAD plans of our assets across Scotland.
- The need to develop a climate change impact tool as a key management tool.
- An understanding that we held high quality data sets–from archives to technical reports–that were not easily accessible.
- A robust condition assessment tool that incorporated risk to cultural significance.
- A backlog of conservation, maintenance and infrastructure work.
- A need to focus on statutory compliance.

The EAMP project concluded and evolved to a new range of focused projects:

- A Resource Needs Assessment which set out the current and future needs of our assets and how we would adapt and evolve to meet them.
- A Matrix-based prioritisation tool to aid decision making re investment and resource allocation.
- Impact modelling of a changing climate on our properties and rolling out a methodology to the broader sector (required of us under the 2009 Scotland Climate Change Act).
- The delivery of a research project to digitise the condition survey methodology we had developed as part of a larger Asset Management System, PICAMS.
- The design and delivery of that Asset Management System.
- The role of BIM in our work and the Asset Management System.
- The creation of an Asset Management Plan and Corporate Investment Plan.

In considering an approach to an asset management system, we considered the commercially available asset management systems. There is no bespoke heritage asset management system and whilst there are many high-quality systems available, they are based on asset obsolescence and renewal, which is obviously counter to the objectives of conservation.

Table 1. Objectives for an Asset Management system for Historic Environment Scotland

	Objective	Essential	Desirable
1	The system should fulfil our unique operational needs in managing cultural heritage assets.	X	
2	The system should be able to generate condition inspection information in line with the reporting requirements under the scheme of delegation.	X	
3	Capture Data in digital form throughout the activity and engender greater national consistency.	X	
4	Field use required in remote locations often off line.	X	
5	Able to accommodate our condition monitoring and inspection regime with functionality development possible.	X	
6	User friendly portal or interface to collate and present complex data sets from different locations and formats.		X
7	Able to support access to and retrieval of digital assets including photos, drawings, plans, survey information, spatial data, documents and other records.	X	
8	Able to relate to other internal and external databases, including Canmore, Heritage Management, Collections, Archaeology, BGS databases. Web based potential.	X	
9	Able to be supported by our internal systems staff.		X
10	Modular and flexible to adapt in the future.	X	
11	Incorporate or be designed to incorporate 3D point cloud data sets to use as 3D data interfaces now or in the near future. Able to manage raw data where possible.	X	
12	Able to incorporate the unique digital assets created by HES staff in spatial data particularly.	X	
13	Able to manage BIM interfaces	X	
14	Where development is required, the potential to realise commercial benefits for HES if required.		X
15	Geospatial referencing should underpin the system.	X	
16	The system must increase operational efficiency and be customisable for our user needs.	X	
17	Live and dynamic system that will be interrogable by many different fields.	X	
18	Incorporate legacy data from historical condition surveys.	X	
19	Identify and manage resource needs.	X	
20	Identify and manage inspections, alerts and routine maintenance works items.	X	

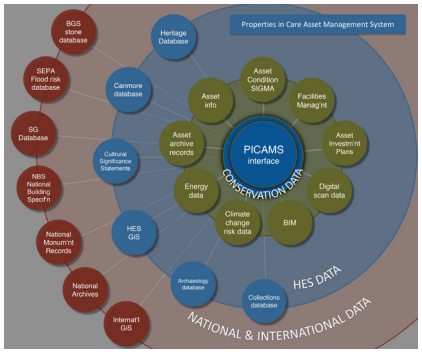

Figure 6: PICAMS outline (Source: authors).

Mindful of our focus on the documentation of digital assets and where this might go in the future, we set out to plan a system that would fulfil our needs but also allow us flexibility in the future as technology evolved, particularly around integration of 3D spatially based models for asset management in terms of a recognisable user interface. Our brief for PICAMS set out the objectives (Table 1).

PICAMS is outlined in Figure 6. At the heart of PICAMS sits a relational database. The condition survey tool, HES- SIGMA, is the critical component in the system and therefore the first element to be developed and tested. Other datasets held within HES include digital image archives, drawing archives (digitised and CAD), designation information, site management information, archaeology datasets and climate change information. In January 2017, the initial development of the HES-SIGMA survey tool was completed and it is now being used as a default condition survey system.

Creating a bespoke conservation survey tool: HES-SIGMA

Previously, conservation architects undertook detailed condition surveys on a site by site basis. The primary aim of this was to generate conservation and maintenance programmes at sites and across the estate for a five-year period. The output format was typically a Microsoft Word document. This was fine up to a point but was inefficient and made it very difficult to collate data and extract national perspectives and priorities or consider trends and impacts.

Through a long association with British Geological Survey in Scotland, we were aware of a field based survey system for geological data gathering using a geospatial relational database on an ArcGIS system. The SIGMA system allowed BGS to capture data in the field remotely before uploading to a central system. An initial research project has led to the development of HES-SIGMA, an evolution of the geology tool for application to historic sites (Historic Environment Scotland 2015). HES have worked with the British Geological Survey (BGS) since 2015 to develop

this integrated digital site assessment system that provides a refined survey process.

The new HES-SIGMA system essentially stores and presents conservation and maintenance information for our sites; with the additional capability to use the information to plan effective programmes of conservation and maintenance by answering the simple *what, who, why, where and when* questions either for an individual site or the entire estate at a particular point in time or over a period of time. It is a live system that can be interrogated in many ways, including geo-spatially, and is linked to many other datasets within, or external to HES.

Users can populate custom-built data entry forms to record maintenance issues and repair specifications for architectural elements ranging from individual blocks of stone to entire building elevations. Photographs, sketches, and digital documents can be linked to architectural elements to enhance the usability of the data. Predetermined data fields and supporting dictionaries constrain the input parameters to ensure a high degree of consistency and facilitate data extraction and querying.

Presenting the data within GIS provides a versatile planning tool for scheduling works, specifying materials, identifying skills needed for repairs, and allocating resources. The overall condition of a site can be monitored accurately over time by repeating the survey at regular intervals (e.g. every 5 years). Other datasets can be linked to the database and other geo-spatially referenced datasets can be superimposed in GIS, adding considerably to the scope and utility of the system. The system can be applied to any geo-spatially referenced object in a wide range of situations, thus providing many potential applications in conservation, archaeology and related fields.

Key to HES-SIGMA is the capture of the data used to measure condition. The methodology for calculating this condition indicator is set out in the HES document *Baseline Condition of the Properties in the Care of Scottish Ministers, October 2015* (Historic Environment Scotland 2015). Each element is recorded spatially within the condition data capture process

Figure 7: Field trials of SIGMA system. (Source: Historic Environment Scotland).

as a Monument Observation Point (MOP) and is given a Condition Indicator. This indicator measures the urgency of the action required together with the risk presented to the cultural significance or physical access to the monument by not carrying out that action. It is an Urgency x Risk score with an inbuilt measure of the potential loss of cultural significance and access for each element. The Urgency is attributed as a numerical value between and 1 and 6, representing defined time bands ranging from immediate to within ten years. The Risk is attributed as a value between 1 and 3, quantifying the risk of no action as either serious, significant or negligible.

From the original BGS SIGMA, unique GIS layers were developed for a number of pilot sites. This included dictionaries pertinent to the monuments, in itself a challenging task given regional variations and traditions. New survey fields and templates were developed and trialled in the field alongside condition survey fields and maintenance actions required which could generate work tasks and resource indicators (Tracey *et al.* 2016).

The highly variable nature of the historic assets required prolonged development of a standard lexicon and being flexible enough to deal with any asset. That the assets we care for are essentially fixed, allowed us to build accurate site by site frameworks that will be viable for some time. The defined and restricted fields and dictionaries developed are of critical importance to providing consistent and sound analytical data.

The key features of HES-SIGMA are:

- Individual architectural elements are recorded as separate entities associated to individual sites (e.g. buildings) and are fully linked to the site to which they belong by means of a unique identifier, GPS location and data fields with supporting 'site hierarchy' dictionaries.
- Predetermined data fields and supporting dictionaries guide and restrict the range of conservation and maintenance properties that can be recorded, ensuring a high degree of consistency in the dataset.

- Conservation and maintenance properties can be recorded for the different architectural elements of an individual site.
- Once the survey is complete, the recorded data can be interrogated directly in the database or visualised within a Geographic Information System (GIS).
- A report generator tool enables the data to be output in the form of tailored Microsoft Word documents, thus suiting any project requirement.

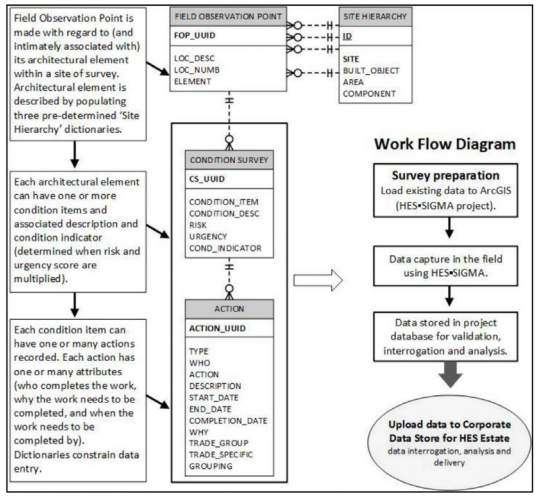

Figure 8: Integrated logic and workflow for HES-SIGMA (Source: courtesy of BGS NERC).

HES-SIGMA allows data to be downloaded to the tablet field device at base, including other data files, maps and photographs. On site, observations made by the field operative relating to condition and maintenance issues are recorded against architectural elements. Prior to recording observations, the location of the architectural element is identified by clicking on the desired position within the site polygon to create a new 'field observation point' (FOP). Once the FOP has been created, a 'Switchboard' form automatically

opens allowing the user to enter additional location information using 'site hierarchy dictionaries'.

Each site has pre-developed 'Site hierarchy dictionaries' to ensure consistency across the dataset and between users, and to provide the ability to monitor maintenance issues on the same architectural element over time. This also allows for data analytics on an ongoing basis by conservation staff. On the 'Switchboard' form, location information and architectural element descriptions are input; photographs, sketches and samples (e.g. stone, mortar) can be attributed to the architectural element described; and access to the more detailed data entry forms for recording condition and maintenance 'issues' is provided. Photographs taken in the field, along with sketches, can be retained in the system and hand writing recognition and field selection is used for data input.

'Description', 'Risk', 'Urgency' and 'Condition Indicator' observations on condition and maintenance issues are attributed to each architectural element in the 'Condition Survey' form. Actions can be recorded, again using a pre-determined dictionary of actions, and a timescale attributed. The specialist skills required may also be identified to quantify resource requirements and generate work packages for specialist conservators, engineers etc. HES-SIGMA field data is uploaded to the central database on return from the field. It is also designed to automatically generate standard reports from the field survey such as work packages.

Applications in education and training

At an early stage of digitally documenting heritage assets, it was clear this was a powerful tool for education purposes. An early perception that this was an ideal route for engaging 'digital natives' in terms of young people, was somewhat flawed because it assumed that the digital models in themselves would sufficiently impress a young audience. The acceleration of gaming technology and the expectations of young people in this regard meant this quickly became irrelevant. Indeed, many young

people pursued 'retro technology' where blocky and unrealistic visualisation was considered favourable.

We consider the following to be most attractive in this regard:

- Remote access to sites which are not available due to location, cost, safety or conservation requirements.
- Visualisation of assets which have been lost and virtually reconstructed
- Re-creation of historic locations or events for the purposes of interpretation.
- Providing high quality replica objects or scaled buildings from datasets which can be handled and used as teaching tools.
- Combining traditional conservation and analytical techniques to present data sets in a different way.
- The ability to manipulate datasets to provide unique perspectives on structures – cross sections and perspectives.
- The ability to virtually construct and deconstruct in order to illustrate technical and construction approaches.

St Kilda, a remote and sensitive archipelago of the West Coast of Scotland, is a World Heritage site for natural and cultural reasons. Digital documentation of the island, the extant building features and details have allowed us to create a high quality digital model which can be used to virtually transport visitors to this location. In combination with 3D audio, this can become a powerful experience. The burial chamber of Maeshowe is not accessible to all, given the low and long entrance passageway. A high quality digital model as an immersive 3D experience allows visitors to experience the site remotely. This approach cannot replace the authenticity of the real but it can add value in many ways.

The digital reconstruction of the 1938 Empire Exhibition in Glasgow by Glasgow School of Art has created a high quality digital model of an important architectural event showcasing the modern movement

in a range of buildings and features. Developed with a peer review group of architectural historians, this model allows us to digitally transport students from what is now a green field site. The tour leader deploys the same narrative as if they were leading a walking tour.

Evolving corporate thinking around the first national Historic Environment Strategy 'Our Place in Time' synthesised through our Corporate and Directorate Plan, had prompted us to shift our thinking in broadening the impacts, outcomes and leverage our conservation work could deliver. Central to this was the delivery of the Engine Shed in Stirling, which was conceived to be a national and international centre for building conservation. Open to the public, the Engine Shed aims to engage a new generation with their built heritage, create informed clients and raise standards in building conservation. Central to this is formal and informal education space and research activity through our well established technical, scientific and digital research.

The facility is designed to position centuries old traditional skills and materials alongside new digital technologies and research. The integration of these

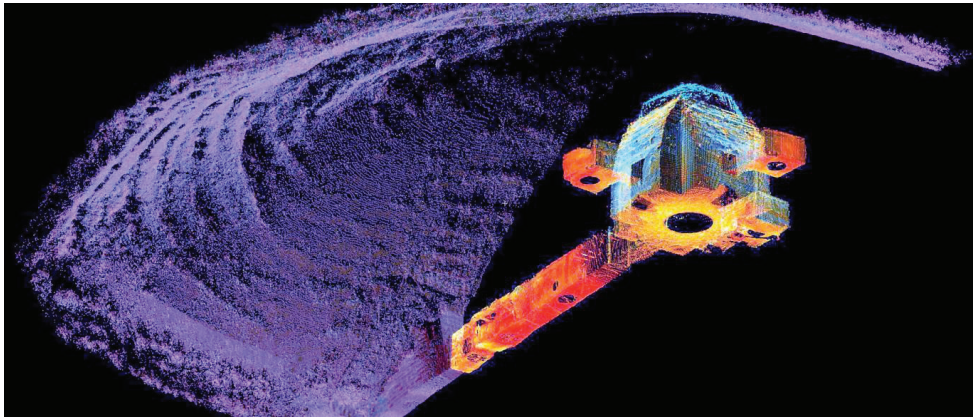

Figure 9: Maeshowe burial chamber, Orkney. (Source: courtesy of the Centre for Digital Documentation and Visualisation).

approaches is designed to send a message to visitors in that cultural heritage is not only valid for its own sake, but for the sustainable benefits it can continue to bring now and in the future.

A 3D 4k projection auditorium provides a location where we can bring remote heritage to Scotland. Based on our experience of the auditorium created by the Glasgow School of Art, whilst the quality and visual impact is key, the underpinning knowledge and expertise remains critical. In that respect, the expertise of a narrator in the room as the audience explores an ancient Indian step well or stands atop the Sydney Opera House provides an authoritative perspective and enhances the experience.

The core exhibit at the Engine Shed is built around displays of traditional materials and buildings, science and technology as applied in the heritage sector. A large map created from satellite images is the key feature in the building. This high-resolution image is in itself of interest, but iPads are used to trigger augmented layers of information from the map. Fifty key Scottish buildings emerge from the map which can be manipulated by the user, representing regional variations or architectural periods in development. Layers of additional information showing climate change models, building stone quarries, underlying geology, locations of designated buildings and other spatial information can be accessed as the system evolves. Our objective for the Engine Shed is to create a melting pot of expertise and innovation, marrying the most traditional materials and skills alongside emerging technologies and science. Our experience has shown that the integration of approaches advances our objectives considerably.

Notes

1. US Patent 'Advance applications for 3-D autoscanning LIDAR system', US 6781683 B2

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References

Historic Environment Scotland. 2015. Condition Monitoring System for Properties in the Care of Scottish Ministers and Associated Collections. http://www.historic-scotland.gov.uk/hes-condition-monitoring-system.pdf

National BIM Standard – United States. 2014. "Frequently Asked Questions About the National BIM Standard-United States - National BIM Standard - United States." Archived from the original on 16 October 2014. Accessed 17 October 2014. https://www.nationalbimstandard.org/faqs

Tracey, E. A., N. Smith, and K. Lawrie. 2016. "Recording, Monitoring and Managing the Conservation of Historic Sites: A New Application for BGS Sigma." In *13th International Congress on the Deterioration and Conservation of Stone*. http://nora.nerc.ac.uk/514325/1/Tracey_final.pdf

Wilson L., A. Rawlinson, D. S. Mitchell, H. C. McGregor, and R. Parsons. 2013. "The Scottish Ten Project: Collaborative Heritage Documentation." In *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, edited by P. Grussenmeyer, XL-5/W2, 685-690.

Wilson L., D. K. Pritchard, C. McGregor, and D. S. Mitchell. 2012. "Two Avenues for Data: Rosslyn Chapel as a Terrestrial Scanning Case Study." In *Proceedings of the XXII Nordic Surveyors Congress,* Oslo 2012. Kart og Plan 72, 315-320.

Wilson L., A. Rawlinson, D. S. Mitchell, D. K. Pritchard, and H. C. McGregor. 2011. "3D Documentation of Global Historic Sites: The 'Scottish Ten' Project and its Applications for Cultural Heritage." In *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences,* edited by F. Remondino and S. El-Hakim, XXXVIII-5/W16, 39-44.

Wilson L., D. S. Mitchell, A. Davey, and D. Pritchard. 2010. "Digital Documentation of Historic Ferrous Metal Structures: 3D Laser Scanning as a Conservation Tool." *Metal 10, International Conference on Metal Conservation.* Interim Meeting of the International Council of Museums Committee for Conservation Metal Working Group. Charleston: Clemson University Press, 279-286.

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