digital cultural heritage: FUTURE VISIONS

Edited by Kelly Greenop and Chris Landorf

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13–15 November 2017 in London, United Kingdom
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The papers published in these proceedings are a record of the symposium mentioned on the title page. They reflect the authors' opinions and are published as submitted in their final form with limited editorial change. Their inclusion in this publication does not necessarily constitute endorsement by the editors.

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The symposium Convenors received a total of 33 abstracts. All abstracts underwent a double-blind peer review by two members of the Symposium Organising Committee. Authors of accepted abstracts (24) were invited to submit a full paper following presentation of their draft papers at the symposium. All submitted full papers (8) were again double-blind peer reviewed by two anonymous reviewers and given the opportunity to address reviewer comments. Papers were matched as closely as possible to referees in a related field and with similar interests to the authors. Revised papers underwent a final post-symposium review by the editors before notification of acceptance for publication in the symposium proceedings.

Please note that the paper displayed as an abstract only in the proceedings is currently being developed for an edited book on digital cultural heritage.

Innovative new data collection and digital visualisation techniques can capture and share historic artefacts, places and practices faster, in greater detail and 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 crowd-sourced data all have the potential to engage new audiences, engender alternative meanings and enhance current management practices. At a less tangible level, new technologies can also 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, gaps still exist between these evolving technologies and their application in everyday heritage practice. Following the success of a sister conference in Brisbane, Australia in April 2017, this symposium focused on the emerging disciplines of digital cultural heritage and the established practice of heritage management. The symposium aimed to provide a platform for debate between those developing and applying innovative digital technology, and those seeking to integrated best practice into the preservation, presentation and sustainable management of cultural heritage.

The symposium was designed to encourage critical debate across a wide range of heritage-related disciplines. We welcomed papers from practitioners and academics working in cultural heritage and related fields such as architecture, anthropology, archaeology, geography, media studies, museum studies and tourism. We particularly encouraged papers that explored the challenges of digitising tangible and intangible cultural heritage, those that identified issues with digitisation and digital interaction, and those that addressed the theoretical challenges posed by digital cultural heritage.

Kelly Greenop and Chris Landorf
EDITORS and SYMPOSIUM CONVENORS

digital cultural heritage: FUTURE VISIONS London Symposium

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13-15 November 2017 in London, United Kingdom
Conference convenors Dr Kelly Greenop and Dr Chris Landorf

DAY 1 Morning
Monday, 13 November 2017

08:30 – 09:30	**Conference registration** *[room tbc]*
09:30 – 10:00	**Conference opening** *[room tbc]*
10:00 – 11:00	**KEYNOTE ADDRESS** **Professor Sarah Kenderdine,** ECOLE POLYTECHNIQUE FEDERALE DE LAUSANNE Modelling the World in Experimental Museography *[room tbc]*
11:00 – 11:30	Morning tea *[room tbc]*
11:30 – 13:30	**SESSION 1 – Breadth** *[room tbc]* Session Chair: Andong Lu (tbc) Toby Burrows Cultural Heritage Collections as Research Data Sally MacLennan and Natalie Vinton Virtual Explorers: Using digital technology to share and celebrate cultural heritage in New South Wales Bernadette Devilat 3D Laser Scanning Built Heritage: The case of St. Boniface church in London Sambit Datta, David Beynon and Joshua Hollick Interaction with Architectural Collections using Immersive Stereoscopic Visualisation
13:30 – 14:30	Lunch *[room tbc]*

Conference registration details can be found at:
https://digitalculturalheritageconference.com/registration/

DAY 1 Afternoon
Monday, 13 November 2017

14:30 – 15:30	**KEYNOTE ADDRESS** **Tim Williams,** UNIVERSITY COLLEGE LONDON Archaeological Heritage Along the Silk Roads: Digital futures *[room tbc]*	
15:30 – 16:00	Afternoon tea *[room tbc]*	
16:00 – 18:00	**SESSION 2 – Macro** *[room tbc]* Session Chair: Chris Landorf Dante Abate, M. Faka, S. Hermon, N. Bakirtzis, G. Artopoulos, and O. Daune-Lebrun From Analogue to Digital: 40 years of archaeological documentation and management at the Neolithic UNESCO World Heritage site of Choirokitia (Cyprus) Yang Geng and Huo Dan Digital Reconstruction and Interaction of Linear Cultural Heritages – Taking Ancient Post Roads in Northeast China as an Instance Tiziana Casaburi Rome's Archaeological Area Valorization through Multimedia Presentations Risto Järv Estonian Place-Lore on a Digital Map	**SESSION 3 – Modelling** *[room tbc]* Session Chair: Kelly Greenop Dijana Alic Designing Diversity: Capturing culture in digital form James Ritson A Comparative Analysis of Modelling Techniques for the Reduction of Energy and Carbon Emissions in a Victorian Dwelling Maria Manuela Leoni Web Modern Cultural Heritage in Post-1945 Milan Patrizia Schettino Augmenting Empty Spaces with Content from Digital Archives: Pilot study on the visitor experience and the Villa Ciani 3D

DAY 2 Morning
Tuesday, 14 November 2017

08:30 – 09:00	**Conference registration** *[room tbc]*
09:00 – 10:00	**KEYNOTE ADDRESS** Professor Andong Lu, NANJING UNIVERSITY Digital Agency and Narrative-Augmented Reality *[room tbc]*
10:00 – 10:30	Morning tea *[room tbc]*
10:30 – 12:30	**SESSION 4 – Depth** *[room name/number tbc]* Session Chair: Sarah Kenderdine (tbc) Yehotel Shapira The Absolut/e's Digital Emblems: Jewish-Messianic alteration of East Jerusalem Eleni Kotoula, Kiraz Goze Akoglu, Shi Weiqi, Yin Yang, Stefan Simon and Holly Rushmeier CHER-Ob for Cultural Heritage Research: Unsleben Jewish cemetery case study Dante Abate and Caroline Sturdy Colls A Multi-Resolution and Multi-Sensor Approach to the Documentation of Treblinka Extermination and Labour Camps in Poland Francisca Sousa, Elia Roldao, Alexandra Encarnacao and Pedro Serra Conservation Challenges of Contemporary Art: Preservation issues in the digital era
12:30 – 13:30	Lunch *[room tbc]*

DAY 2 Afternoon
Tuesday, 14 November 2017

13:30 – 14:30	**WORKSHOP** Joann Russell and Lyn Wilson, HISTORIC ENVIRONMENT SCOTLAND Practical Applications of Digital Technologies by Scotland's National Heritage Body *[room tbc]*	
14:30 – 15:00	Afternoon tea *[room tbc]*	
15:00 – 16:30	**SESSION 5 – Participatory heritage** *[room tbc]* Session Chair: Joann Russell (tbc) Rosie Brigham Holyrood Castle, Machrie Moor and citizen science Mehti Ghafouri Digital Cultural Heritage for Participatory Cultural Heritage Conservation Ahmet Denker From Dipteros to Pseudo-Dipteros: Ionic Temples of Aegean Turkey	**SESSION 6 – Digital heritage** *[room tbc]* Session Chair: Tim Williams (tbc) Mollie Claypool We Have Never Been Digital: Architectural design and the heritage of building practices Xu Ding Importance of Digital Strategies in Chinese Traditional Village's Conservation Eftychios Savvidis Future Pasts, Past Future: Or material preservation in an Increasingly digital world
16:30 – 17:30	**Conference closing panel session** *[room tbc]*	
17:30 – 18:30	**Conference closing drinks** *[room tbc]*	

DAY 3 Morning
Wednesday, 15 November 2017

10:00 – 12:00	**SITE VISIT** Museum of London 150 London Wall, London EC2Y 5HN https://www.museumoflondon.org.uk/museum-london

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* Published as an abstract only. The full paper is currently being developed for submission to an academic journal for a special edition on digital cultural heritage.

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University of Oxford
University of Western Australia

Cultural Heritage Collections as Research Data: Towards Computationally Amenable Collections

Abstract:

This paper focuses on the re-use of data relating to collections in libraries, museums and archives to address research questions in the humanities. Large-scale research into the history and significance of cultural heritage materials is heavily dependent on the availability of collections data in appropriate formats and on a suitable scale. Until recently, this kind of research has been seriously limited by lack of access to curatorial data. Collection databases have not been available for downloading in their entirety, or have not been made fully available on the Web. There has been a disconnect between curatorial databases and researchers, who have been generally unable to contribute their findings to institutional databases. Some recent "collections as data" initiatives have started to explore approaches to best practice for "computationally amenable collections", with the aim of "encouraging cultural heritage organizations to develop collections and systems that are more amenable to emerging computational methods and tools' (Collections as Data 2017)". This paper discusses three projects that are addressing these issues in similar ways, and uses them to derive lessons and recommendations for future best practice in making collections data available for computational reuse by researchers.

Keywords: Cultural heritage; Collections data; Provenance; Collections data reuse; Computational amenability; Linked dData

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Dr Toby Burrows is a Senior Researcher in the Oxford e-Research Centre at the University of Oxford, and also holds a Senior Honorary Research Fellowship at the University of Western Australia. He has previously been a Marie Curie International Incoming Fellow at King's College London, and has held visiting fellowships at the University of Pennsylvania, the Vrije Universiteit Amsterdam and Churchill College Cambridge. His research interests include the digital humanities, the history of collecting, and medieval manuscripts.

Introduction

The importance of cultural heritage collections for research in the humanities, arts and social sciences (HASS) has long been recognised. Though this is not the only reason why such collections have been assembled, it is certainly one of the most important. The recent National Research Infrastructure Roadmap Report for Australia (2017) emphasises the dual nature of these collections; not only do HASS research platforms encompass the physical collections, they also include 'online portals that facilitate the digitisation of and digital access to original artefacts, materials and knowledge' (Australian Government 2017:33). The Report emphasises discoverability and accessibility as priorities, together with 'enhanced digitization, aggregation and interpretation platform processes'. The digital forms of these collections are particularly crucial for research that uses the methodologies, technologies and critical perspectives of the digital humanities (Flanders 2014).

At the same time, an initiative to understand these collections as data is gathering pace in the United States. Under the auspices of the Library of Congress and the Institute of Museum and Library Services, this 'Collections as Data' programme 'aims to foster a strategic approach to developing, describing, providing access to, and encouraging reuse of collections that support computationally-driven research' (Always Already Computational 2017). One of the drivers for this initiative is the perception that, as Miriam Posner argues, 'Libraries and archives [and museums] are increasingly making their materials available online, but, as a general rule, these materials aren't of much use for computational purposes' (Posner 2017).

This paper examines three projects which are addressing the 'collections as data' imperative within the framework of cultural heritage and digital humanities. The first project is 'Collecting the West', in which Western Australian researchers are working with the British Museum to deploy and evaluate the ResearchSpace software, which is designed to integrate heterogeneous collections data into a cultural heritage knowledge graph that can be annotated by researchers. The second project

'Mapping Manuscript Migrations', funded by the Digging into Data programme involves combining collections data from a range of digital sources to reconstruct the histories of large numbers of medieval and Renaissance manuscripts. The third project is HuNI the Humanities Networked Infrastructure, which is building a 'virtual laboratory' for the humanities by reshaping collections data into semantic information networks.

These three projects have been chosen as case studies because they share a common commitment to enabling the reuse of collections data by researchers, and have a similar understanding of the value of collections data as the basis for building knowledge graphs. The lessons learned from the projects will be used to develop recommendations for best practice in the future, presented in the final section of this paper.

Collections as data

In what sense can collections actually be considered as data? There has been a tendency to try and align digital infrastructure for the humanities and social sciences with the model commonly adopted in the sciences: the data consist of digital content, described by accompanying metadata (Borgman 2007: 215-217). This might work for the social sciences; a service like the Australian Data Archive contains statistical data files, together with descriptive metadata about them. But the analogy begins to break down for the humanities, where, for cultural heritage objects, the descriptions are as important for research purposes as the digital images of cultural heritage objects. The objects themselves, and their digital representations, can only be accessed through the statements that researchers and curators make about them. A more useful approach, it seems to me, is to elide the distinction between 'data' and 'metadata', and to treat descriptions of objects as research data in their own right (Burrows 2011). It follows from this that a productive definition of 'collections data' must encompass the descriptions of objects as well as the objects themselves and their digital representations.

There are various reasons why this kind of collections data is important for research. The most obvious is in order to trace the history of the individual objects themselves and their relevance as evidence for more general research questions and themes in art, architecture, archaeology, history, literature and other humanities disciplines. As Neil MacGregor vividly demonstrated, the history of almost any object can reveal a great deal about changing cultures over time (MacGregor 2010). A manuscript like the so-called Crusader Bible illustrates this point. Made in mid-thirteenth century France, it later travelled to Naples and then to Krakow, from where it was taken as a gift for the Shah of Persia in Isfahan. Eventually it returned to Western Europe by way of Cairo, and migrated into the world of connoisseurship, manuscript collecting, and conspicuous consumption – ending up in the Morgan Library in New York in the early twentieth century (Abels 2014).

Another important reason for analysing collections data is to investigate the broader history of ownership and collecting. How and why these cultural heritage objects survived to the present day, who has been involved in their history, what they tell us about the priorities and motives of private and institutional collectors alike: these are all important questions underlying the nature of collections today. This speaks to more than just the significance of each specific object; it bears witness to the changing meanings of these objects over time, and to their changing place in a more general social context. And it emphasises the way in which the collections as they exist today are not neutral or objectively representative assemblages of cultural heritage objects. Instead, they reflect the priorities, attitudes and values of specific people and institutions at particular times and places.

A significant project examining these kinds of questions is 'Collecting the West', which is looking at the history of objects relating to Western Australia, many of which are now in British and European collections. An important element in that history involves the acquisition, removal, theft and repatriation of Australian Indigenous artefacts, such as those collected by early European settlers in the 1830s as well as those acquired for re-sale in Europe by travellers like Emile Clement and Paul Denys Montague between the 1890s and the 1930s (Adams 2016).

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A project of this type requires the identification and linking of collections data from a range of different sources. In the case of Western Australian Indigenous material, these include the British Museum, the Pitt Rivers Museum in Oxford, the Smithsonian in Washington, and the Hamburg, Frankfurt and Dresden Museums in Europe, as well as numerous collections in Australia and various smaller institutions across the world.

The Biography of Things

Of particular interest within this type of collections data is the evidence relating to the ownership and provenance of each item. Ownership histories are central to understanding the changing nature of objects over time, and provenance provides crucial evidence for what Igor Kopytoff calls the 'cultural biography of things'. He notes that 'there are many biographies: sheer physical biography, technical biography (repairs), economic biography, social biographies – the owner's economy, ownership and class structure, kin relations' (Kopytoff 1986:68).

Kopytoff is especially interested in the relationship between commoditization, where objects are things which can be bought and sold in the market-place, and singularization, where objects are unique signifiers of cultural value, which exist outside the market-place. As he observes, 'in the homogenised world of commodities, an eventful biography of a thing becomes the story of the various singularisations of it, of classifications and reclassifications in an uncertain world of categories whose importance shifts with every minor change in context' (Kopytoff 1986:89).

For several centuries at least, there has been a thriving market for antiquities, cultural heritage objects and art of many kinds. While the commercial value of specific types of items may have fluctuated significantly over time, it is generally the case that competition to acquire them has been intensifying, to the point where many objects can only be afforded by wealthier individuals and bigger institutions. This has led to such events as the sale of Leonardo's 'Salvator Mundi' for $450.3 million in 2017 and the sale of the Rothschild Prayer Book for over £8 million in 2014.

This type of 'biography of things in terms of ownership' (Rivers 1910, quoted by Kopytoff) also involves their place in networks of ownership. Ownership does not take place in a vacuum; as Jennifer Van Horn says of 18th-century American private ownership:

> Artifacts played an important role in creating cohesion: consumers assembled similar goods to form communities through their shared tastes and distinctive modes of object use. (Van Horn 2017:8).

The collecting and ownership of what we now regard as cultural heritage objects have taken place within networks of shared interests and tastes. As Van Horn points out, there are in fact two networks, or assemblages, involved here,: one of people and one of things:

> Networks are often understood as webs that map out a series of interconnected people or, in this case, objects (often artifacts that are related to one another through physical resemblance and common modes of use). (Van Horn 2017: 9).

The ownership of cultural objects at specific times by specific people or organisations tells us something significant about the way in which these objects embody shared cultural values. They show how these networks of ownership change over time, reflecting the changing place of objects in culture and society. In as much as these objects serve as carriers of culture and knowledge, their movements can also reveal the dissemination of ideas across cultures and over time, by a process in which networks of ownership and exchange serve as evidence for networks of knowledge and culture. The best evidence for these patterns can be found in the provenance and ownership history data from collection records.

Bringing Data data Together

Telling the story of these changing networks of ownership usually means bringing together collections of data from different sources, and from different types of cultural institutions. The technical issues involved in this process are far from trivial. Different metadata schemas and formats, different vocabularies and different levels of aggregation must all be linked up in a coherent way and exposed through an interface that enables browsing and searching. The most obvious method of doing this is by combining the incoming records into a single database which relies on a standard metadata schema and focuses on the objects themselves. This is the solution preferred by large national and international aggregators such as Trove in Australia, the Digital Public Library of America and even Europeana. But this approach almost inevitably seems to involve reducing the content of each aggregated record to a minimum, affecting both the richness and the discoverability of the data.

More ambitious though more experimental is the use of Linked Data and Semantic Web technologies, focusing on the relationships between objects, persons and events and enabling more complex semantic navigation. This approach has the potential to retain much more of the semantic richness of the data, and even to add value to it by situating it within a broader context of knowledge graphs and networks (Hyvönen 2012). Some projects using this approach are discussed below.

Political and policy issues are equally significant. Institutions vary greatly in their willingness to share data, for several different reasons: a feeling that their data are not of sufficient quality; an assumption that data are important intellectual property; a need to raise revenue through sales of digitized objects; and so on. They also vary greatly in their ability to share data (from a technical point of view), or to support all but the simplest type of export or download. In relation to Linked Data specifically, the institution may well take the view (as the National Library of Australia has done recently) that the 'business case' has not yet been proved – that is, that there is insufficient demand to justify investing time and money in establishing suitable processes.

Collections Data in Action

Despite this range of issues and potential barriers, there are a growing number of examples of major institutions sharing their collections data, in both the museum and library worlds. In the library sector, the OPenn service makes available descriptive data and images relating to manuscripts held in the University of Pennsylvania Library. Each manuscript has a descriptive file (TEI-encoded[1]) and a set of digital images, all of which can be downloaded and reused freely. The Bodleian Library (Oxford University) is doing something similar for its new medieval manuscripts catalogue. In addition to a new Web catalogue, the descriptive data are available for download from a GitHub[2] repository as TEI-encoded files.

Several major museums have also made their collections data available, enabling researchers and users to analyse, create and play (Fitzpatrick 2017). The release of the collections data of the Museum of Modern Art (MoMA) in 2014 led to a series of experiments, including an analysis of the collection of paintings by size and an analysis of the Museum's acquisition activities in which year of creation was mapped against year of acquisition. The Tate Gallery (London) released its collections data in 2013 as CSV files.[3] Among the uses made of the data was to re-work them as a network graph using the Neo4j[4] software (Cunningham 2014). This enabled users to find and display (among other things) the shortest path of relationships between two artists, such as Augustus John and William Johnstone.

More unexpected and entertaining uses of the collections data have included Twitter bots which automatically tweet database records from institutions like the Tate Gallery and the Rijksmuseum (Amsterdam), accompanied by an image of the object. More unusual still was a performance of MoMA's (New York) collections data as a series of spoken texts read by Museum staff (Thorp 2015).

Several current projects are working with collections data to answer complex research questions and build humanities-oriented infrastructure. The 'Collecting the West' project is bringing together data relating to Western Australian objects held in collections in Australia and Europe. The software being used is the British Museum's ResearchSpace, which maps collections data to the CIDOC-CRM[5] ontology and enables complex semantic exploration of the results. Initially limited to the British Museum's own collections, it is now been tested by other institutions in Europe and North America. ResearchSpace, which is built from the Metaphactory platform, enables researchers to work with collections data by adding annotations and arguments to objects and other entities.

OxLOD (Oxford Linked Open Data) is taking a generally similar approach, mapping heterogeneous collections data from Oxford University's museums and libraries to produce an interdisciplinary platform for cultural heritage research. An estimated 200,000 digital records will be linked and mapped in the initial phase of this project. This project builds on work previously done for the CLAROS initiative, and is employing a Linked Data approach based on the CIDOC-CRM ontology. Oxford University did conducted a survey of its cultural heritage collections in 2016, which identified significant gaps in descriptive data about the collections, with about 40% undescribed (Cannon and Madsen 2016). It also revealed that only a tiny proportion of the collections have been digitised – probably less than 1%.

Another project working in the same general area is 'Mapping Manuscript Migrations', funded by the Digging into Data Challenge for 2017-2019. A collaboration between institutions in the United Kingdom, the United States France and Finland, this project is bringing together data from a range of major databases to map and analyse the histories of as many manuscripts as possible. The initial data sources include the Schoenberg Database of Manuscripts, which contains observations relating to the provenance of specific manuscripts; the Bodleian Library's new Medieval Manuscripts Catalogue, which contains TEI-encoded descriptions; and two databases services from the Institut de recherche et d'histoire des textes – the Medium database, with brief descriptions of manuscripts, and the Bibale database, with provenance records. Data from these sources are linked through a common data model, and expressed as Linked Data in RDF[6] format.

This project in its turn builds on an earlier investigation into the history of the vast manuscript collection of Sir Thomas Phillipps (1792-1872). Using collections data from various library and museum sources, I traced the history of a sample of his more than 40,000 manuscripts, which were dispersed to a range of public and institutional collections in the century after his death. The histories of individual manuscripts can be mapped and visualised, together with the network graph of people, places and institutions involved in these events (Burrows 2017). Phillipps collected all kinds of manuscripts, from beautiful and lavish volumes to ephemeral scraps of paper, and the history of his collection reveals a good deal about the interplay between connoisseurship and antiquarianism. The evidence for his activities is large and varied, but there are various difficulties with making use of the data. Many modern collections are poorly documented, with objects lacking any kind of descriptive data. Many library and museum databases handle provenance information in a way that is difficult to use computationally, and a surprising number make it very hard to download bulk data.

Another service which relies heavily on the reuse of collections data is HuNI, the Australian virtual laboratory for the humanities, which ingests records from library catalogues as well as data from various archives (Burrows and Verhoeven 2015). It also aggregates data from the Trove digitised newspaper collection, and from reference works, bibliographies and event-oriented databases, amounting to more than thirty in all. HuNI has recently added a pipeline from ingesting data for collections created with the Omeka[7] software.

HuNI re-formats collections data by extracting entities from incoming records and making them available for linking and visualising, in the form of nodes on a network graph. Interpretations can be added to the data by users, in the form of relationships and links between nodes, using terminology created by the user. Entities can also be selected and saved in users' own collections, employing their own categorisations and classifications. The network can be explored visually, and can be searched for all nodes connected to a specific node, up to five links away, as well as for the shortest path between two nodes.

One of HuNI's main aims is to enable vernacular, user-driven knowledge structures, rather than simply importing those found in the data sources. This is one of the biggest issues arising from the reuse of collections data: the way in which these databases embody a specific set of terminologies, vocabularies and ontologies – a particular view of the world. Whose authority do the data represent? For the most part, this is the curatorial perspective of the collecting institutions, rather than the perspectives of researchers or of the wider community – let alone the perspectives of the Iindigenous communities from which many significant cultural objects originate.

What these projects and services have in common is the idea of taking collections data and using them to create new knowledge structures, especially in the form of network graphs of relationships between entities – including people, places and objects. While there are other things that can be done with collections data (such as the comparison of images using the International Image Interoperability Framework,[8] and the analysis of the texts carried by cultural objects), network graphs are a powerful way of uncovering the meaning and significance of the knowledge embedded in cultural heritage collections.

These three projects share a common interest in using collections data to answer research questions, not just as a route to discovering the contents of cultural heritage collections. They aim to make it possible for research to work actively with collections data, rather than simply consuming collections data for searching and browsing. They also show how collections data can be exploited to address research questions around the nature of collections themselves and around the development of knowledge graphs.

Next Steps

To make services like these possible, collections data need to be made available in certain ways and under certain conditions. Recommendations for best practice, at the moment, tend to be focused mostly on processes and procedures, encompassing download formats, licensing, and availability in particular (Fitzpatrick 2017). These are undoubtedly important; having collections data easily accessible in bulk on the Web, under a Creative Commons licence that permits free reuse, is essential. Download formats are more debatable: APIs[9] are not necessarily the best approach, given that their use is likely to require a significant level of technical expertise (Tauberer 2014). XML[10] dumps and CSV files are easier to use, but may not contain all the elements in the source database.

As the interest of researchers in reusing collections data continues to grow, however, cultural heritage institutions increasingly need to start looking beyond simply making their data available for bulk downloading or via an API. One of the major use cases is to link together data from different institutions, without diminishing the semantic richness, in order to ask questions on a larger scale. At the moment, researchers are having to do much of this work themselves. This raises two important questions: should institutions help this process, and what kind of infrastructure might be built as a result?

The prominence of Linked Data in the solutions being adopted by researchers strongly suggests that institutions should make their data available in formats suitable for incorporation into Linked Data environments. While many institutions might not yet see a 'business case' for this approach, others like the British Library and the British Museum have already followed this route. Making available an RDF version of a relational database would be a significant contribution. But even embedding into that database identifiers that point to widely-used Linked Data ontologies and vocabularies like VIAF,[11] GeoNames[12] and Wikidata[13] would be valuable. So too would taking a critical look at ways of improving the computational value of ownership and provenance data in these records. Enabling researchers and curators to annotate and add to the data is also emerging as an important requirement.

Beyond this, though, lies the wider landscape of digital infrastructure. The Santa Barbara Statement on Collections as Data (2017) observes that 'Working toward interoperability entails alignment with emerging and/or established community standards and infrastructure.' At present, the Linked Data

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landscape is largely being built by research groups rather than cultural institutions, which still tend to focus on their own collections. In this context, an initiative like 'Linked Pasts', which has emerged from the Pelagios Commons, is an important development, offering a vision of joining up disparate Linked Data projects in the humanities to create a 'wider ecosystem' (Grossner and Hill 2017).

As long as these kinds of initiatives remain tied to research projects, their future sustainability will be reliant on the uncertainty of grant funding. Collecting institutions should look closely at them as outcomes of the reuse of collections data, and consider seriously the value of partnerships with the researchers involved. Building knowledge networks that represent the history and transmission of culture as seen through the biographies of objects is a major research goal. Collections data have a vital role to play in that process.

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References

Abels, R. 2014. "Cultural Representations of Warfare in the High Middle Ages: The Morgan Picture Bible." In *Crusading and Warfare in the Middle Ages: Realities and Representations: Essays in Honour of John France*, edited by S. John and N. Morton, 13-35. Farnham: Ashgate.

Adams, J. 2016. "Magic and Memory: Paul Denys Montague's Collection from New Caledonia." *Journal of the History of Collections* 28 (2): 279–292.

Always Already Computational: Library Collections as Data. 2017. https://collectionsasdata.github.io/

Australian Government. 2016. *National Research Infrastructure Roadmap*. Canberra: Australian Government.

Borgman, C. L. 2007. *Scholarship in the Digital Age: Information, Infrastructure, and the Internet*. Cambridge: MIT Press.

Burrows, T. 2011. "Sharing Humanities Data for E-Research: Conceptual and Technical Issues." In *Humanities Perspectives on Digital Scholarship*, edited by N. Thieberger, 177-192. Melbourne: PARADISEC. http://ses.library.usyd.edu.au/bitstream/2123/7938/1/Burrows.pdf

Burrows, T. 2017. "The History and Provenance of Manuscripts in the Collection of Sir Thomas Phillipps: New Approaches to Digital Representation." *Speculum* 92 S1:S39-S64.

Burrows, T., and D. Verhoeven. 2015. "Aggregating Cultural Heritage Data for Research Use: The Humanities Networked Infrastructure (HuNI)." In *Metadata and Semantics Research, 9th Research Conference, MTSR 2015, Manchester, UK, September 9–11, 2015: Proceedings*, edited by E. Garoufallou, R. J. Hartley, and P. Gaitanou, 417-423. Cham: Springer.

Cannon, C., and C. Madsen. 2016. "The Future of Finding at the University of Oxford." Paper presented at CNI Fall Membership Meeting, Washington D.C. Accessed 12-13 December 2016. https://www.slideshare.net/mccarthymadsen

Collections as Data. 2017. "Shaping Humanities Data: Use, Reuse, and Paths Toward Computationally Amenable Cultural Heritage Collections." https://collectionsasdata.github.io/dh2017/

Cunningham, L. 2014. "Graphing the Tate." *Larkin Cunningham* [blog]. Accessed 22 December 2014. http://larkin.io/index.php/2014/12/22/graphing-the-tate/

Fitzpatrick, L. K. 2017. "Shared practices in museum open collections data." *Medium*. Accessed 22 February 2017. https://medium.com/berkman-klein-center/shared-practices-in-museum-open-collections-data-72e924c4849a

Flanders, J. 2014. "Rethinking Collections." In *Advancing the Digital Humanities*, edited by P. Longley Arthur and K. Bode, 163-174. London: Palgrave MacMillan.

Grossner, K., and T. Hill. 2017. "From linking places to a linked pasts network." http://kgeographer.com/pubs/LinkedPastsNetwork_7Dec.pdf

Hyvönen, Eero. 2012. *Publishing and Using Cultural Heritage Linked Data on the Semantic Web*. San Rafaell, CA: Morgan & Claypool.

Kopytoff, I. 1986. "The Cultural Biography of Things." In *The social life of things*, edited by A. Appadurai, 64-91. Cambridge: Cambridge University Press.

MacGregor, N. 2010. *A History of the World in 100 Objects*. London: Penguin.

Posner, M. 2017. "Actually useful collection data: some infrastructure suggestions." In *Always Already Computational: Library Collections as Data: National Forum Position Statements*. https://github.com/collectionsasdata/collectionsasdata.github.io/raw/master/aac_positionstatements.pdf

Rivers, W. H. L. 1910. "The Genealogical Method of Anthropological Inquiry." *Sociological Review* 3 (3): 1-12. *Santa Barbara Statement on Collections as Data*. 2017. https://collectionsasdata.github.io/statement/

Tauberer, J. 2014. "Bulk Data or an API?" https://opengovdata.io/2014/bulk-data-an-api/

Thorp, J. 2015. "A sort of joy: performing MoMA's 120,000 object collections database." *Medium*. Accessed 27 July 2015. https://medium.com/memo-random/a-sort-of-joy-1d9d5ff02ac9

Van Horn, J. 2017. *The Power of Objects in Eighteenth-Century America*. Chapel Hill: University of North Carolina Press.

Endnotes

1 The Text Encoding Initiative (TEI) is "a consortium which collectively develops and maintains a standard for the representation of texts in digital form. Its chief deliverable is a set of Guidelines which specify encoding methods for machine-readable texts, chiefly in the humanities, social sciences and linguistics." See http://www.tei-c.org/

2 GitHub "is a web-based version-control and collaboration platform for software developers… Git is used to store the source code for a project and track the complete history of all changes to that code." (https://searchitoperations.techtarget.com/definition/GitHub)

3 CSV files are comma separated values files, that can be imported into any spreadsheet or relational database software.

4 Neo4j is an open-source software for managing graph databases.

5 CIDOC-CRM is the Conceptual Reference Model (CRM) of the Comité International pour la Documentation (CIDOC), in English the International Com mittee for Documentation, of cultural heritage implemented by ICOM, the International Council of Museums. It "provides definitions and a formal structure for describing the implicit and explicit concepts and relationships used in cultural heritage documentation" see http://www.cidoc-crm.org/

6 Resource Description Framework (RDF) "is a standard model for data interchange on the Web. RDF has features that facilitate data merging even if the underlying schemas differ, and it specifically supports the evolution of schemas over time without requiring all the data consumers to be changed" see https://www.w3.org/RDF/

7 Omeka software "provides open-source web publishing platforms for sharing digital collections and creating media-rich online exhibits" see https://omeka.org/

8 International Image Interoperability Framework (IIIF) provides common application programming interfaces that support interoperability between image repositories, to enable ease of viewing both images and their associated metadata, see http://iiif.io/about/

9 API is an Application Programming Interface, a "set of commands, functions, protocols, and objects that programmers can use to create software or interact with an external system" see https://techterms.com/definition/api

10 Extensible Markup Language (XML) is "is a simple text-based format for representing structured information" that is both human-readable and machine-readable, see https://www.w3.org/standards/xml/core

11 VIAF (Virtual International Authority File) "combines multiple name authority files into a single OCLC-hosted name authority service. The goal of the service is to lower the cost and increase the utility of library authority files by matching and linking widely-used authority files and making that information available on the Web" see https://viaf.org/

12 GeoNames is a "geographical database covers all countries and contains over eleven million placenames that are available for download free of charge" see http://www.geonames.org/

13 Wikidata "is a free and open knowledge base that can be read and edited by both humans and machines. Wikidata acts as central storage for the structured data of its Wikimedia sister projects including Wikipedia, Wikivoyage, Wikisource, and others" see https://www.wikidata.org

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3D Laser Scanning Built Heritage: St Boniface´s Church as a Teaching Eexperience

Abstract

The use of new technologies to record existing architectures is increasing as they become cheaper and more accessible than ever before. Among them, 3D laser scanning (also known as LiDAR) is of particular relevance for surveying built heritage since it can provide full documentation of the reality in the form of a three-dimensional coloured point-cloud, measurable and with a precision of millimetres, in a short period of time. Although its use is not new, especially in the subject of cultural heritage, its inclusion in architectural education is recent. The quality and comprehensiveness of the data, from which architectural drawings are obtainable at any scale, among other products such as images, videos, and 3D printed models, challenges the traditional way of surveying buildings and can have further implications for architectural studies. This paper reflects on the first teaching experience of 3D laser scanning applied to built heritage at The Bartlett School of Architecture, UCL, which challenged previous uses of this method by capturing a complete building and generating architectural products from it in a few classes. Using the case of St Boniface´s Church in London, the objective of this paper is to account for and reflect on the data obtainable in just one day of on-site 3D laser scanning capture. Framing these products within a brief revision of surveying methods of buildings over time, the paper establishes the importance of 3D laser scanning for recording built heritage. The workflow of on-site data collection, processing and model making in only a few sessions is presented as a way to speculate over new architectural possibilities when the reality is available as-built with accuracy. Approaching an era where almost everything can be captured digitally might have implications for the way the physicality of historic buildings is perceived and preserved.

Keywords: 3D laser scanning; St Boniface´s church; Built heritage; Surveying; Teaching

Surveying heritage buildings

Over time, buildings have been recorded using different techniques, which has had a direct impact on architectural representation. However, it is hard to find evidence of that process before the Renaissance and the architectural treatises of that period.

> We can find the roots of modern architectural representation in a large body of drawings surviving from the sixteenth century onwards. The evidence is more sparse from earlier times. Virtually nothing survives from antiquity and the early Middle Ages — some Egyptian papyruses, the marble plan of Rome, a newly discovered full-scale elevation of the pediment of the Pantheon, and the parchment plan of the abbey of St. Gall being notable exceptions. (Ackerman 1997, 41)

There is no clarity around how these drawings captured the measurements of the buildings they represent, which leads to the question of how accurate they are. There is also no certainty that these drawings had the purpose of representing something already built. Before the concept of scale drawing existed, Ackerman (1997) notes that full-scale drawings of massive constructions were often drawn on the ground. Similarly, engravings of as-built windows and spires have been found in the masonry of buildings, suggesting an embedded process of design based not only on verbal communication, but also on models and templates. This suggests that scaled architectural drawings were not needed for the construction of new buildings.

> Architecture has not always been an art of drawing. For much of history, right up until the Italian Renaissance, architecture was a mechanical craft, and buildings were conceived and made by artisan workers who laboured and toiled on building sites, cutting stones, laying bricks and sawing timber. (Carpo 2013, 128)

Therefore, the construction *as-built* would be the best source of information and how measurements are extracted from it would define the accuracy of that operation. From proportional units and methods to the use of the most advanced technology, surveying heritage buildings is a task that has improved over time mainly regarding the quality of the result in relation to the time invested.

> Primitive practices make use of a familiar 'yardstick' as a unit of measurement. Sources of measuring yardsticks are usually the human body, or the structure itself. The human source provides measuring units as the person's pace, handspan, or height. Such units are obviously handy and convenient. (Elwazani 1989, 84)

However, precision was an issue. Proportional drawings and sketches 'based on counting uniform construction units' (Elwazani 1989, 84), are still used as a way of taking fewer measurements on-site; 'the rest is estimated by proportion' (Elwazani 1989, 85), although not suitable for the documentation of important structures due to its low accuracy.

Hand-measured drawing is probably the most known and used method for surveying existing buildings, with a precision that would depend on the surveyor´s experience and type of structure. Triangle methods,[1] and the use of complementary instruments, such as levels,[2] theodolites,[3] plane tables,[4] and more recently digital laser measurers, would improve the result. Other complementary devices, such as the adjustable combs,[5] were used until the 1980s and were key to obtaining the shapes of intricate details — for example, mouldings — that were then transferred to paper. These methods are still used in architectural education, not because of their accuracy but as a way of observing the reality in a spatial way, and to develop representational tools in which drawing — especially drawing by hand — can remain relevant to the discipline, particularly given the current digital emphasis in education.

Photography is commonly used as a complementary technique for surveying buildings since it is fast and accessible. Although it cannot capture dimensional information directly from the built reality, measurements can be extracted from photographs with the techniques of rectified photography, photogrammetry and stereo-photogrammetry. The latter allows for the creation of three-dimensional digital models using several images of objects and specially created algorithms. However, these are better for documenting objects, murals paintings and details, rather than for surveying architecture. The limitations of photogrammetry include difficulty in applying the technique to large-scale buildings, and how expensive it can become when high accuracy is needed:

> It is almost impracticable to obtain complete photogrammetric archives covering the very minutest detail when the subject is a major building. Defining the specific purpose of a survey is certainly one of the most important tasks over which architects and photogrammetrists must help one another. (ICOMOS 1968, 162)

Despite the advances in photogrammetric techniques nowadays, it is time-consuming to obtain quality data of complete structures using it. This is why it is common to find a combination of these methods to obtain a metric survey of a building, especially if cultural artefacts and works of art are part of it. In the context of technological advances, these methods will become outmoded rapidly, which is why the focus of this paper is not on describing them.

One of the techniques that has had the most impact on the way heritage buildings are currently surveyed is 3D laser scanning. It is an efficient way — in terms of time and resources — of accurately recording historical environments compared to the previously mentioned methods. There is a range of 3D laser scanning techniques described, classified, and exemplified with case studies by current literature. For example, Historic England (2018) provides guidance for the correct selection of methods and their application to the surveying of built heritage. The most popular ones, which involve capturing the reality by projecting light over a surface to digitally reconstruct its geometry — for example, the Sense 3D Scanner — are limited in range; useful for objects, but not for capturing entire built spaces. Simpler imaging techniques used to generate a three-dimensional model of an object use principles of photogrammetry and stereo-photogrammetry — such as Agisoft. From them, this paper focuses only on 3D laser scanning using a terrestrial Faro Focus x330, mounted on a surveyor tripod.

In this method, the measurements are taken by a rotating 360º laser beam, which captures millions of points of the surfaces it hits. Then, a photo camera, embedded in the scanner, takes photographs to colourise the points, creating a three-dimensional digital model of the reality with a precision of millimetres. It captures everything in sight, even those elements that were not initially intended to be part of the survey. 3D laser scanning is not a new technology,[6] but has developed rapidly. The equipment is still expensive, although half the price it was a couple of years ago, ranging from £40,680 to £50,325 depending on the model.[7]

Currently, surveying heritage buildings will usually consider a mixture of methods, defined according to the importance of the structure and the time and funding available for that task. ‘Few buildings are surveyed using a single technique. A number of techniques, both direct and indirect, are commonly deployed and the data integrated to obtain a finished survey’ (Bedford and Papworth 2009, 4).

However, since 3D laser scanning could be seen as the most comprehensive of those methods in terms of obtaining measurable data of buildings in a short period, it can — even if used alone — provide the information necessary for an almost complete architectural survey of a building. Thus, this paper focuses on testing that principle in an educational context, by applying and understanding the 3D laser scanning process as a practical teaching experience.

DEVILAT

3D laser scanning is being taught in a series of elective classes open to students and staff at The Bartlett School of Architecture, University College London (UCL), covering the general aspects of the method through to its specific applications for built heritage[8] and virtual reality.[9] The aim of these classes is to provide a practical set of tools for operating and post-processing 3D laser scan data in order for participants to use and apply this knowledge in their research and designs. Critical thinking is encouraged at the beginning of the course by showing a series of examples of the scanner's use in innovative ways that can inform architectural approaches, yet not limited only to the discipline. By enabling the participants to interact with the 3D laser scans directly, they can discover their own ways of applying and thinking about the threshold between digital and real.

In the two sessions of classes focused on the general method, part of the school's building is scanned with the students who first learn how to operate the equipment, and then how to post-process the data and create images and videos. Figures 1 to 4 are some images obtained using two scans done during classes, which took less than seven minutes each.

The built heritage classes of 2016-2017 academic year considered the 3D laser scanning of St Boniface's church in London, a case defined by the Survey of London, based also at The Bartlett School of Architecture. Focusing only on that building, the objective was to generate a complete survey, testing if it can provide all the measurements required to create detailed technical drawings for architectural purposes, considering a limited scanning time of one day on-site. This was a constraint to test how much could be done in a short period, in order to make easier comparisons with other surveying techniques, but also to create a scenario that would have reduced costs, since one of the expensive parts of a 3D laser scanning survey is accessing the equipment. As a complementary objective, the idea was to share the products created from this survey with the community involved in the building selected, with the potential of being used for

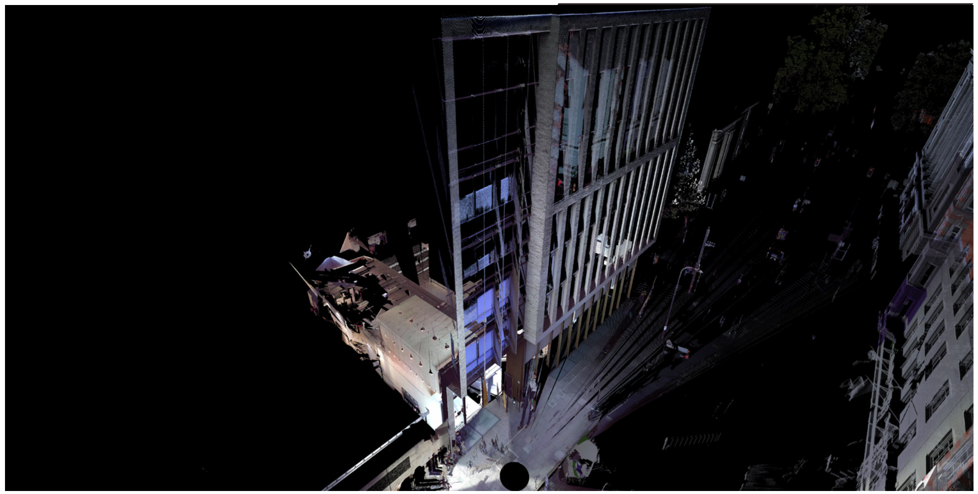

Figure 1. Aerial view of 22 Gordon Street, London, where The Bartlett School of Architecture is located. It was rendered using only one scan done outside the building during the first general class in 2017. (Source: author).

Figure 2. Elevation of the main façade of 22 Gordon Street. (Source: author).

future repairs or retrofitting projects or just as new forms of representation.

These built heritage classes consisted of five sessions that covered the whole workflow of scanning: introduction and planning of a 3D laser scanning survey (half a day); on-site 3D laser scanning of St Boniface's church (one day); alignment of the three-dimensional data (half a day); digital drawing (half a day); meshing and modelling (half a day); and 3D printing (two day workshop). These sessions built upon the contents of the general method classes, allowing a more specific focus on architectural applications and the discussion of 3D laser scanning implications for the preservation of historical environments.[10] The classes are practical and technical based on the assumption that covering the whole process of 3D laser scanning on-site to post-processing would enable students to understand the logic behind this method. Since the principles are common to similar scanning techniques, this approach would allow participants to adapt to new technologies in the future.

St Boniface's church

The current Roman Catholic Church of St Boniface is a post-war building located in Adler Street in London, built in 1960. It is a distinctive example of modern architectural design. The current building replaced the previous church, which was 'entirely destroyed in September 1940 by a high-explosive bomb' (Survey of London 2016). The initial design was done by the German Architect Toni Hermanns in 1954, which was rejected by The Archdiocese. The design was then revised by Plaskett Marshall & Partners, obtaining approval 'in 1957 after debate over the cubic or auditory nature of the main space, progressively non-processional for a Catholic congregation at this date' (Survey of London 2016).

This church was selected as a case study for several reasons. First, the nonexistence of architectural drawings of the building, so the surveying of it *as-built* was relevant for the work of the Survey of London. Second, its size and simple spaces helped the task of completing the 3D laser scanning in only one day.

Figure 3. Interior view of 22 Gordon Street. (Source: author).

Figure 4. Interior section of 22 Gordon Street using only two scans. (Source: author).

Third, the church has embedded artworks within its structure that could be documented along with the rest of the building, such as a mural on the altar wall, decorated railings and carved wood details.

3D laser scanning on-site survey

As the main area of the church is one only large space, not interrupted by columns or other elements, it was captured by only a few scans, giving extra time to capture the exterior, access space, narthex and presbytery. During the survey, spherical and paper references were used, and the scanner was moved into different locations in order to capture the whole building.[11] As the 3D laser scanner only captures surfaces, to get the exterior façades of the building, it was required to scan from the streets. One of the challenges of doing this was the weather since the model of 3D scanner used cannot operate when raining. The survey was adjusted accordingly to scan exterior spaces when the rain stopped temporarily, obtaining 28 scans in total that captured millions of points.[12]

Since the 3D scanner model used is terrestrial, aerial information cannot be captured from the street level, unless the scanner is placed in a higher position. In this case, it was possible to capture aerial data of the church's roof and its surroundings from the roof terrace of an opposite building (Figures 5 and 6).[13] Another limitation of 3D-laser-scanners is that they capture everything in sight, which means that unwanted elements can interfere in the target — such as trees and people. Automatic filters are embedded in the post-processing software[14] to discard irrelevant information and noise from the scene, improving the desired visual product. Manual editing can also help to eliminate unwanted information, which increases post-processing times.[15] Considering the comprehensive outcome, these limitations are minor, and most of them are currently overcome by the latest developments in hardware and software, as the technology is advancing fast and complementary equipment is currently on the market to help fill possible voids during the scanning process.

Post-processing and creation of products

The post-processing of the data captured on-site was done during the following three sessions of the course. Besides digital navigation, the resultant 3D point-cloud was used to generate a series of sub-products, such as images (Figures 7 to 9). The information was also used in black and white despite being captured in full colour (Figure 10). Sectioning the point-cloud allowed technical views to be generated — plans, sections and elevations — that can be rendered and printed later at any architectural scale (Figures 11 to 17). However, technical vector drawings are most common to use as a survey product for heritage buildings, for which the technical views served as a measurable reference upon which to draw (Figure 18).

As with any other representation method, 3D laser scanning offers its own particular aesthetic quality. However, the transparency and immateriality of the rendered images contrasting with the physical building they depict are a subject left for further studies. The relevant aspect to mention here — in terms of

Figure 5. 3D laser scanning from the roof terrace of a hotel opposite to St. Boniface's church in London. (Source: author).

Figure 6. Top view of St Boniface´s church and its surroundings, rendered from the 3D laser scanning survey done in December 2016. (Source: author).

representation — is the fact that as the images from 3D laser point-clouds are computer generated, they might mislead the viewer as portraying something that is not real, despite representing probably the most precise record of St Boniface's church done so far. To avoid that, the black background has been chosen by the author as a way to distinguish and avoid confusion with digitally created models or other forms of documenting, such as photographs. This is relevant to mention in the context of the widespread use of digital modelling to recreate the previous status of constructions and augmented reality mainly for touristic purposes in the cultural heritage domain.

In the last session, the three-dimensional aspect of this 3D laser scanning survey was better conveyed via the creation of models. While in architecture, models are usually created as a medium for designing buildings, in this case, the models were created from an *as-built* condition, as a way to represent reality. This reverse operation potentially allows us to capture and transform any existing architecture into a miniature scale, and to replicate it as much as required, with implications for the originality and authenticity of the heritage building. In order to do this, the 3D laser point-cloud was converted into a mesh, and then into a 3D printable format (Figure 19). Due to the high-resolution of the 3D laser scanning, the data was subsampled, which means using only a small proportion of the points measured to facilitate the conversion process.

The technical views and models (Figures 20 to 22) were created during the final part of the course, a two-day workshop, which included a final open presentation also attended by members of St Boniface's church community. These products were generated by the four participating students and given to the priest of the church, as a way to make the 3D laser scanning survey accessible and potentially useful in the future, especially relevant since there were no updated planimetrical drawings of the church.

In only five sessions and a workshop, corresponding to a total of five days of teaching and practice, the students learned how to use 3D laser scanning in their

Figure 7. Aerial view of the church and its surroundings. (Source: author).

Figure 8. Interior view of the church. (Source: author).

Figure 9. Interior view from over the altar of the church. (Source: author).

own projects — from capture to post-processing. This experience has a direct implication for surveying built heritage in comparison to a hand-measured method, which, even when complemented with other techniques such as photogrammetry, would have taken more time on-site and to post-process in order to generate similar products, as demonstrated in previous studies (Devilat 2014, 2016).

The complete 3D laser scanning survey of St Boniface's church needed on average six persons and one day of on-site data capture (six person-days). Alignment of the 3D data was done by one person in two days (two person-days). The creation of images and technical views was done by three persons in two and a half days (seven and a half person-days). The creation of a linear plan drawing from 3D data was done by one person in four and a half days. Finally, the creation of digital models and 3D prints was done by two persons in two and a half days (five person-days). This would be a total of 32 person-days.

Figure 10. Black and white exterior view of the church. (Source: author).

Even if a similar survey could be done in the same period, 3D laser scanning offers more possibilities and stands as a more comprehensive record due to its three-dimensional quality, leading to further uses (Figure 23).[16] This potentially eliminates the need to define its purpose *a priori* and generates a digital record that can serve for other uses in the future. In this regard, documenting the reality using 3D laser scanning is being used internationally for built heritage at risk, creating digital models that can persist over time beyond their physical version, for example, Cyark.[17] Archiving the surveying material generated then becomes key. This is why the data created in the teaching context of the classes is uploaded to The Bartlett 3D Scan Library, an online archive of 3D laser scanned buildings,[18] which might have an essential role in the future.

As the first teaching experience of this kind at The Bartlett School of Architecture, UCL, measuring its impact can be difficult since its implications and applications are embedded at many levels in students' designs and research. However, the main objective

Figure 11. Isometric view of the church. (Source: author).

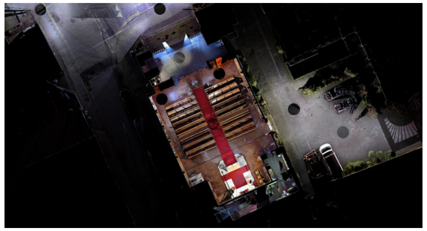

Figure 12. Ground floor plan of the church. (Source: courtesy of E. Savvidis and M. Daouti).

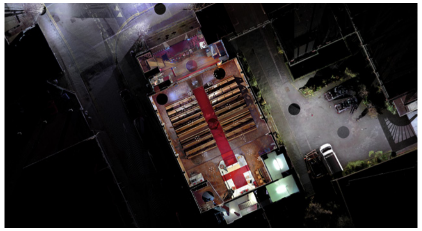

Figure 13. First-floor plan of the church. (Source: courtesy of E. Savvidis and M. Daouti).

Figure 14. North façade elevation of the church. (Source: courtesy of E. Savvidis and M. Daouti).

Figure 15. West façade elevation of the church. (Source: author).

Figure 16. Longitudinal section of the church. (Source: author).

Figure 17. Transversal section of the church. (Source: courtesy of E. Savvidis and M. Daouti).

of the course, to enable students to use this method in their own projects, is exemplified by the work of Anastasios Theodorakakis for St Dunstan in the East, London, which stands out as a form of enquiry regarding that space as a real/digital palimpsest (Figure 24).[19]

Conclusion

With the availability of a measurable 3D model of the reality provided by the laser scan data, the way of surveying buildings is adapting and updating. Its convenience has the potential to change how we intervene and preserve historic buildings. Such an accurate and fast recording method has not been widely available before, which has direct consequences for their replication and digital presence beyond the physical building. This is also relevant since it leads us closer to the idea that more heritage buildings can be documented in a more comprehensive way, where the method applied has proven to be useful to obtain a large amount of information in short period of time, even in a teaching context.

Providing access to the 3D laser scanning equipment, it has been shown how this method can be taught and practised while carrying out a metric survey, with challenges the way architectural surveying is usually done. Additionally, the 3D laser scanning can serve as a basis to inform and speed up the production of traditional representation methods, such as the linear drawings of plans, sections and elevations. This has the potential of breaching the gap between traditional and current surveying technologies.

The experience shown challenges the notion of 3D laser scanning as an expensive method, since the compression of the on-site scanning and teaching in only five sessions and a workshop, was a way to render the method as affordable by comparison with the amount of workforce and time that would be necessary to obtain and process the same amount of data with traditional methods. In this regard, the unavoidable and still high cost of possessing a 3D

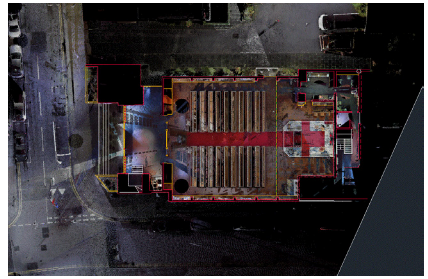

Figure 18. Linear digital drawing of the plan over the 3D laser scanning of St Boniface's church. (Source: courtesy of H. Jones).

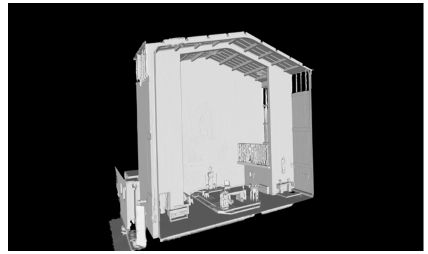

Figure 19. Model of the altar of the church after converted into a mesh using MeshLab software. (Source: author).

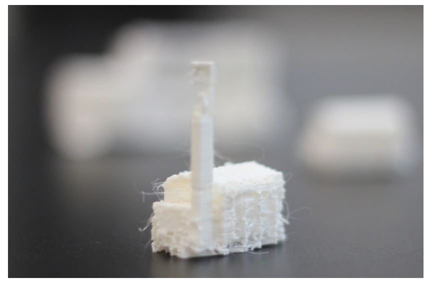

Figure 20. 3D printed models of the church based on the 3D laser scanning data of 2016. (Source: author).

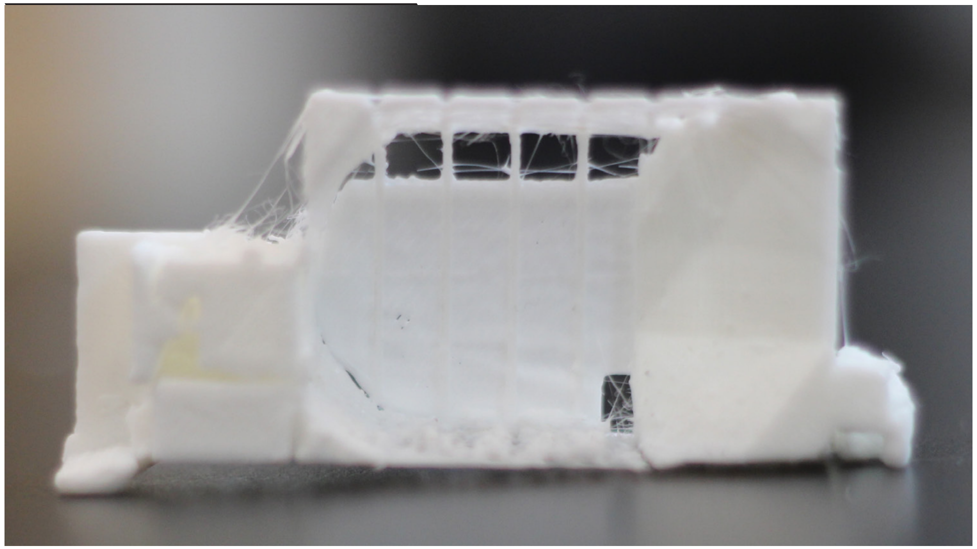

Figure 21. 3D printed models of the church based on the 3D laser scanning data of 2016. (Source: Author).

Figures 22. 3D printed models of the church based on the 3D laser scanning data of 2016. (Source: Author).

laser scanner can potentially be lowered with the alternative of hiring the equipment for just one day.

The three-dimensional quality of the 3D laser scanning record establishes a new standard of documentation where there is no fixed point of view — as with photography — or where the record is limited to what was carried out at a particular moment for a determined purpose. In this case, all the products were rendered after the data collection on-site, with a digital model that is archived for future purposes, potentially going beyond the teaching experience presented here.

Finally, the possibility of capturing almost all spaces of a case study also changes the mindset from an architect's point of view, by providing the media over which detailed and precise interventions can be designed to fit perfectly in the reality. Thus, a longer course could have the potential to extend the study of digital recording technologies in architecture — especially as a method of analysis and research when applied to historical environments — and its further implications.

Supplementary material

A video exploring the 3D-laser-scan model of St Boniface's church in London is available from https://vimeo.com/251035025.

Figure 23. QR code to a video showing the 3D-laser-scan model of St Boniface's church in London. Also available from https://vimeo.com/251035025. (Source: author).

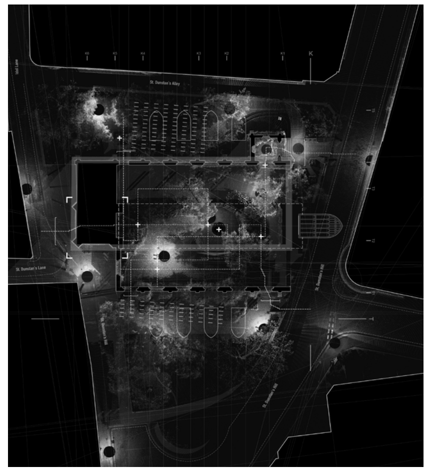

Figure 24. Superimposition of technical drawings on top of the plan obtained from the 3D laser scanning of St Dunstan in the East, London. (Source: courtesy of Anastasios Theodorakakis).

References

Ackerman, J. 1997. "Villard de Honnecourt's Drawings of Reims Cathedral: A Study in Architectural Representation." *Artibus et Historiae*. 18: 41–49.

Bedford, J., and H. Papworth, eds. 2009. *Mh* Swindon: English Heritage.

Carpo, M. 2013. "The Art of Drawing." *Architectural Design* 83: 128–133.

Devilat, B. 2014. "3D Laser Scanning for Recording Heritage Areas in Post-Earthquake Re-construction. The Cases of Lolol and Zúñiga in Chile." *Visibile Invisibile. Percepire la città tra descrizioni e omissioni. Proceedings VI AISU CONGRESS,* edited by S. Adorno, G. Cristina, and A. Rotondo, 2013-2024. Rome: Scrimm Edizione.

Devilat, B. 2016. "Recording of Heritage Buildings: From Measured Drawing to 3D Laser Scanning." In *Drawing Futures*, edited by L. Allen and L. C. Pearson, 236–240. London: UCL Press.

Elwazani, S. 1989. "Development of Criteria for Selecting Methods of Documentation of Historic Structures." PhD diss., The Catholic University of America.

Historic England. 2018. *3D Laser Scanning for Heritage. Advice and Guidance to Users on Laser Scanning in Archaeology and Architecture*. Swindon: Historic England.

ICOMOS. 1968. "Summary Report on the Symposium 'Application of Photogrammetry to Historic Monuments'." Paris: ICOMOS.

Survey of London. 2016. "St Boniface German Church, 47 Adler Street." Accessed 16 May 2018. https://surveyoflondon.org/map/feature/308/detail/#the-german-roman-catholic-church-of-st-boniface-adler-street

Endnotes

1 Triangle methods 'are based on constructing one or more triangles from identified dimensions on site or on the structure. Not all dimensions are measurable or known, of course. The unknown dimensions are calculated by using the concept of similar triangles or trigonometric equations. Either approach, similar triangles or trigonometry, requires only a few hand measurements; both are suitable for documenting the heights of tall buildings.' (Elwazani 1989, 88-89).

2 'The level is an instrument for determining heights of points on the surface of the earth.' (Elwazani 1989: 103).

3 Theodolites are used to measure angles and dimensions in a vertical or horizontal plane (Elwazani 1989).

4 Plane tables must be 'appropriately located, oriented, and levelled, sight is taken to a target by the alidade. A line is, then, drawn along the alidade rule. This line represents the direction tying between the station point of table and the target.' (Elwazani 1989, 114).

5 'It consists of a row of parallel metal plates that can slide in a metal carriage. When measuring, the plates are pressed against the molding; the shape thus formed is then transcribed to a drawing.' (Elwazani, 1989, 76).

6 The National Research Council of Canada was among the first institutes to develop the triangulation-based laser-scanning technology in 1978. The specific 3D-laser-scanning type used in this exercise — which is based on portable features and light detection — was invented and patented by Ben Kacyra and Jerry Dimsdale in 1998. Source: Wikipedia: https://en.wikipedia.org/wiki/CyArk [Accessed 16th May 2018].

7 Excluding VAT (20%). Source: Faro Europe quotation for new and latest models. Older models are discontinued but would be cheaper if bought second-hand. Maintenance would add a cost of approximately £2,500 per year, depending on the model.

8 3D laser scanning general and built heritage classes are taught by the author.

9 Taught by Fiona Zisch. During the first year of implementation (2016-2017), there was an additional subject on fabrication and robotics where, for example, the 3D laser data was used as environmental data to calibrate robotic arms.

10 The role and impact of 3D laser scanning for heritage contexts at risk of disappearance is further studied in the author's PhD thesis: 'Re-construction and record: exploring alternatives for heritage areas after earthquakes in Chile' supervised by Professors Stephen Gage and Camillo Boano.

11 The on-site 3D laser scanning was done by the author with the help of 12 students during one day in December 2016.

12 890,064,288 points exactly.

13 Aerial drones are commonly used for capturing data from above to complement terrestrial scanning.

14 Scene 5.5 was used.

15 Pointools Edit Pro 1.5 was used.

16 Additionally, the author has created a video from the 3D laser scanning point-cloud, since its three-dimensional quality is better disseminated as a video that can be seen on any device, considering that the high resolution of the points captured require powerful hardware to be visualised otherwise. Available from: https://vimeo.com/251035025

17 http://www.cyark.org/ [Accessed 16th May 2018].

18 https://bartlett3dscanlibrary.com/ [Accessed 16th May 2018].

19 Available from: https://bartlett3dscanlibrary.com/2017/10/01/st-dunstan-in-the-east-city-of-london/ [Accessed 16th May 2018].

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Rome's Archaeological area valorization through multimedia presentations

Abstract

This paper focuses on the conservation of archeological landscapes in urban contexts and the specific case of Rome's archaeological area. The aim is to understand how the concept of cultural heritage transformed from a characterising sign of the elite to a resource for large-scale tourism. However, what could be done to make the archaeological evidence more accessible without decreasing the scientific quality of the cultural offer? The use of augmented reality (AR) as a guide on the site has been experimented with in multiple forms throughout the Archaeological Area of Rome and has increased visits even amongst the citizens of Rome (Ministero dei beni e delle attivita culturali e del turismo , 2018). From an analysis of the current cultural offering and comparison with other international sites, it has been possible to develop guidelines that combine this type of representation and ensure a balance between the real and virtual world. It emerged that the use of AR as a narrative tool for ancient events led citizens to 'wear' the garment of the tourist in their own city, rather than bring their urban reality into the archaeological context. Indeed, in Rome's case the urban context continues to assume features aimed at touristic exploitation. Banal souvenir shops and mediocre restaurants have replaced the once highly frequented artisan workshops that characterised the landscape around the archaeological area. To integrate urban archaeology into everyday life as a space in the city and to valorise cultural heritage, the simple image of elements constituting the original archaeological landscape is not enough. In order to save the cultural identity of this heritage, it is necessary to preserve its context and respect the authenticity of the locations, not to fall into the mere (though didactic) spectacle of the cultural heritage.

Keywords: Cultural heritage; Virtual reality; Virtual restoration; Archaeology; Multimedia; Conservation

Introduction

The context for this paper is the current debate on the valorisation of archaeological landscapes in urban contexts. The paper begins by reflecting on the significance of heritage in contemporary civilisation and considering how the concept of exploiting cultural assets has changed. The case to be examined is the Central Archaeological Area of Rome (CAA), taken as a symbolic example of an archaeological landscape immersed in a city centre. The objective is to identify what new systems are used by public institutions and other conservation bodies, and to identify which systems would be useful to reconcile the exploitation of the CAA with the needs of contemporary society in order to make spaces geared for tourism, but also a cultural draw for citizens (Ancona et al. 2012).

The research takes as its starting point the need to highlight the archaeological landscape in an urban context as an active element in processes that transform the city (Manacorda 2007). These processes are increasingly affected by the inevitable effects of globalisation. It is important to acknowledge these effects in order to control and guide them rather than being overwhelmed by them. For some time now, a technological revolution has been underway, bringing the use of the computer as a mechanism for production, distribution and communication into the cultural arena. New technologies have helped make it possible to conduct broader research, to analyse, study and, only then, valorise cultural assets (Bonacini 2014, 21-89).

Technology is one tool being used by authorities to bring local citizens back into archaeological areas, encouraging their use by the creation of museum pathways across an area. This paper considers what could be done to make the share of archaeological evidence more accessible without decreasing the scientific quality of the cultural offering. The paper concludes by questioning whether the new forms of use are enough to bring citizens into the area to reclaim the city without turning them into tourists.

Theoretical background

In the case of Rome, to be able to develop a good plan for the use of augmented reality it is crucial to be aware of the archaeological landscape one is dealing with and of the connection this has, and has always had, with the city that has grown up around it (Brancati et al. 2015). The choices made in organising the CAA have not always been driven by the desire to make the reading of archaeological finds accessible to everyone; interpreting them has often been the sole preserve of scholars.

Evidence of this trend is found in the way that the area of the Roman Forum and the Imperial Forums feature a layout that is heterogeneous in time and space. For example, in the area of the Roman Forum there are structures dating from Ancient Rome existing side by

Figure 1. The ancient Settimio Severo Arch and the baroque facade of Church Santi Luca e Martina in the Roman Forum. (Source: Piranesi, G. B. 1748. *Views of Ancient and Modern Rome*).

side with buildings of later construction, such as the Chiesa dei Santi Luca e Martina, built in the 7th century on the ruins of an earlier building, which was in turn built on the site of the *Secretarium Senatus* (Armellini 1887, 451-453), an annex to the Curia (Figure 1).

Another example is Via Alessandrina, built in the 16th century at the behest of Cardinal Michele Bonelli, with its surviving traces lying between the areas covered by the Forums of Augustus, Nerva and Traiano (Nibby 1841, 237) (Figure 2). Yet this place was, until a few years ago, a more fully integrated part of the urban fabric than it is today. The interactions between the

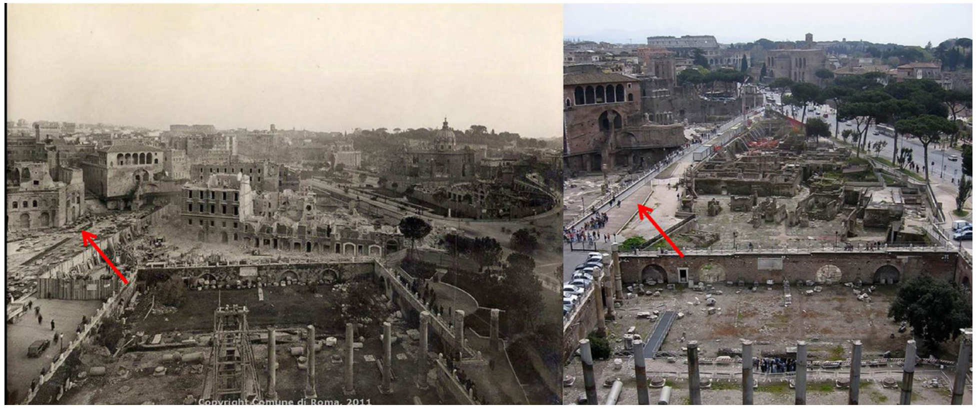

Figure 2. Alessandrino district, Rome. L: partial demolition of the Alessandrino district for the liberation of the Imperial Forums and realization of the new archaeological area settlement. R: via Alessandrina is still visible as a Renaissance trace immersed in the ruins of the Roman Empire, whose demolition is underway today between heated debates. (Source: courtesy of Sovraintendenza Capitolina).

city and the archaeological landscape represent the most significant change since the creation of the Monumental Zone in Rome. It is, in fact, by analysing relationships with the urban context that we can understand how much and in what way the effects of the tourist market have influenced the development of this area (Ricci 2002).

The Monumental Zone was created in 1887 by a 'declaration of public utility to isolate some monuments in the southern part of Rome and connect them by means of walkways and public parks' (Commissione reale per la zona monumentale di Roma, 1914) (Figure 3). As was highlighted in the report

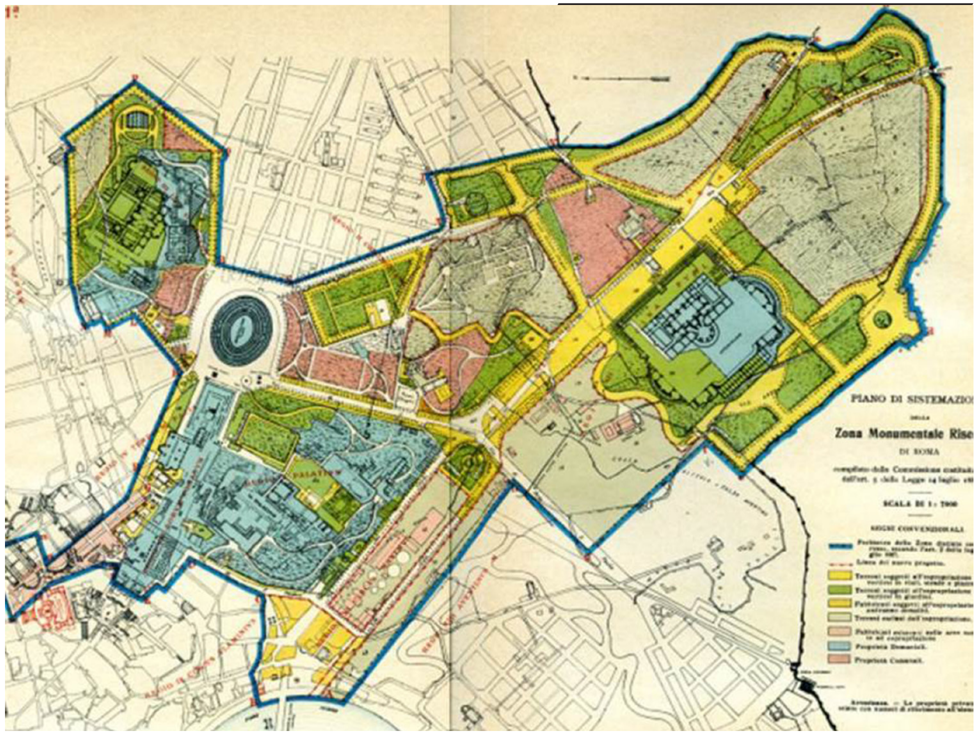

Figure 3. Plan of the Reserved Monumental Zone, 1887. (Source: L'Opera Della Commissione Reale.1914. *La zona monumentale di Roma e l'opera della Commissione Reale*. Rome: Publishing Union).

attached to the Monumental Zone plan, the aim of the work was to safeguard the cultural heritage from building speculation and improve areas considered to be among the most insalubrious in the capital. The implementation of this project, carried out over the subsequent decades, included providing citizens with a pathway linking public parks, and broad tree-lined avenues, intended to encourage the use of the archaeological heritage within the urban context of the capital. There were various later actions altering the layout of the area; the most significant, in terms of the grandiose nature of the works, were the interventions completed during the Fascist period (Figure 4). However, before the advent of mass

Figure 4. Demolition of the Velia Hill for the construction of Via dei Fori Imperiali, 1932. (Source: M. F. Boemi and C. M. Travaglino. 2006. *Roma dall'alto: Exhibition Catalogue*. Rome: Universita degli studi Roma tre).

tourism, the area remained an integral part of the daily life of the capital.

There are various examples of the use of this area by citizens unconnected to the tourism aspect of visits to the archaeological park. Beneath the Arch of Constantine, for example, was the finishing post for the Waiters' Race (Figure 5). This event took place around the 1930s and saw Roman waiters taking part in a race carrying a loaded tray around the Coliseum and finishing under the Arch of Constantine (Roma Ieri Oggi, 2017). On another occasion, also in the '30s, a blessing of motor cars took place in the vicinity of the Basilica of St. Frances of Rome. St Frances is the patron saint of motorists and the Basilica named

in her honour lies between the Roman Forum and the Temple of Venus and Rome. This event last took place on 12 March 2017 on the Via dei Fori Imperiali (Figure 6). One of the most significant contemporary examples, the 1960 Rome Olympics, should also be mentioned. Spectators arrived to watch the wrestling in the spectacular setting of the Basilica of Maxentius, which was used again in the 1970s for the architect Renato Nicolini's film festival, 'Estate Romana'. The Park, too, was open to the public and used by the inhabitants of the area as an urban space, as were the grounds of the historic Roman villas, a heritage site for the world, but also for the city.

In theory, the current trend is to no longer interpret urban archaeology as somewhere remote from daily life, but as a space in the city in which individual sites or a single monument is an integral part of a unified local area with an integrated service infrastructure (Segarra Lagunes 2000). On the one hand, this approach allows the conservation of architectural finds and, on the other, it ensures that the city's heritage is used to meet the contemporary needs of the city, there being a fluid connection, without the physical and perceived barriers existing at some of the other archaeological sites in the capital such as, for example, the Largo di Torre Argentina. The problem still sits on the desk of academics and administrators, in an attempt to integrate theory into the implementation of well-intended plans. One of the responses suggested by a selection of institutions as a way of attracting citizens back to live in the archaeological centre leans towards the use of multimedia as a narrative tool for the events that affect the ancient ruins.

Figure 5. The Waiters' Race, Colosseum Square, 1930. (Source: www.romaierioggi.it).

Hypotheses development

The use of augmented reality as an on-site guide has been tried in various forms in the CAA and has achieved a degree of success, not only with tourists (Figure 7). In the case of the Domus at Palazzo Valentini, gradually revealed by lighting, the visitor enters into a dark space, in which the various sections

Figure 6. Colosseo square, celebration of S. Francesca Romana, 1949. (Source: courtesy of courtesy of A. Wanderlingh and U. Salwa. 2007. *Cento anni di Roma*. Napoli: Intra Moenia).

are illuminated as the narrator tells their story (le Domus Romane di Palazzo Valentini, n.d.). Another example, in the Imperial Forums, is the route through the structured space in the Forum of Caesar, which passes through the hypogea areas below Via dei Fori Imperiali and allows visitors to explore areas previously off-limits to the public. Similarly, the show in the Forum of Augustus, which projects the history of the Forum and the fire of 64 AD in the time of Nero onto to the massive wall of the Suburra district (Viaggo Nei Fori, 2015). A further example is Santa Maria Antiqua, with its narrative explaining the complexity of its artworks (Co-Op Culture, 2018) and the history of the Domus Aurea from construction to the *damnatio memoriae,* and from its rediscovery in the Renaissance through to 20th century digs (Figure 8). This can be experienced in person by visitors thanks

Figure 7. The central archaeological area today: localisation of case studies on digital reality supporting the use of cultural heritage. (Source: courtesy of Google. 2017. The Central Archaeological Area).

to the use of immersive reality (Co-Op Culture, 2018), which is also used for the Coliseum tour 'Live Ancient Rome' (Falcone, 2017).

From an analysis of current cultural offerings and comparison with other international locations, there emerges a need to establish some possible guidelines that should be common to these types of representation. The CAA's new forms of usage with the assistance of multimedia are a consequence of rapid technological development, but they must be consistent with relevant rules and regulations (London Charter 2009; Seville Principles 2011; The Florence Declaration on Heritage and Landscape as Human Values 2014). This action is vital in order to ensure a balance between the real world and the virtual world, and to provide exhibitions that communicate cultural heritage in a way that is both scientific and easy to understand.

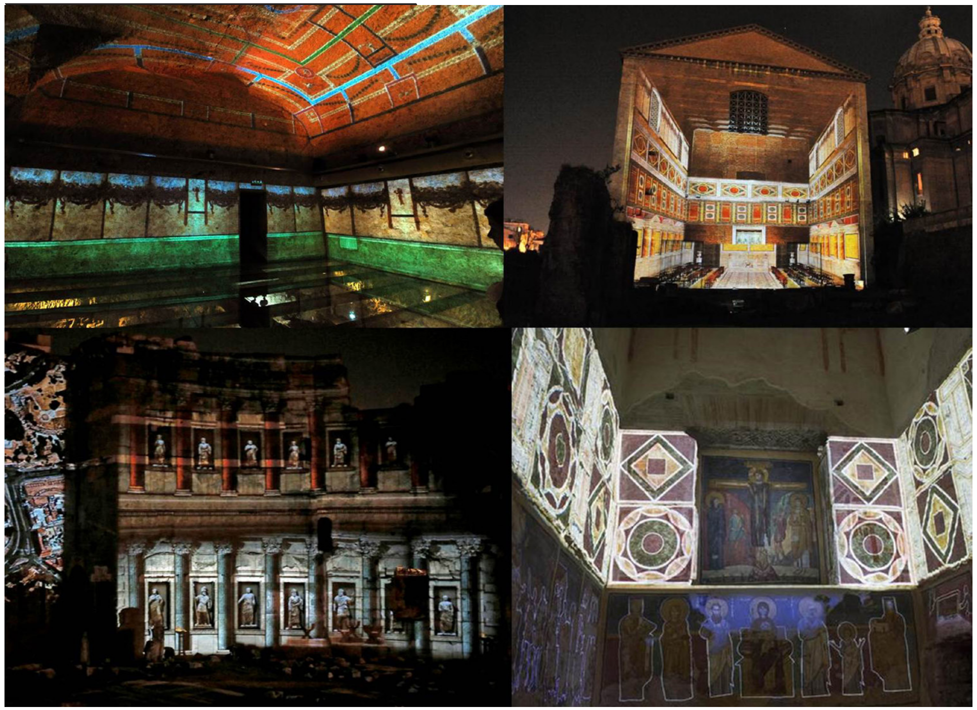

Figure 8. Videomapping. Top L: Roman Domus of Palazzo Valentini. Top R: Caesar Forum. Bottom L: Augustus Forum. Bottom R: S. Maria Antiqua (Source: courtesy of Sovraintendenza Capitolina and SSCol).

Research method

Based on the experience of applying multimedia methods in recent years in both Rome and other international locations, the characteristics of various forms of use of the visual arts in relation to cultural offerings, and the merits and defects of each form, have been analysed in accordance with principles 2.2 e 2.3 of the London Charter. The aim was to identify the individual contexts that each form was best suited to in order to restore the archaeological areas to those who live there and not to tourism alone (Bonacini 2014; Biagi Maino and Maino 2017).

By studying the current range of cultural offerings, heterogeneously connected through use of

augmented reality, a number of aspects have been identified as determinants of the quality of the representation offered. These parameters can be divided into two main categories: direct assessment or explicitly identifiable, and indirect assessment or easily inferred by studying the cultural offering. In terms of direct assessment, the following criteria have been identified:

- Type of digital technology used, from laptops to headsets (Brancati et al. 2015);
- Degree of autonomy in enjoying a cultural asset. The Archeoguide method with personal headsets for each visitor, or the ARAS method with headsets at the location that anyone can choose to use or not use (Bonacini 2011);
- Predominance of the real or the virtual on the tour route (e.g. at Palazzo Valentini where the view of reality is subordinate to the show on offer because the darkness of the room does not allow the real ruins to be fully appreciated);
- Scientific nature of the contents with explicit referencing of sources, historical rigour applied to reconstructions and philological authenticity;
- Availability of one or more interpretation aids;
- Communication format whether in person, a hologram or a narrating voice;
- Whether the visit follows a set route or there is free choice;
- The option to access more detail on what has been shown via augmented reality e.g. iTACITUS and MobiAR models (De Paolis et al. 2007, Empler 2015).

Indirect assessment criteria are summarised as follows:

- Interaction between the visitor experience and the heritage site, including links between what is seen in the stories and the architectural finds visited;
- Whether user action is active or passive. An active visit has greater autonomy and flexibility, and a passive visit has the user watching films or looking at documents;

- Possibility of replicating the type of visit and, if so, in what contexts;
- Possibility of organising the visit by planning it first remotely;
- Opportunities to replicate the visit virtually, running through it again remotely (refer to post visit activities 4.5, 4.6 in the London Charter);
- How evocative is the media show in terms of what has been defined as 'emotional resources' (Giannotta et al. 2014);
- Compliance of the reconstruction with binding legal framework in Italy and Europe.

Analysis and Results

From analysing the characteristics of the new ways to make use of the CAA, a varied picture emerges, seeming to present two worlds that are apparently antithetical: the archaeological remains evoking a vanished culture, and technological interventions representing a world that is continuously and rapidly evolving (Manacorda 2007). To avoid bringing about the destruction of the evocative symbolism of the ruins that stimulate the visitor's capacity for abstraction, what is seen should also communicate cultural content. This is to make 'understanding through concepts and understanding by seeing into a positive-sum combination, reinforcing or at least integrating with each other' (Sartori 1998).

From these reflections arises the need to devise guidelines for the new ways to make use of the CAA that have emerged from rapid technological development, as proposed in relevant charters and legislation and based on what has already been achieved by virtual reconstruction. There is also a need to explore the significance and use of virtual restoration, by highlighting the potential and the challenges of a relatively recent discipline that must not view technology as an end in itself, but as a means to support the process of conservation and valorisation. A further need exists to extend current protection to the cultural identity of heritage to the areas of urban fabric around the CAA, because it is necessary to also preserve the context in order to ensure that cultural values are passed on (Manacorda 2007). Based on the findings of this research, a scenario opens up that offers a number of usage opportunities that could be developed in the immediate future. Additional possible uses include:

- Visualising the city of the future based on planned and not yet realised projects. For example, work on structures or architectural ensembles, using the development of a virtual restoration project to show what it will look like before it is actually created;
- Visualising alternative scenarios for the city of the future;
- Bringing together information on tourist and city services that visitors can use before or after the visit, such as transportation systems, accessing the area, ticketing information and various types of tourist services available;
- Using preferences shown by the visitors during their visit to invite 'cultural recalls' or further visits to the area;
- Developing virtual tours that include the urban area, to show parts of the city and walkways that have now gone or have profoundly changed, looking at them from a broader architectural angle (based on London's Streetmuseum[1]) (Kerruish, 2010);
- Opening up the cultural offering to people with disabilities (London Charter 2009, 11). For example, special tours using avatars to communicate information in sign language e.g. Google Glass 4Lis model, created for the Egyptian Museum of Turin;
- Creation of exhibitions that also show the restoration work carried out to give ruins the appearance that the visitor can see with their own eyes, possibly in the context of special tours.

Only if technology is seen as a tool that can be adapted to meet the need to preserve and protect cultural assets, abandoning the view of technology as the final objective, is a real collaboration possible

Figure 9. Virtual restoration of a two-lane window of S. Giovanni in castrum Church in Bisceglie. (Source: courtesy of CNR, ITC of Bari).

between the 'scientific' world and the 'human' world (Bennardi and Furferi 2007).

Discussion, implications and limitations

Even in the absence of physical material, virtual restoration represents a first step towards real restoration. Virtual restoration can be incorporated where, for example, the traces of the past may not be sufficient to determine with certainty the actual appearance of a structure. It can also be used as an alternative to carrying out restoration work aimed more at increasing mass tourism rather than safeguarding monuments (Limoncelli 2012). In this way it would be possible to avoid reconstruction work aimed solely at 'promotion' without conservation.

Less common, but still widespread, are examples of reconstructions that are created arbitrarily

with the aim being not to interpret the ruins and restore their dignity, but to restore some view to better sell the archaeological panorama to tourists, even where this is in conflict with the restoration charters (Limoncelli 2012). With virtual restoration visualisations, it is possible to offer a reconstruction scenario that includes decorative furnishings, for example, without impacting on the physical structure of the monument (Figure 9). One possible use is in the case of archaeological assets in a very poor state of preservation where reconstruction would have to be very substantial. Alternatively, in the case of decorative features for which we have evidence in graphical reproductions or of where only faint traces remain.

Multimedia exhibits offer a reconstructed visualisation of reality. Even when it is a virtual restoration, therefore, the principles that would apply to a real restoration should always be followed. That is, a philological construction should be produced and adapted to the specific instance it is applied to. It would be desirable, in this regard, to repeat a 'how it was, where it was' created *ad hoc* for each structure, in order to create a suitable virtual restoration. It is interesting to promote virtual restoration not only for didactic purposes, but also for it to be used to support monitoring of the state of deterioration of structures (Giannotta et al 2014). In terms of the landscape of the contemporary city, virtual restoration would be useful for ensembles or structures:

- That have been destroyed by wartime events or natural disasters;
- That have become unusable or unsafe;
- That are no longer visible because they have been demolished;
- Whose usage has to be restricted for reasons of conservation or ownership, but which could thus still be viewed.

In augmented reality reconstructions during recent years, great attention has been placed on the original urban context. The question remains how the context in which these archaeological ensembles are located

Figure 10. The oven, housed in the spaces of the surviving structures of the Forum of Nerva with entry from the famous "colonnacce". (Source: Anonymous. 1870).

should be dealt with today. Are urban policies in line with universally recognised principles for protecting and safeguarding the cultural identity of heritage assets? For example, by Administrative Decree 8410/09 the Sicily Region introduced the Regional Charter for Memory-Places in line with the principles for the protection of cultural intangibles ratified by the Paris Charter of 1972. In the case of Rome, can we still speak of 'memory-places' in relation to the urban areas surrounding it?

What surrounds the CAA is, indeed, no longer an urban fabric lived in by its inhabitants, with artisan shops on the Rione Monti, for example (Figure 10). Today, the landscape in the area around the CAA is heavily geared to the tourist market, which is

Figure 11. Relief of tourist activities in the central area of Rome. The innkeeper locates the B&B, the offers of stay and the restaurants. (Source: courtesy of Roma Tre University, Architecture Department, Working Group for the Colosseum Valley Plan).

definitely a long way from, and unrelated to, the noble intentions of the cultural debate on the idea of reconnecting archaeological areas with the urban fabric of the contemporary city (Figure 11). However, what makes the archaeological landscape are the traces of mankind on the land, including in relation to the symbolic aspects that are characteristic of mankind in contemporary times (Manacorda 2007). Thus, what needs to be recovered is not merely the view of the architectural elements that made up the landscape of the archaeological site in an urban environment in its original phase of life. To restore the CAA to the city, wide-ranging technical policies are needed that take account of:

- The historical dimension: this means reconstructing the history of the urban fabric that is inextricably entwined with that of today;

- The technical dimension: planning for archaeological digs must take account of the needs of the living and modern city, so must link into town planning;
- The planning dimension: alongside the theme of knowledge sits the idea of linking the major excavations to parts of the contemporary city.

In this context it would be appropriate to work not only on individual archaeological finds, but also to assert the value of memory as an active factor for development, rather than exploit its resources to produce (Limoncelli 2014). Changing course in terms of conservation policies has become a necessity in order to protect heritage. Unfortunately, the case of Rome is not unique. This phenomenon has also affected other Italian and international locations, such as Amsterdam and Barcelona. In the light of these reflections a scenario is opening up in which the implications for the future must involve collaboration between the technical side and planners. Protective measures need to be adopted at a territorial level that can safeguard the authenticity of the historic centres of European capitals, increasingly trapped between managing large number of visitors, the benefits tourism brings to the economy, and the need to avoid debasing the cultural offering to ensure that the cultural identity of heritage is handed down to future generations, as well as communicated to those here now.

CASABURI

References

Ancona, A., A. Contino, and R. Sebastiani. 2012. "Conclusion." In *Archeologia e città: Riflessione sulla valorizzazione dei siti archeologici in aree urbane, Atti del Convegno,* edited by A. Ancona, A. Contino, and R. Sebastiani, 250-256. Rome: Palombi.

Armellini, M. 1887. *Le chiese di Roma dalle loro origini sino al secolo XVI*. Rome: Tipografia Editrice Romana.

Aymonino, A., and P. V. Mosco. 2006. *Spazi pubblici contemporanei. Architettura a volume zero*. Milan: Skira.

Bartolone, R. 2013. "Dai siti archeologici al paesaggio attraverso l'architettura." *La Rivista Di Engramma* 10: 58-90.

Bennardi, D., and R. Furferi. 2007. *Il restauro virtuale. Tra ideologia e metodologia*. Florence: Edifir.

Benton, T., and C. Cecil. 2010. "'Heritage and Public Memory."' Iin *Understanding Heritage and Memory*, edited by T.im Benton, 7–43. Manchester: Manchester University Press.

Biagi Maino, D., and G. Maino. 2017. *Principi e applicazioni del restauro virtuale.* Florence: Edifir.

Bonacini, E. 2011. *Nuove tecnologie per la fruizione e valorizzazione del patrimonio culturale.* Rome: Aracne.

Bonacini, E. 2014. "La realtà aumentata e le app culturali in Italia: storie da un matrimonio in mobilità." *Il Capitale Culturale* 9: 21-89.

Brancati, N., G. Caggianese, G. De Pietro, M. Frucci, L. Gallo, and P. Neroni. 2015. "Tecnologie Indossabili di Realtà Virtuale e Aumentata per la Fruizione Interattiva del Patrimonio Culturale." *Atti del I workshop internazionale Beni Culturali e Tecnologie, Laboratori Open su Scienza, Arte e Innovazione*. Naples: CNR.

Ciotti, F., and G. Roncaglia G. 2010. *Il mondo digitale. Introduzione ai nuovi media.*, Rome: I Robinson .

Co-Op Culture. 2018. "Santa Maria Antiqua Between Rome and Bisanzio." Events.Accessed 7 December 2018 . https://www.coopculture.it/en/events.cfm?id=425

Co-Op Culture. 2018. "Domus Aurea -– Visit at Domus Aurea's Archaeological Restoration Site with Virtual Reality"." *Places.* Accessed 7 December 2018. https://www.coopculture.it/en/heritage.cfm?id=51

Denard, H, ed. 2009. *London Charter Draft 2.1.* Accessed 7 December 2018. http://www.londoncharter.org/fileadmin/templates/main/docs/london_charter_2_1_en.pdf

De Paolis, L. T., P. Bourdot, and A. Mongelli, eds. 2017. *Augmented Reality, Virtual Reality, and Computer Graphics, Proceedings of IV International Conference, AVR 2017.* Cham: Springer.

Dezzi Bardeschi, C. 2007. *Archaeology and Conservation: Theories, Methodologies and Field Practices.* Milan: Maggioli.

Empler, T. 2015. "APP Design Using Augmented Reality to Disseminate Cultural Heritage." *Disegnare idee immagini*, 50: 60-69.

European Commission. 2014a. *Cultural Heritage: Digitization, Online Accessibility and Digital Preservation.* Report on the Implementation of Commission Recommendation 2011/711/EU. 2011–2013.

European Commission. 2014b. *Horizon 2020 Work Programme 2014-2015 13. Europe in a Changing World – Inclusive, Innovative and Reflective Societies*. Brussels: European Commission. Accessed 20 August 2015. http://ec.europa.eu/research/participants/data/ref/h2020/wp/2014_2015/main/h2020-wp1415-societies_en.pdf

Falcone, Antonia. 2017. " Live Ancient Rome: aA tTour of the Colosseum in vVirtual Rreality." *Archeomatic*. Accessed. 3 May 3, 2017. https://www.archeomatica.it/ict-beni-culturali/live-ancient-rome-un-tour-del-colosseo-in-realta-virtuale

Fazio, F. 2005. *Gli spazi dell'archeologia: Temi per il progetto urbanistico*. Rome: Officina Edizioni.

Giannotta, M. T., F. Gabellone, and A. Dell'Aglio. 2014. *Fruizione di contesti archeologici inaccessibili. Il progetto Marta racconta.* Lecce: Edizioni Grifo.

International Forum of Virtual Archaeology. n.d. *"Principles of Seville*" Accessed

International Council of Monuments and Sites. 2014. *"The Florence Declaration on Heritage and Landscape as Human Values*." Accessed 7 December 2018. https://www.icomos.org/images/DOCUMENTS/Secretariat/2015/GA_2014_results/GA2014_Symposium_FlorenceDeclaration_EN_final_20150318.pdf

Kerruish, Jack. 2010. "Streetmuseum.". Youtube video, 1:50, 17 December 20108. https://www.youtube.com/watch?v=qSfATEZiUYo

Le Domus Romane di Palazzo Valentini. n.d. *The Excavations*. Accessed 7 December 2018. https://www.palazzovalentini.it/domus-romane/index-en.html#visita

Limoncelli, M. 2012. *Il Restauro virtuale in archeologia*. Rome: Carocci.

London Charter. 2009. "Draft 2.1" Last modified 1 February 2009. Manacorda, D. 2007. *Il sito archeologico: fra ricerca e valorizzazione*. Rome: Carocci.

Milgram, P.,. and H. Takemura, H. A. and Utsumi, A. and F. Kishino F. 1995. "'Augmented Reality: A cClass of dDisplays on the rReality-vVirtuality cContinuum'.", publishedI in *SPIE Telemanipulator and Telepresence Technologies, Proceedings of SPIE Volume 2351,* edited by H. Das, 282-292.,*Proceedings* Bellingham: The International Society for Optics and PhotonicsVol. 2351.

Ministero dei Bbeni e delle A attivita Cculturali e del Tturismo. 2018., *Rilevazioni e dati statistici* (Rome: 2015 Ministry of Cultural Heritage and Activities and Tourism - Statistics Office, 2018). Accessed 7 December 2018. http://www.statistica.beniculturali.it/Visitatori_e_introiti_musei_17.htm

Ministero dei Beni Culturali e del Turismo. 2004. *Decreto Legislativo 42/2004, Codice dei Beni Culturali e del Paesaggio*. Accessed 7 December 2018. https://www.beniculturali.it/mibac/multimedia/MiBAC/documents/1226395624032_Codice2004.pdf

Ministero dei Beni Culturali e del Turismo. 2007. *Atti X Borsa Mediterranea Del Turismo Archeologico*, Paestum 15-18 November 2007. Acessed 7 December 2018. http://www.beniculturali.it/mibac/multimedia/MiBAC/documents/1257347181815_Opuscolo_Paestum_internet.pdf

Moschini, D. 2001. "Restauro Virtuale. La tecnica per il recupero digitale delle informazioni nascoste." *Kermes - La Rivista del Restauro* 41: 45-54.

Nibby, A. 1841. *Roma nell'anno MDXXXVIII*. Rome: Tipografia delle belle arti.

Ricci, A. 2002. "Remote Memory." In *Archeologia e urbanistica. XII Cycle of Lessons on Applied Research in Archaeology,* edited by A. Ricci, 107-124. Florence: All'insegna Del Giglio.

Roma Ieri Oggi. 2017. "Corsa dei camerieri (1930)". Youtube video, 0:59, 16 August 2017. https://www.youtube.com/watch?v=u1hGzSRP0R4

Royal C commission for the Mmonumental Aarea of Rome. 1914. *La zona monumentale di Roma e l'opera della Commissione Reale.*, Roma: Union Editrice.

Sartori, G. 1998. *Homo videns. Televisione e post-pensiero*, Rome: Laterza.

Segarra Lagunes, M. M. 2000. *Archeologia urbana e progetto di architettura*, International Seminary, Roma 1 - 2 Dicembre 2000, Rome: Gangemi.

Eve, S. 2012. "Augmenting Phenomenology: Using Augmented Reality to Aid Archaeological Phenomenology in the Landscape." *Journal of Archaeological Method and Theory* 19 (4): 582-600.

Viaggio Nei Fori. 2015. *Viaggio Nei Fori*. Accessed 7 December 2018. http://www.viaggioneifori.it/en/

Viscogliosi, A. 2015. "A Study of the History of Architecture: Tradition and High-Tech." *Disegnare idee immagini*, 51: 80-90.

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A Comparative Analysis of Modelling Techniques for the Reduction of Energy and Carbon Emissions in a London Victorian Dwelling

Abstract

There is an increasing acceptance that dealing with the existing built environment is critical if carbon reduction and energy consumption targets are to be met. Computer modelling has become an important and accepted tool in the assessment of the environmental performance of historic buildings. While the results have been questioned by many it remains an important part of any sustainable strategy for the improvement of buildings.

This paper focuses on one particular case study that compares three strategies for assessing the energy consumption improvements of a Victorian urban dwelling.

The study compares the computer-modelled results from the carbon emissions and energy consumption computer simulation program NHER against previous datasets of improvements against the real-life actual improvements. The paper discusses the issue of computer modelling as a method of assessment of environmental improvement in the historic built environment. The paper will show the limitations of the software in the decision-making process and the importance of intangible factors that affect the environmental performance of a historic dwelling. It will show that while it is difficult to match the exact energy use of the building using computer modelling, it is an effective tool in showing the impact of sustainable improvement interventions.

Keywords: Computer energy modelling; Sustainable refurbishment; Historic housing; Energy use; Human behaviour

Introduction

There is now an acceptance that if any of the sustainability targets are to be met, the environmental performance of the existing built environment has to be improved. However, much of the advice given to historic homeowners is at best ineffective or, at worst, damaging to the historic fabric. This paper looks at the largest stock of the UK's historic dwellings, the Victorian suburban dwelling. This paper is part of a larger study into the environmental benefits of conservation-based building maintenance and benign improvements to this type of housing stock.

One of the key tools used to assess options for energy consumption reduction is computer modelling. This paper will look at the issues when these maintenance and benign based interventions are applied using a computer energy modelling package. Results from this model are compared with outputs from other datasets; all of these are then measured against the actual energy reduction results in the dwelling. The study highlights the difficulties in computer modelling small changes to the building that not much can have impacts on the energy performance of the dwelling.

Context

There are over 4.7 million pre-1919 dwellings in England alone (EHCS, 2009); this would require over 325 home refurbishments every day from now until 2050 if UK carbon reduction and other sustainable goals are to be met. The pre-1919 housing stock in the UK has, on average, the worst SAP score and the highest carbon emission of any house age group, and typically, over twice the maintenance costs compared with modern housing for basic repairs. However, historic houses usually have a higher market value because they have intrinsic historic value and are valued more by potential purchasers (EHCS, 2009).

The context of sustainability also needs discussing. For a project to be sustainable in this context, it has to meet the requirements of environmental factors, respect the heritage and cultural importance of the building and remain within the financial limitations of the dwelling owners. This interpretation of the sustainable triple bottom line is key to understanding the context of this paper and the wider study. It should also be recognised that while this study is focused on energy consumption, there are many other factors that need to be taken into account across all three categories of the sustainable triple bottom line. These factors include waste production, water usage, upfront costs, changes in lifestyle, impact on house value and planning guidance. Many of these are not easily defined and are therefore difficult to model, hence require professional judgement.

Dwellings are perhaps the most heterogeneous of all of building stock and they are the most continually adapted buildings. Different people have varying levels of comfort in terms of heating and similar dwellings may have very different lifestyle occupancy and usage. This variety adds an increased complexity to accurate computer modelling. Each set of owners of a dwelling make their own changes to the property, therefore the properties that may have originally been built to the same design are in fact unique via these various updates and alterations. This continual process of renewal allows for houses to adapt to changes in lifestyle which means the building can remain a viable dwelling. It could be argued that dwellings have survived decades and centuries are inherently adaptable because of their continued successful use. This is recognised by national conservation and heritage bodies as defining building conservation as the management of change rather than simply the preservation of a heritage asset.

Project aims

This paper comes out of a larger study looking at how conservation-based principles can help improve the environmental performance of historic dwellings. The wider project hypothesis is '*The most sustainable strategy for owners of historic suburban housing does not lie in sustainable focused refurbishment of their dwellings but in historic building maintenance and benign improvements.*' The overall aim of the project is to show that by improving building maintenance and carefully selected interventions, the environmental performance of historic dwellings could be significantly improved and at the same time be economically viable and culturally beneficial to the preservation of the historic asset thus meeting the triple bottom line. As part of that process, computer modelling was used extensively, alongside other techniques within the project. This paper focuses on the variances between the modelling results, existing datasets and the combined findings from the rest of the study. This paper looks at the difficulties of computer modelling software in modelling the energy performance improvements of these smaller changes typically used in this methodology.

Historic building maintenance and benign changes

It is important to understand that the fabric and the appearance of a historic dwelling has a cultural significance - the building itself is an artefact and historical asset (EH, 2007). Preventative maintenance is internationally recognised and has been central to building conservation legislation and charters (Forster and Kayan, 2009). Building maintenance and conservation plans are an accepted part of building conservation work. However, they are rarely carried out in historic dwellings. In fact, it is much more common for reactive repair to be implemented, rather than preventive maintenance (Forster and Kayan, 2009).

It is important to emphasise that the terms 'maintenance and repair' should not be as interchangeable as they might be for other building types. This is because no matter how well thought of the repair is, it will involve some form of damage, removal or replacement of the historic fabric (Dann and Worthing, 2005). Maintenance is important in protecting cultural significance because correct maintenance is the least destructive of all the interventions take place in the process of conserving the historic built environment. The idea of approaching work from a minimum intervention methodology is best summarised by the Burra Charter 'as much as necessary, as little as possible' (ICOMOS, 1999). The methodology for this study is the improvement in energy saving and carbon reduction with as little damage or change to the inherent heritage of the historic dwelling. In the case study house used in this paper, the changes were changing electricity supplier, replacement of insulation in the roof space, replacement of the gas boiler and the replacement of windows (the reasoning for changing the windows will be discussed later in the paper).

The Historic Town Forum (2011) supports this methodology stating that 'One of the most energy efficient ways to preserve historic buildings is to ensure that continued, regular maintenance is carried out to safeguard its historic fabric.' Both the Historic Town Forum and English Heritage encourage the use of benign changes to improve the environmental performance of a historic dwelling. Benign changes are changes to the building that either have little or no effect on the heritage of the dwelling, or do not damage the dwelling fabric itself or the way it needs to perform or react.

The key part of this methodology involves professional and knowledgeable inspection of the property. This inspection should involve highlighting any necessary repairs, and identifying the vulnerable parts of the dwelling that need regular inspection and maintenance (such as clearing of rainwater goods and painting of exterior woodwork). Along with these inspections of the fabric, inspections of the dwelling services identifying such elements as the age of the boiler and quantifying key areas of heat loss and energy wastage throughout the building are required. The report from such inspections should then identify preventative maintenance strategies for the individual historic dwelling, identify any urgent repairs and suggestions for benign environmental improvements to the historic dwelling. It is also important that any benign sustainable improvements suggested are forward-looking, for example, if a new hot water cylinder is required, the one that is recommended/fitted is one with multiple in-lets/heating coils to allow for future integration of renewable technologies.

Computer modelling

Energy modelling software packages can be roughly divided into two major types: static and dynamic. The main difference between static and dynamic simulation is that static modelling packages assume that variables are constant with respect to time. This means that in static modelling packages there is no accumulation in the system model so factors such as thermal mass are not correctly modelled. Conversely, dynamic modelling packages account for the mass and energy rate of accumulation within the system which leads to a closer modelling to actual building behaviour (Da Silva, 2015). Static modelling packages model the material aspects of the building such as the wall, roof construction and window and door types. They also include fuel type and heating sources. Dynamic modelling packages are more complicated. As well as taking into account aspects of static modelling criteria, they also add on other factors depending on the package these include air movement (TAS, IES-VE) and people movement and activity.

Newer packages are also now integrating past energy usage to provide more accurate modelling results. The modelling package used in this study was NHER, which is a static modelling package. It was chosen as it is one of the energy modelling programmes that UK government approved to provide energy performance certificates and ratings (SAP) for residential buildings (NES, 2012). It is worth noting that the UK government currently only allows certain static modelling packages to be used in the residential energy assessment process. While NHER is a static modelling package it does have limited dynamic features such as occupancy rate and limited usage modelling (Bothwell et al 2011). NHER Plan Assessor focuses on energy use and gives a location-specific model. It models basic occupancy behaviour and the geometry of the building along with space and water heating, lighting, hot water tank size and insulation and cooking appliances.

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Modelling will presume a generic typical usage because this allows for comparison between buildings. However, this does lead to inaccuracy when compared to actual energy usage. Each modelling package makes various assumptions regarding behaviour of the occupants and how the building is used, which creates a typical error when comparing predicted energy consumption to actual. The modelling packages were designed for modern buildings and, therefore, U-values of some of the construction elements within traditional buildings is inaccurate (Baker 2011). This, along with other factors such as thermal mass, can lead to inaccurate energy performance results from the static computer modelling packages. The NHER package is SAP based so certain assumptions are made: heat loss through party walls, the energy consumption of non-listed appliances and forms of secondary heating are given a set figure, which may not match the real-life building; again adding to the inaccuracy of the results.

Due to the limited range of options available in the NHER package, it was difficult to model all of the benign changes. It was also difficult to model the lifestyle changes that the occupant had discussed during the refurbishment process. Each of these issues would have had an impact on the differential between the modelling results and the actual energy consumption readings.

The limitations of computer modelling need to be understood. Energy modelling packages calculate the energy consumption and carbon emissions of a building and predict the impact of various interventions on the building. The package itself does not suggest what interventions to include or what would be suitable for a particular dwelling and cannot discuss various planning and heritage implications of such an intervention. This is an important context to understand as it is up to the professional to decide what interventions to model. This leads to important points of the study of understanding which key interventions are most likely to have a positive reduction on the energy consumption of the building while still meeting the planning heritage requirements

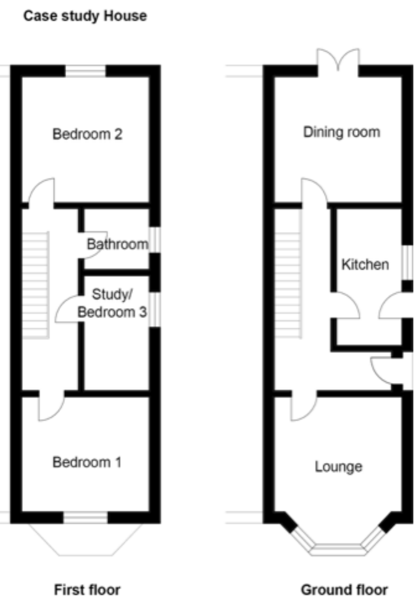

Figure 1. Plan of the house

as well as the budgetary limitations of the client.

The choice of intervention is rarely down to the improvement of environmental performance alone. Other factors such as home improvement, reducing energy costs, repair and building improvement are all part of the client's decision-making process. While the professional advising the client can recommend a particular intervention, it is up to the client themselves to make the decision on whether to proceed with such an intervention.

Case study building

The building used in this case study is a 3-bedroom Victorian suburban dwelling (Figure 1 and Figure 2). The property was in poor condition but structurally sound. The walls are solid 9-inch brick with timber floors. The roof is timber frame with slates and insulation fitted above ceiling level. The windows were single glazed and in a very poor condition with many not fitting properly. The front door was thin with no draft proofing. The boiler was at least 10 years old and not working properly. The rest of the heating had not been serviced. The kitchen appliances were at least 5 years old and probably much older. The house already had energy saving light bulbs and the roof space was insulated with old +/- 100mm fibreglass insulation.

The current owners were a couple who recently purchased the property and wanted to not only improve the condition of the property, but also improve its environmental performance. One of their first steps was to change their energy supply to a supplier that provides its electricity from wind power. The new energy supplier needed monthly meter readings from the client that were submitted and stored online. These energy readings formed the base of the actual energy consumption of the house of the building. The new owners had made the decision about what changes they wanted to make to the building; these were mostly based on lifestyle requirements rather than any energy consumption or heritage aspects. However, the owners were aware of the need to preserve the overall visual and fabric heritage of the building as well as being focused on improving its' environmental performance. The owners as first-time buyers did not have access to large financial resources to refurbish the property. Their first building change within the first few months after moving in was to remove the old roof insulation and refit thicker high-performance insulation. The boiler was replaced 11 months later with a high efficiency condensing boiler.

The final change was the windows. There were two reasons for the decision to change the windows for

Figure 2. Photo of the front of the house

a double-glazed version. First, the existing windows were in such poor condition that it was financially difficult to justify the refurbishment. Secondly, the security requirements of the area meant that the cost for the contents insurance of the building increased considerably by not having secured double glazing on the ground floor windows. The windows chosen were designed to match the period of the building and were of sash timber construction with double glazed units. They were fitted to the entire front and side windows.

Methodology

The data was collected on the actual energy consumption from the case study dwelling. These were taken directly from both the standard gas and electricity meters in the dwelling; this formed the basis for the energy consumption data.

For comparison, three further datasets were created following the same improvements to the original dwelling so that comparison could be made between different techniques used in modelling improvements to existing dwellings. For the first set the dwelling was modelled in NHER Plan Assessor in its state at purchase, then the further energy improvements were modelled. The second set was sourced from existing datasets and national databases of improvements to existing dwellings, and the third set was from original data from the wider project (Ritson 2012). These changes to the actual property were modelled via each methodology and the energy performance improvements shown in percentage terms to allow for easy comparison.

To create the NHER plan assessor model, a survey was carried out of the building and detailed notes taken and the recorded information input to the modelling package. This accompanied a series of interviews with the current occupier to gather information on occupancy rate and energy usage behaviour. Further information was also obtained via existing survey documentation when the property was purchased, and the previous occupant's information pack left with the current owner. This provided a relatively accurate set of data to construct the computer model.

An additional set of data was also created to model the behaviour changes the current owners had made. This was following the interviews with the current owners of the dwelling who had said that they were actively changing their behaviour to reduce energy consumption within their dwelling. So, for each change an additional improvement of 10% was added to model the behaviour changes because it has been shown through various studies that behaviour change can increase the effectiveness of physical improvements to the energy performance of the building (Kelly, 2013). The reason that this had to be added as a separate set of data is that the static modelling package used could not model behaviour change.

Results and comparison

Table 1 shows the result of the actual energy saving and the result of the different modelling techniques for each intervention to the house and the actual and predicted energy savings. The results show that there are differences between the various modelling technique results as compared to the actual energy savings recorded in the dwelling.

Change House	Actual	Modelling	Modelling with behaviour changes	Wider data set	Similar from the study
	Percentage saved	Percentage saved	Percentage saved	Percentage saved	Percentage saved
Base House	0%	0%	0%	0%	0%
Roof Insulation	9%	1%	11%	6%	3%
Roof Insulation + Double Glazing	20%	4%	14%	20%	5%
Roof Insulation + Double Glazing + New Boiler	46%	29%	39%	36%	36%

Table 1. Table showing results of the various interventions on energy performance

The actual house results and the different modelling techniques all show that intervention of double glazing and roof insulation have a lesser impact on the energy performance of the dwelling. The biggest saving by far is the installation of a new boiler. This is in line with the rest of the findings in the wider study. One of the most energy-efficient improvements that can be done to any historic dwelling is making sure that the existing heating system (in this case a gas boiler) is as efficient as possible. Overall, while the results are different, the rates of change shown by the gradient in the bar chart (Figure 3) between the changes remains reasonably consistent. There are smaller improvements in energy efficiency for the roof insulation, which increase with the double glazing and finally the largest increase due to the new boiler. The rates of change are reasonably consistent and, therefore, it can be concluded that while the modelling packages and the datasets may not be accurate in predicting precise energy consumption, they at least will show a reasonable state of accuracy in the amount of savings that will be incurred by using a particular intervention. The difficulty of modelling benign changes in behaviour can be clearly shown by the column of behavioural changes much closer matching the actual energy savings that were achieved by the real-world dwelling. This is evidence of the lack

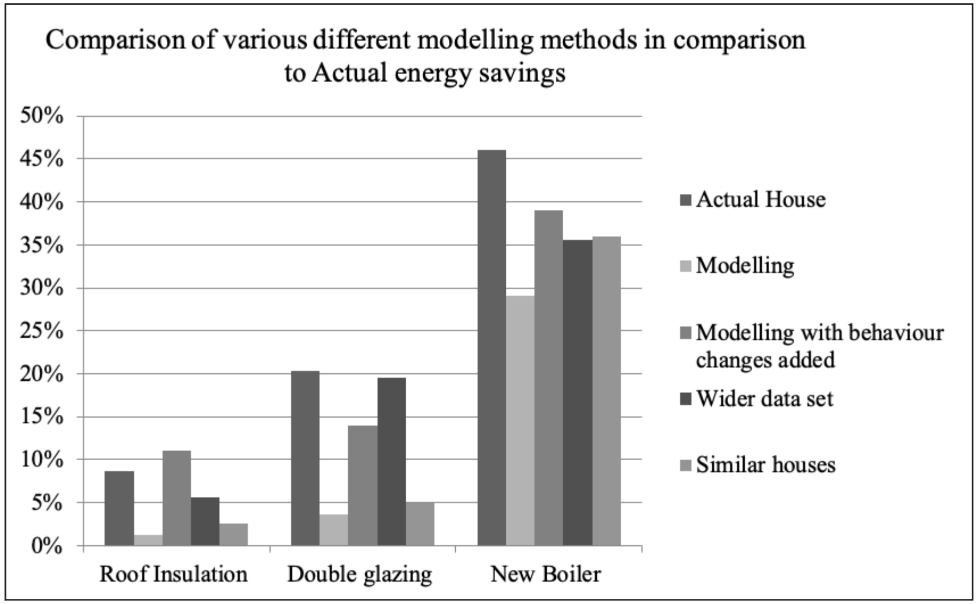

Figure 3 Table showing the results of the interventions on energy performance via the various methods

of homogeneity in the residential built environment coupled with the variances of lifestyle.

The inability of the static modelling package to model behaviour changes can be seen in the results. When the estimated 10% improvements are added to the NHER modelling result they more closely match the results from the actual house. The lack of detail and the inability to change to key U-values of the building elements, along with the limited options such as quality of the windows add further to the inaccuracy of the computer modelling package results. The results also show that the wider data sets from other case studies were closer to matching the actual energy saving improvements of the house. The intervention that showed the biggest discrepancy was the introduction of the double glazed window. This might be explained by the poor condition of the original windows, with some not able to close properly and the inability to model these factors in the NHER 'base' model of the property. The modelling package simply assumed an improvement of single glazed to double glazed units. A positive result was that all the modelling and prediction methodologies used in the study underestimated the improvements would have had on the energy performance of the house. This is encouraging as it adds evidence that small benign changes to a historic dwelling can have greater improvement to their energy and carbon emission performance.

Future

While currently only static modelling packages are approved for use in residential buildings, the growth of embedded and paired dynamic modelling in packages such as Revit and IES coupled with the growth of smart meters and heating control systems creates the possibility for more accurate dynamic modelling of residential buildings in the future (Zhou and Yang. 2016). While not currently approved, the possibility of more accurate models will lead to more accurate results compared with actual energy consumption. However, no matter how accurate the results are they will be still based on a prediction and one of the major difficulties in modelling residential buildings is that occupants all live different lifestyles. The lack of homogeneity in the residential built environment, coupled with different personal lifestyles will always lead to an inaccuracy in predicted energy consumption results compared to actual energy usage.

While the more data that can be fed into a dynamic model such as heating, timing, and temperature and electricity consumption will lead to more accurate results, the future prediction will be based solely on past behaviours.

Results from all of the methods of modelling show that benign changes can make significant improvements to the energy performance of a historic dwelling. However, they do fall short of some of the more extensive sustainably-focused refurbishments. It has to be noted, however, that these more extensive sustainable refurbishments often have a much higher impact on the heritage of the building as well as being much more financially expensive to implement. A judgement has to be made on whether the impact of the heritage justifies the improvements to environmental performance of the building.

The results above show that the impact that behaviour can have on the energy consumption of a building in real life. And while the building may very well be improved significantly by either benign or environmental focused refurbishments, it is still dependent on the occupant of the building behaving and using the building in the correct way.

Conclusion

One of the key reasons that the results from the computer modelling package do not match the actual results is due to the lack of detailed options when inputting the information to the NHER model. As previously described the windows in the original dwelling were in a very poor condition with many of them not closing properly and in a very poor state of repair. However, NHER Plan Assessor does not give this level of detail in the options of the original base model of the dwelling. Another key factor is the lack of detail that can be provided for other subtle changes, for example with the existing roof insulation in the original dwelling, the age and efficiency of the insulation was much reduced. Therefore, there will be a much greater saving when the new high efficient roof insulation was installed even though the thickness and the stated U-value was not that different from the previously installed insulation. Again, this shows a discrepancy between real-world building and a computer modelling package.

SAP-based models such NHER are designed to give an overall picture of a building's energy performance rather than to give an exacting and accurate figure that matches every building's actual energy consumption. It does provide a 'what if' guide to the success of typical sustainable improvements in a typical dwelling (Todd 1995). However, if the improvements are not typical or the dwelling is of traditional construction, the accuracy of the results will be reduced. However, the biggest variability in any prediction will be the occupants' behaviour and lifestyle and this variability will always be the weak point of any modelling package or prediction methodology. The future integration of smart metering and dynamic modelling could lead to a more accurate interpretation of behaviour with a dwelling. This increased data could lead to better assessments for more effective environmental improvements to dwellings.

All of the different modelling methods and the actual results show that the most worthwhile intervention was the replacement of the gas boiler. The gas boiler was used for both space and water heating which is the largest consumer of energy within a dwelling. The replacement of a boiler has very little heritage impact on the building. The smaller benign and behavioural improvements have had a positive impact in decreasing the energy consumption, however, it should be noted that different behaviour changes could have also had a negative impact on the energy consumption. As stated by Kelly (2011) 'Dwellings are heterogeneous. A decarbonisation strategy that works well for one may not work for another.' Results from the all of the methods of modelling show that benign changes can make significant improvements to the energy performance of a historic dwelling. Further improvements to the environmental performance of the building are possible but have to be justified against the impact of heritage and the financial outlay required. This decision cannot be modelled and comes down to policy and professional judgement.

References

Baker, P. 2011. "U‐values and Traditional Buildings." *Historic Scotland Technical Paper 10*. Edinburgh: Historic Scotland.

Bothwell, K., M. Sach, and P. Mallion. 2011. "Retrofit of Existing Housing in the United Kingdom: The Carbon Reduction Possibilities." In *PLEA 2011 – 27th Conference on Passive and Low Energy Architecture, Proceedings Volume 2*, edited by M. Bodart and A. Evrard, 589-594. Presses Universitaires de Louvain: Louvain-la-Neuve.

Dann, N. and D. Worthing. 2005. "Heritage organisations and condition surveys." *Structural Survey* 23 (2): 91-100.

Da Silva, F. J. 2015. "Dynamic Process Simulation: When Do We Really Need It?" *Process Ecology*. Accessed 3 May 2018.

http://processecology.com/articles/dynamic-process-simulation-when-do-we-really-need-it

English Heritage. 2007. *Valuing Our Heritage*. London: English Heritage.

Communities and Local Government. 2009. *English House Condition Survey 2007, Annual Report*. London: Communities and Local Government Publications.

Forster, A. M. and B. Kayan. 2009. "Maintenance for Historic Buildings: A Current Perspective." *Structural Survey* 27 (3): 210-229.

Historic Towns Forum. 2011. *Saving Energy: A Guide for Owners of Historic Homes*. Bristol: Historic Town Forum.ICOMOS. 1999. *The Burra. Charter. The Australia*

ICOMOS Charter for Places of Cultural Significance. Burwood: Australia ICOMOS.

Kelly, S. 2013. "Energy Efficiency and Human Behavior." Accessed 18 February 2017. http://www.cam.ac.uk/research/discussion/energy-efficiency-and-human-behaviour

Kelly, S. 2011. "Do Homes that are more Energy Efficient Consume Less Energy? A Structural Equation Model of the English Residential Sector." *Energy* 36 (9): 5610-5620.

Kindred, B. 2004. "Maintaining Value Through Maintenance" *Context: The Institute of Historic Building Conservation* 85: 21-22

NES. 2012. "What is an NHER Rating?" Accessed 20 February 2012 http://www.nesltd.co.uk/blog/what-nher-rating

Ritson, J. 2012. "Building Maintenance and Benign Improvement Strategies as a More Sustainable Refurbishment Strategy for the English Historic Housing Stock." In *Heritage 2012: 3rd International Conference on Heritage and Sustainable Development, Proceedings Volume 3,* edited by R. Amoeda, S. Lira, and C. Pinheiro, 2005-2015. Barcelos: Green Lines Institute for Sustainable Development.

Todd, S. 1995. "Part L and Energy Rating Applied to UK Housing." *Structural Survey* 13 (2): 26-32.

Zhou, K. and S. Yang. 2016. "Understanding Household Energy Consumption Behaviour: The Contribution of Energy Big Data Analytics." *Renewable and Sustainable Energy Reviews* 56: 810-819.

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CHER-Ob for Cultural Heritage Research: Unsleben Jewish Cemetery Case Study

Abstract

The use of digital techniques for data capture, analysis, interpretation and dissemination is becoming a standard for cultural heritage research, including archaeological, historical, architectural and conservation studies. Nevertheless, specific software that meets the needs of cultural heritage professionals is still at an early stage of development. As a result, highly specialized or generic image processing, viewing and analysis software is being used in combination with databases and data management systems, adding another level of complexity to interdisciplinary cultural heritage studies. This paper introduces CHER-Ob (Cultural HERitage-Object), a new open-source integrated platform for cultural heritage research developed to meet documentation, data management and analysis, collaboration and sharing needs. The conceptual design of CHER-Ob, its compatibility with commonly used imaging data types (2D and 3D images, Reflectance Transformation Images (RTI), Computed Tomography (CT)) and textual information, and its features and functionality, such as the multilevel annotation framework, the automatic report and video generation, the metadata schema, the bookmark, screenshot, searching, sorting and filtering options are discussed. As a case study, a dataset from the historic Unsleben Jewish Cemetery in Bavaria, Germany, derived from the 'Unfolding Communities' project was analysed and different approaches for interacting with diverse datasets at a collaborative research environment are presented. Considering the different stakeholders, the complex and diverse dataset of historical/archival information and imaging data, the intangible aspects of the cemetery and its connections to the lost Jewish community, the Unsleben Jewish Cemetery case study is ideal to demonstrate the features of CHER-Ob.

Keywords: 3D digital modelling; Reflectance Transformation Imaging (RTI); Aerial imaging; Data integration; Multidisciplinary study; CHER-Ob

Introduction

Cultural heritage studies cover a broad area of research and their various aspects and dimensions can be explored only in a multidisciplinary research environment. The diverse nature of the data collected varies from 2D and 3D images to numerical instrumental analysis results, unstructured textual and oral information. Rapidly developing imaging and analytical technologies influence not only the quality and quantity of data captured, but also the way experts from different disciplines access and interact with the heritage record. Systems that provide holistic approaches to data interpretation, easy retrieval of information, tracking of the development of projects and sharing of their results are prerequisites for the success of any interdisciplinary cultural heritage project.

CHER-Ob (Cultural HERitage-Object), a new open-source platform, was developed to encourage cooperative research and enhance the interaction between cultural heritage professionals and digital technologies. It proposes a new methodology for managing 3D and 2D visualizations as well as textual and conservation science data, analysis and evaluation, documentation and sharing of information. The software and the source code, a detailed manual and a quick guide, an introductory video, and further educational materials as well as sample projects are available online (Yale University 2016; Shi 2017; Yale Graphics Group 2016; Kotoula, Akoglu and Wang 2017).

Previous work and current software limitations

Cultural heritage datasets consist of a variety of files in different formats, including imaging, numerical and textual data. In case of visual information, digitized drawings and photographs, provide evidence for the previous states of objects or sites. For example, the Yale's Dura-Europos photographic archive presents a vivid picture of life in a Roman city in the third century A.D. (http://media.artgallery.yale.edu/duraeuropos/). 2D images and 3D models document the existing remains, as in the case of the excavations at the Neolithic site of Çatalhöyük in Turkey (http://www.catalhoyuk.com). 3D virtual reconstructions emphasize the appearance, use and function of sites across time. 3D modelling techniques enable the visualization and verification of hypothetical scenarios, a characteristic example is the use of computer graphics for the visualization of Portus, which was the maritime port of Imperial Rome (http://www.portusproject.org). Although digital technology offers new possibilities for cultural heritage research, the limitations of the available software packages including (1) the lack of software compatible with all commonly used file formats, (2) the lack of enhanced methods of interaction with digital files, and (3) the existence of software for a small community of experts, have an impact on cultural heritage research and practice.

The current common practice aims to reach conclusions and provide answers to research questions by an independent exploration of each dataset, leading to observation and characterization of features, before the attempt to integrate the available evidence. During such explorations, the need to use multiple software packages is one of the limitations. For example, in case of Reflectance Transformation Imaging (RTI) technology, the currently available viewers (Malzbender, Gelb, and Wolters 2001; Palma et al. 2010; Hunt, Lundberg, and Zuckerman 2014) do not enable comparative simultaneous analysis of RTIs and other 2D or 3D visualizations, even though previous studies have proved the value of integrated imaging approaches for an in-depth analysis of objects and sites (Miles et al. 2014; Robinson et al. 2015; Jones et al. 2015).

Additionally, 3D software packages focus on image and geometry processing rather than the interpretation and analysis of 3D models in correlation to other available evidence in the form of 2D images or texts. Although online 3D tools, like 3D Heritage Online Presenter (3DHOP) (Potenziani et al. 2015), 3D Semantic Annotation Portal (3DSA) (Hunter and Yu 2011) and 3D ICONS (D'Andrea et al. 2012), provide a means of communication between the viewer and the 3D model via annotations, their contribution at a larger research perspective is limited, due to the absence of cooperative research tools and export functions. Similarly, powerful specialized software for Computed Tomography (CT) data (Graphics 2016) offers useful analytical tools for the exploration of volumetric models but provides an extremely narrow view of the object under examination, since features of great importance cannot be visualized, including the colour of the digitized object.

Software packages released for fragments matching (Arbace et al. 2012; Andreadis, Papaioannou, and Mavridis 2015) and simulation case studies (Papadopoulos 2010), are valuable for cultural heritage research but their high level of specialization limits their use to a small community of experts. Other options taken under consideration are the qualitative analysis software, which proved to be valuable research tools in particular in social sciences, characterized by advanced data organization and incorporating different data types (Friese 2014; Bazeley and Jackson 2013), but unfortunately not compatible with commonly used imaging formats such as RTIs and 3D models.

An open source platform for shared analysis in cultural heritage research

The main goal of CHER-Ob is to enhance the way that researchers access and interact with several types of complimentary information from various sources, such as scientific and imaging data. The software inherits components of management and documentation systems, annotation tools, viewers and digital imaging processing tools in a single platform, resulting in the enhanced interpretation of findings and informed decision-making. The main conceptual design of the software is based on two key parameters the Cultural Heritage Entity (CHE) and the Project. CHEs are collections of available information about tangible (object or sites) or intangible cultural heritage that represents the already existing knowledge. Projects are different types of studies focused on answering specific research questions about single or plural CHE(s) (Shi et al. 2016; Yale Computer Graphics 2016; Wang, Akoglu, and Rushmeier 2017).

When literature review, data collection and processing are completed, CHER-Ob users create one or more CHE(s), containing images and texts, which serve as the main sources of data to be studied in CHER-Ob project environment. During the development of a project, users explore the visualizations and their metadata, add bookmarks, annotations and new files, making use of search, sort and filter options. The evolution of the projects can be tracked by the navigation tool. Worth mentioning is that within CHER-Ob environment, the generation of new knowledge takes place in projects while users examine, analyse and interpret the data. Users' name and timestamp in addition to evidence-based statements are key features that are tracked protecting the intellectual rights of each contributor and preserving data provenance information. After the completion of the 'Project', users may combine new data to the initial CHE(s), extract sub-projects and merge with other projects. CHER-Ob encourages data sharing providing customizable automatic report and video generation options. CHER-Ob supports the following functions:

- enhanced access to textual and visual information
- viewing and annotating imaging data
- classifying, searching, sorting and filtering textual data
- report and video generation
- sharing data
- collaborative research.

In addition to 2D, 3D and volumetric data types supported by 'Hyper3D' (Kim, Rushmeier, and Ffrench 2014), CHER-Ob's functionality is broadened by the introduction of multiple RTI viewing. The annotation system supports five diverse types of notes. General annotations refer to files, while point, surface, polygonal and frustum annotations are used as pointers for features revealed during the examination of visualizations. 2D images can be embedded to annotations. Easy organization and retrieval of annotations are possible via the classification

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schema and the sort, filter and search options. The classification schema includes ten predefined categories that represent a simplified version of the Getty Classification of Works of Art (Baca and Harpring 1996) and an additional user-defined category. In addition to the already mentioned simplification, colour coding was also introduced to further enhance interaction with the imaging data.

Regarding geographical information, CHER-Ob relates to Google maps, enabling interaction with geographical information systems (GIS). The content of projects and CHE(s) can be exported via the automatic customizable reports in pdf and html formats, encouraging the distribution of information to non-CHER-Ob users for research, publication and archival purposes. Additionally, an integrated video generator based on the images and texts in CHER-Ob Projects and CHEs is useful for dissemination to a broader audience. The systems offer flexibility since users can contribute focusing either on the wider research scope or their individual research interests. Most importantly, CHER-Ob's compatibility with commonly used file formats and additional functionality enables an integrating hypothesis approach based on simultaneously and comparative analysis and interpretation of multimodal data, instead of individual exploration of each file type using different software packages sequentially. In that way cultural heritage professionals have a higher chance to provide answers to research questions and reach evidence-based conclusions (Figure 1).

Case Study

Unsleben Jewish Cemetery

The Unsleben Jewish Cemetery, founded in 1856, is located about 1 km from Unsleben village on a hill to the east, expanding from the southeast to the north in Bavaria, Germany. The cemetery was founded by the Jewish community in Unsleben, which had around 60 families during the 1860s that were completely integrated into the social life of the city until the 1930s. Measures taken against Jews by the Nazi government, such as forbidding private and

commercial relationships between Jews and non-Jews resulted in a large emigration movement and the closure of the synagogue in Unsleben in September 1938.

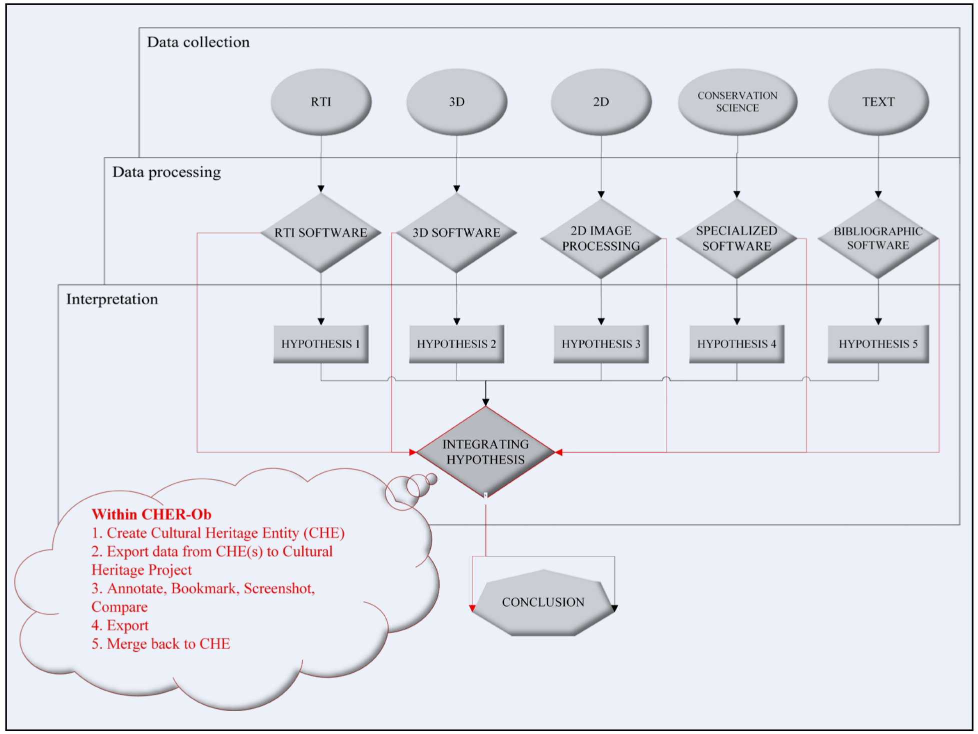

Figure 1. A generic representation of cultural heritage research. Black arrows show the conventional pipeline and red arrows shows the integrated interpretation phase in CHER-Ob.

According to the cemetery book, 229 people were buried in the cemetery from 1856 to 1942. During the Nazi era 13 tombs and 66 name plates were destroyed. The cemetery now consists of 216 tombs with the state of preservation of the existing tombs varying. After the World War II, the cemetery was protected as a historic landmark by the State of Bavaria. New features introduced around 2000 include a limestone wall and, close to the entrance, a memorial honouring the victims of the Holocaust. The cemetery is no longer operational, but it is accessible to visitors and Jewish traditions such as putting pebbles on graves are still observed.

The 'Unfolding Communities' project

Unsleben Jewish Cemetery has been part of the 'Unfolding Communities' project among other Jewish cemeteries in Northern Bavaria like Bad Neustadt. The project combines anthropological and historical research with technological applications, such as assessing the condition and any state of deterioration of gravestones through digital documentation (Caine, Tagar, and Or 2014). The 'Unfolding Communities' project consists of in situ activities (cleaning and documenting the cemeteries, digital image data capture) followed by processing, further data analysis and generation of a web-page for the dissemination of the available information and visualizations (http://judaica-unsleben.de/). This framework may well be adapted for similar projects elsewhere.

The 'Unfolding Communities' project has a multilingual complex nature, tangible and intangible components, as well as a cross-cultural educational work. Undoubtedly, digital documentation of the Unsleben Jewish Cemetery and its interpretation by different stakeholders necessitates an advanced tool for interaction and management of data, research and decision making. Image and video from Unmanned Aerial Vehicles (UAV) and close-range photogrammetry datasets were used for the 3D digital reconstruction of the site. Interactive relighting datasets of individual tombstones were acquired for the generation of RTIs, useful for enhanced visualization of inscriptions and surface topography. Stone characterization and degradation data were collected in an attempt to define the state of preservation and identify the provenance of the materials. Historical and archival information assists in revealing evidence for destroyed tombstones, while information about the lost Jewish community sheds light on the intangible significance of the cemetery. Considering the aerial and close range photogrammetric 3D models and 2D images, RTIs, stone characterization and degradation data in addition to historical/archival information, the intangible aspects of the cemetery and its connections to the lost Jewish community, Unsleben Jewish Cemetery is an ideal case study for introducing CHER-Ob. The multiple categories and data types allow for the testing of how well such a complex set of data can be integrated and what its limitations might be.

CHER-Ob Cultural Heritage Entity

The CHE named 'Unsleben Jewish Cemetery' summarizes the contents of the available historical information. It classifies and organizes the already existing knowledge about the site, which survives as digitized plans and hardly legible hand-written text in German and Hebrew. The CHE 'Unsleben Jewish Cemetery' aims to integrate available information and facilitate easy retrieval of names and dates of those buried within the cemetery as well as the location of their graves. For example, CHER-Ob users can search for a specific name of someone interred within Unsleben Jewish Cemetery and retrieve all the available information, including dates of birth and death and location of the grave in the cemetery. The CHE includes a digitized historic plan derived from the cemetery archive, enriched with textual information. The latter were added as point annotations under the category Stylistic Analysis and Descriptions, colour coded green in CHER-Ob environment. The annotations contain name of deceased, date of birth and death, Cemetery Plan Number and Cemetery Book Number.

Since images can also be included in the annotations, a section of the cemetery book associated with each entry was attached to the point annotations to facilitate easier deciphering and translation of illegible text. The tabs on the right side of the screen provide enhanced access options. Annotations can be reached through the 'Navigation' tab, metadata can be viewed and edited through the 'Cultural Heritage Entity' tab and other functions such as adding general annotations, search, filter, and bookmarks are located at the ‘Application’ tab (Figure 2). This example demonstrates the use of CHER-Ob for documenting data, managing 2D images and textual data, and analysing archival and historical information. All the information included in the CHE is expandable via projects.

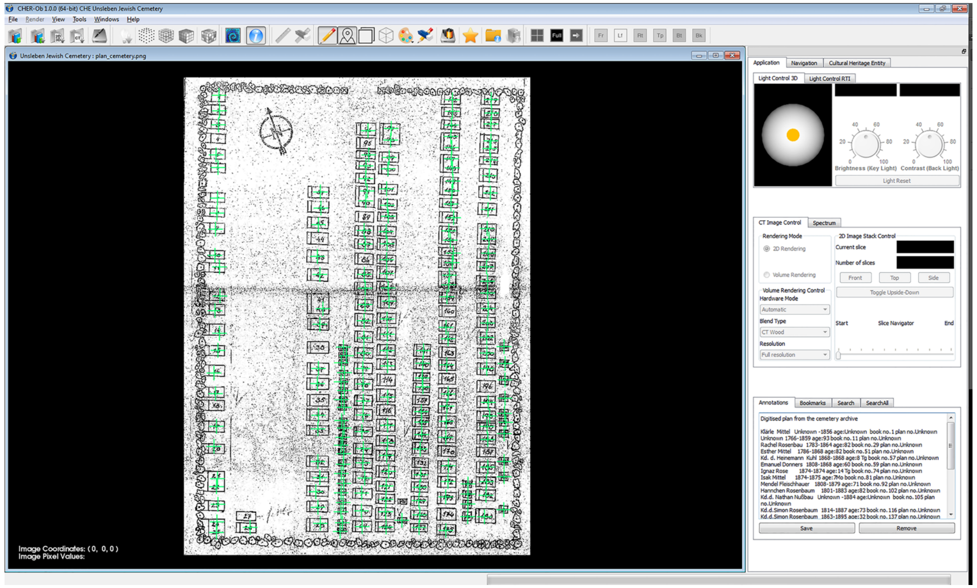

Figure 2. Screenshot from CHER-Ob after the creation of CHE ‘Unsleben Jewish Cemetery’. It shows the annotated digitized historic plan derived from the cemetery archive. General and point annotations refer to archival information and are classified under the stylistic descriptions.

CHER-Ob Projects

The fundamental areas of research for the Unsleben Jewish Cemetery within CHER-Ob were (1) documentation and management of the available dataset, (2) evaluation of 2D and 3D imaging data, (3) translations of text and inscriptions from German and Hebrew to English and (4) comparison of the results of fieldwork with the archival information. Documentation and management of the available data were considered crucial points of the project because of the need to ensure the best use of

available diverse dataset. 2D and 3D images had been used as the means of documentation as well as for online presentation and dissemination purposes. RTI’s efficiency for the visualization of inscriptions was evaluated in comparison to static 2D images. Translations into English were necessary as a way to reach a broader audience, including a large number of descendants of the Unsleben Jewish community who migrated to the USA. Last but not least, historical information and recently acquired data during fieldwork were brought together in an attempt to reveal information either not included in the archive or non-existing due to damage. To achieve these goals independent projects were created in CHER-Ob, such as the Unsleben Jewish Cemetery 2D Imaging Project, Unsleben RTIs Project and the Unsleben Memorial Project.

Unsleben Jewish Cemetery 2D Imaging Project

The ‘Unsleben Jewish Cemetery 2D Imaging’ Project integrates satellite images, aerial and terrestrial photographs captured by members of the project team and visitors, before compiling them with other forms of 2D documentation, such as RTIs (Figure 3). Images of individual tombstones visualize the state of conservation and the stone deterioration features. In cases of well-preserved stones, details such as the name of the deceased and relevant dates are identifiable. Terrestrial general views of the cemetery help the user understand the positioning of the stones within the site. Aerial views provide another perspective and relate the site to the landscape. Combining the above with the cemetery plan and enriching with archival information, helped us to identify graves of families and correlate them to chronological information. CHER-Ob users can explore the available 2D images of the tombstones either independently or in synergy with the cemetery plan and aerial images. The latter is an enhanced methodology for accessing the heritage record. Annotations can be added for identifying interesting features represented in images as well as for developing cross-references across the dataset. For example, stone weathering patterns observed

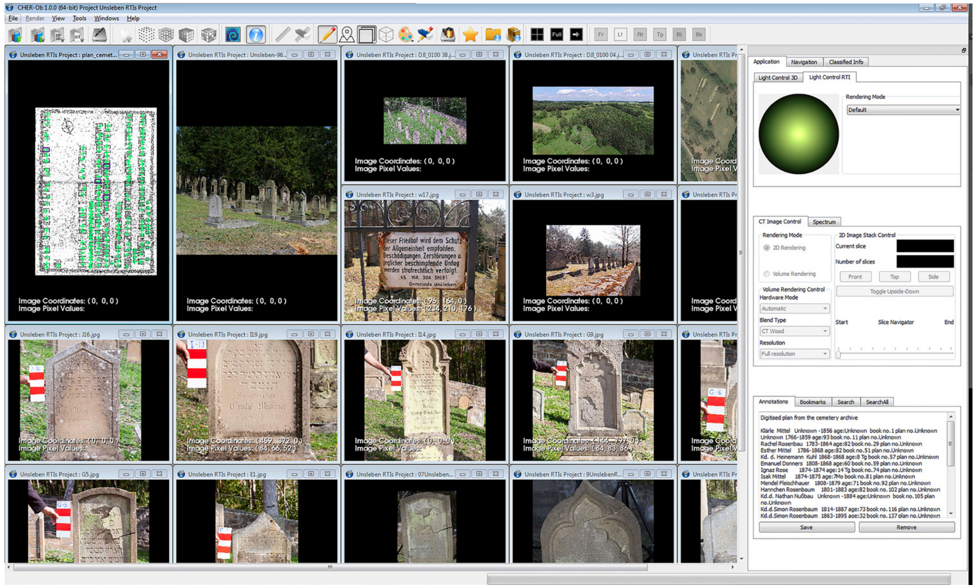

Figure 3. Screenshot from CHER-Ob. A general view of the 'Unsleben 2D imaging project' after compiling all the available information.

during visual inspection are identifiable in computer visualizations and are cross-referenced in CHER-Ob projects. This functionality assists in developing interrelationships not only across the dataset but also between the members of the team, by identifying overlapping research interests and the potential for interdisciplinary projects within the scope of the Unsleben Cemetery and beyond.

Unsleben RTIs Project

The 'Unsleben RTIs Project' aims to define the efficiency of RTI visualization for enhancing the legibility of inscriptions on tombstones, following previous successful application of RTI technology for the study of stones (Gabov and Bevan 2011; Duffy 2010). The 'Unsleben RTIs Project' is significant not only because it attempts to make the inscriptions readable for transferring the information about the lost Jewish community to the present and hopefully to the future but also reveals the ongoing weathering

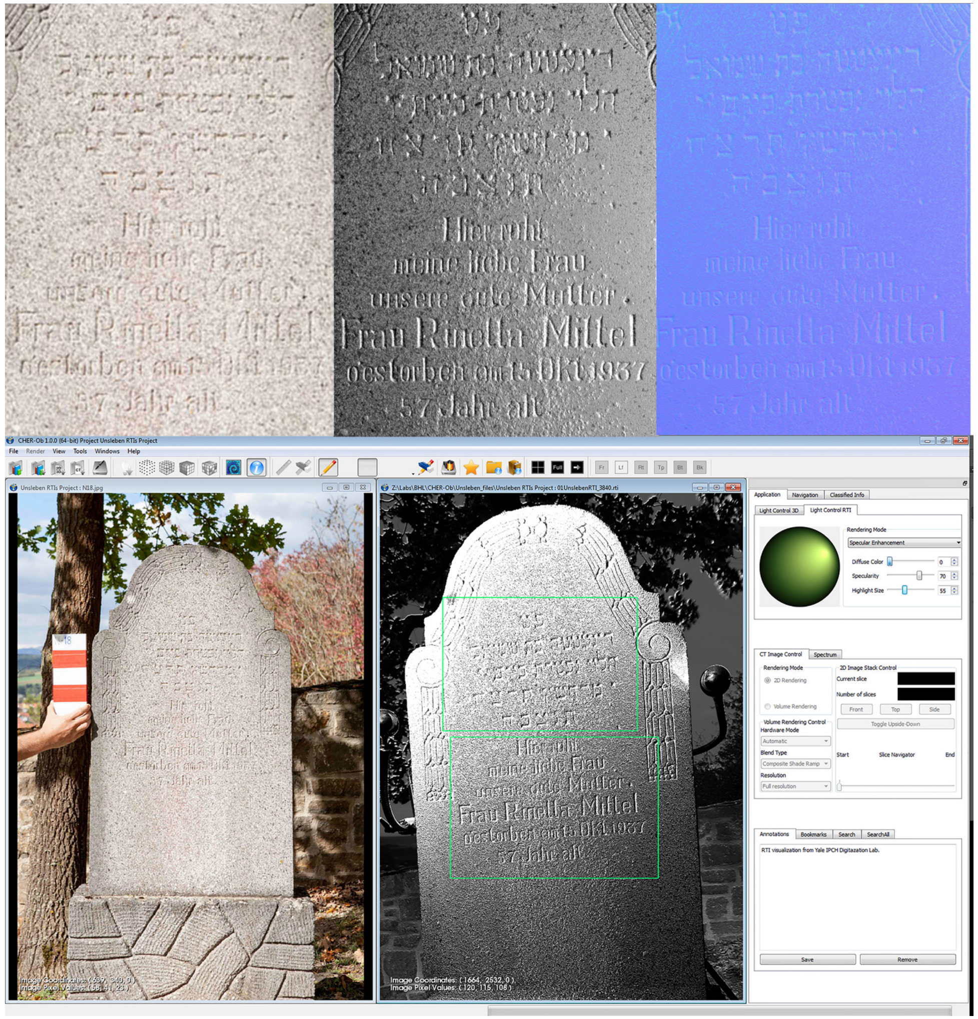

Figure 4. Digital image of gravestone inscription, RTI view in specular enhancement rendering mode and normal map (above from left to right) and a screenshot from CHER-Ob (below) showing the comparative analysis of the RTI visualization and the static 2D image during the development of 'Unsleben RTIs Project'.

of inscriptions due to the different agents of stone decay. As shown in Figure 4, RTIs and static 2D images were imported into the project and annotated in a comparative mode. The simultaneous comparative analysis of RTIs and 2D images of tombstones made possible the evaluation of RTI contribution to the study of the inscriptions in a much easier and more practical way compared to individual visual analysis using widely popular RTI and 2D image processing software. Users add annotations to different tombstones visualization formats (RTI visualizations, 3D models and 2D static images) within the same software during their comparative analysis. In most of the cases these visualizations are complimentary approaches for the documentation and study of the stones and the annotations associated to each image type reveal different aspects of the tombstones. Thus, synthesis of the annotations deriving from different types of visualizations is an essential step before reaching robust conclusions. Within the same software users may examine the available data in a holistic mode, which includes interpretations based on different techniques as well as focused on different aspects of the site, incorporating different background knowledge. The strategies above are useful for broadening our understanding of the site and ability to analyse across a number of different aspects of heritage significance.

On the other hand, this functionality, non-existent before the release of CHER-Ob, enables a more convenient and straightforward comparative analysis of each visualization, regarding their contribution to the project's goal. Even after the completion of the project, via the annotations, users can track the provenance of each observation-characterization, creating an inbuilt historiography of the dataset itself, and the researchers to have analysed and contributed to it. With the assistance of search and filter options (primarily using names as search text), the location of the RTI visualized stones were pointed in the plan. Any inconsistency between the archival-historical and fieldwork data was noted and addressed.

Furthermore, in the future after a second RTI data capture of the tombstones over time, the comparative analysis of the same tombstone visualized in different file formats in addition to comparison of the same tombstone across time will be beneficial. Considering the inevitable material deterioration of the tombstones with time, additional RTI captures in the future will be beneficial for condition monitoring purposes. For example, quantitative RTI methodologies (Manfredi et al. 2013) can be applied for defining the rate of stone deterioration. Because of the multiple RTI viewing and annotation functionality, CHER-Ob can potentially be used for studies of weathering of the gravestones, following our initial visualization and stone characterization, and can ensure that the comparison of data over time will be possible and linked to the overall dataset for the site.

Unsleben Memorial Project

Another CHER-Ob project named 'Unsleben Memorial' was created based on all the available information of modern additions to the site such as the memorial close to the entrance. The data imported include a 3D model, different 2D images of the memorial and the initial CHE. In the project the location of the memorial was noted, in association with existing tombstones in the site documentation. The 3D model was annotated, using surface and volume annotations under different categories. The latter assists in assigning each annotation to the appropriate category based on the GCWA[1] schema and the former provides a way to distinguish annotations referring to the surface of the 3D model compared to its volume. The surface annotation was used for defining the position as well as the names inscribed on the plaque of the memorial. This annotation was added under the category 'descriptions' which is recommended for inscriptions and is colour-coded lime. The close range photogrammetry methodology used for the 3D digitization made it impossible to acquire sufficient data for the upper part of the memorial, because of its height. As a result, this part of the memorial has been poorly reconstructed. The volume annotation added under the category 'documentation' (in purple) serves as an explanation for the quality of the 3D digitization. The volume annotation under the category 'measurements' (in red) colour provides information for the size of the base of the memorial. Data derived from the CHE and the project are

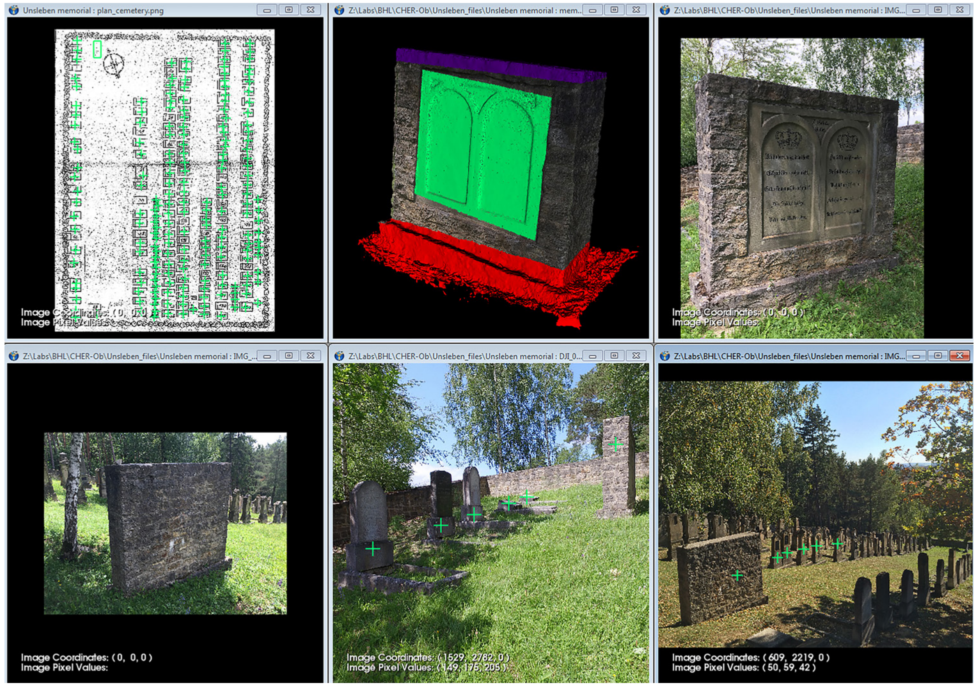

Figure 5: Screenshots from CHER-Ob project 'Unsleben memorial' showing imaging data for the memorial integrated with the archival information.

clearly distinguished in the 'Navigation' tab (Figure 5). During and after the development of the projects, the automatic report generation function was used for creating summaries of the projects, which include annotated imaging data and project information (Figure 6). After the completion of the projects, new data enriched the context of the CHE, which can be used for the creation of new projects.

Discussion

The above-mentioned projects developed in CHER-Ob showcase the potential of low cost, quick and easy-to-use digitization techniques, largely used for recording and documentation, analysis and interpretation, dissemination and as supportive material for conservation intervention and physical reconstruction. The case of Unsleben Cemetery CHER-Ob provides a single access point for 2D and 3D visualizations and textual data, assisting in data management of records and documents. But CHER-Ob not only provides enhanced access to various visualization and information, but also plays a crucial role in virtual visual analysis of the stones. This analysis reveals material evidence and the state of conservation, links the material remains to archival information and assists in the generation of new knowledge for the tombstones and the lost Jewish community of Unsleben.

Digitization technologies offer advanced opportunities for analysis and overcome constraints, such as dimensions, physical properties and geographical location. In the case of Unsleben Jewish Cemetery, RTI reveals the surface topography of individual tombstones, emphasizing details of low relief such as the engraved texts and surface deterioration. RTI, the advanced digital analogue to conventional raking light imaging has been largely used for enhanced legibility of inscriptions. Interactive relighting visualizations are crucial for the Unsleben Cemetery, since the legibility of inscriptions on the tombstones provide the material evidence for connecting existing remains to historical and archival information. Moreover, RTI views reveal surface topography, assisting in defining the weathering patterns on the stones, and by extension help define the state of preservation. 3D digitization enables more accurate illustration and offers an advanced perception of geometry as well as effective comparisons. The use of 3D models of tombstones instead of static 2D images assists in mapping major geometrical transformations, such as material loss, via virtual visual analysis. At a larger scale, aerial

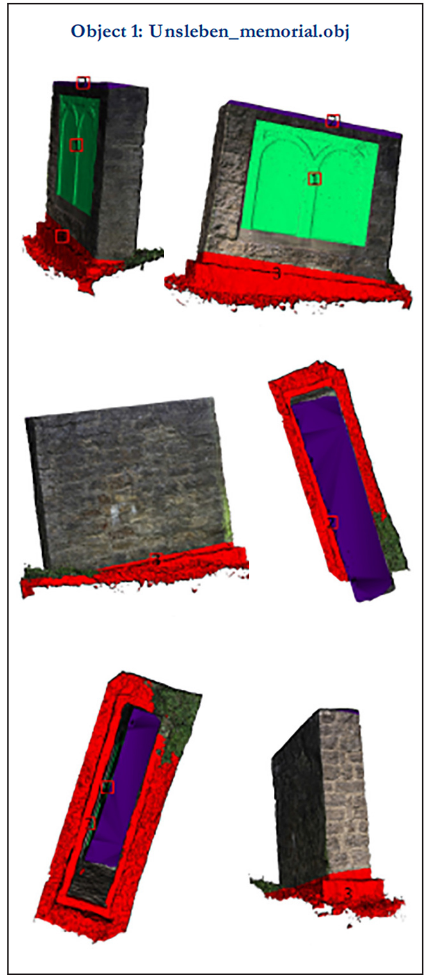

Figure 6. Screenshot from CHER-Ob report showing the representation of an annotated photogrammetric 3D model of the Unsleben Memorial.

photogrammetry (structure from motion) makes it possible to reconstruct the site and incorporate the findings of different visual representations. Archival information about the deceased and their family history and transcription of the engraved text has enriched the digital records of the CHE.

At the same time, this pilot study follows an alternative methodological approach. The diverse multimodal dataset was examined simultaneously in an integrated mode. Information in textual and numerical form was correlated to visualizations. Recently acquired data and historical information were compared in CHER-Ob, which enables the integration of different data types, such as digitised drawings and text from the cemetery archive and visualizations in the form of RTI, 2D and 3D digital images. CHER-Ob analysis reveals that the two datasets were complimentary. For example, tombstones and name plaques destroyed during the Nazi era were absent from the recently acquired dataset, but information can be retrieved from the cemetery archive. Similarly, modern additions, were not included in the historical archive, but were visualized in the fieldwork data. Based on the above, the project generated a more complete record for the site which would have been particularly time consuming and difficult using other computational tools, but was made possible with CHER-Ob integration of historical and contemporary data within one platform.

CHER-Ob provided the necessary tools to researchers for accessing the data within this single platform to lead holistic analysis. Considering that cultural heritage research of a site is never-ending, CHE and Projects in CHER-Ob are documents of the research process for future reference. Co-operative research including projects developed by historians, archaeologists, imaging specialists, conservators and linguists is enabled using CHER-Ob, with data being merged and broadened to enhance our understanding of the material evidence of the site as well as its intangible aspects. The advanced sharing options, including reports and videos, cannot provide the full functionality of CHER-Ob, but they are useful for writing project summaries, creating a digital and/or physical archive and sharing findings with non-CHER-Ob users.

Being able to disseminate the project findings was useful since there are many contributors from different institutions and with different research interests. These materials might be used for public engagement, for encouraging members of the local community and descendants of the Unseleben Jewish families to emphasize the intangible aspects of the project, via sharing their own family histories. The main platform for dissemination of reports in web-based file formats and short introductory videos made with the CHER-Ob software is the world wide web, which is easily accessible by the public. The dissemination of these materials can potentially motivate members of the public to get further involved in the project. Members of the public can generate new material within CHER-Ob, since the software is available for free download and can be used by everyone. It is accompanied by a detailed user manual and further educational material is available online for free. Although video and audio files cannot be added into the annotations of the current version of the software, the stories of the community can be added as texts.

Within CHER-Ob, the links formed between various data types, reflecting diverse aspects of the project, are considered an efficient methodology for further analysis and interpretation of the site. The innovative approach proposed by CHER-Ob is not limited to overcoming technical deficiencies of other platforms for comparative simultaneous analysis, but also act as a catalyst for understanding the knowledge production process during cultural heritage studies, incorporating digital records. For example, the visualizations added to the system by digital heritage experts were linked to the historical/archival information and then annotated by stone conservation scientists and heritage experts. Within CHER-Ob the contributions of each member of the team can be tracked via name tags and time stamps. Thus, at any phase during the development of the project, it is possible to identify how new knowledge about the site is produced. The new knowledge in the project is mainly relevant to the memorial and the stones (condition reports, inscriptions, exact positioning at the cemetery) but also includes the study of archival information.

Undoubtedly, the digital toolkit of cultural heritage researchers is continuously expanding, as demonstrated by the adaptation of novel visualization techniques primarily as means of documentation and recording. This has a major influence on the way researchers access and interact with the heritage record, and by extension, it becomes the foundation of analysis and interpretation of cultural heritage. For example, cultural heritage professionals used to document archaeological/historical sites, buildings and objects in 2D formats, such as drawings and photographs. Today, the use of 3D digitization is becoming popular for cultural heritage recording and documentation. As a result, professionals and researchers access and interact with the records in a way that offers more possibilities for further analysis in 3D space compared to conventional recording, such as structural, visibility and lighting analysis. These new methodologies assist in interpretations regarding the materials and techniques used in the past, the form, function and use of sites, building and objects.

The past decades' focus had been on the development of efficient digitization techniques, but now the focus is shifting from the development of technology and the lengthy list of digital innovations, to people as technology users and the development of effective research methodologies for enhanced interaction between humans and data. CHER-Ob is considered an attempt towards this goal because it proposes a new research methodology for accessing and analysing cultural heritage data in various file formats at a comparative mode simultaneously. This new methodology is not limited to a small community of experts, since the software was designed to be accessible by all cultural heritage professionals without a computational background knowledge. Also, the proposed methodology encourages collaboration across disciplines in the CHER-Ob virtual research environment, for example materials added by experts with different backgrounds can be used and annotated by other members of the team. During the development of the CHER-Ob platform, we had the opportunity to explore the interrelationships between scholars, digital records and visualizations, and understand the impact of methodological choices, including software, in interpretative approaches.

Conclusion

This paper introduced CHER-Ob, the new open-source integration platform for cultural heritage research developed to overcome inefficiencies of widely used computational tools. The most commonly used data types and the limitations of systems employed in cultural heritage research are discussed. A case study, focused on the Unsleben Jewish Cemetery, part of the 'Unfolding Communities' projects, was presented, with an emphasis on CHER-Ob's potential for a holistic research approach, flexible enough to meet the needs of interdisciplinary cultural heritage studies. Additionally, CHER-Ob initiates a discussion for the integration of multimodal datasets and the dynamics of cultural heritage research, having as a starting point its three main concepts; people, sites and technology, but expanded towards methodological choices and interpretations.

Future development goals are the incorporation of different roles assigned to users and personalization, as well as interoperability with data repositories and a closer look at terminology and controlled vocabularies. The users are defined as Creator, being the user who has the unlimited access and modification permit on the CHE(s) and Project Files; Modifier, being the user who has the permit to view and modify the Project Files and Viewer; who can only view and share the information that are permitted by the Creator. Each user may have access to a personalized interface according to professional and role requirements. The connection between data repositories such as ADS (http://archaeologydataservice.ac.uk/), management/inventory systems such as ARCHES

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(http://archesproject.org/) and online image viewers like MIRADOR (http://projectmirador.org/) with CHER-Ob will be explored, having as a goal to provide automatization to the process of data input to CHER-Ob and export to other systems. Ideas that will be considered for the future development of CHER-Ob are the re-design of the user interface, audio and video files additions to the list of compatible data types, CHER-Ob web application, further enhancement of filtering options via selective viewing of annotations, global bookmarks for revisiting a combination of views. Finally, CHER-Ob will be benefit from the experiences of the user community, the contribution of the developer community with the continuous and active support of the project team.

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References

Andreadis, A., G. Papaioannou, and P. Mavridis. 2015. “Generalized Digital Reassembly Using Geometric Registration.” In *Proceedings of the 2015 Digital Heritage International Congress*, edited by G. Guidi, R. Scopigno, J. C. Torres, H. Graf, F. Remondino, L. Duranti, P. Brunet, S. Hazan, and J. Barcelo, 549–56. Granada: IEEE.

Arbace, L., E. Sonnino, M. Callieri, M. Dellepiane, M. Fabbri, A. Iaccarino Idelson, and R. Scopigno. 2012. “Innovative Uses of 3D Digital Technologies to Assist the Restoration of a Fragmented Terracotta Statue.” *Journal of Cultural Heritage* 14 (4): 332–45.

Baca, M., and P. Harpring. 1996. “CDWA List of Categories and Definitions.” Last Revised April 9, 2014. https://getty.edu/research/publications/electronic_publications/cdwa/definitions.pdf.

Bazeley, P., and K. Jackson. 2013. “*Qualitative Data Analysis with NVivo*.” London: Sage Publications Limited.

Caine, M., E. Tagar, and I. Ben Or. 2014. “Unfolding Communities: Imaging the Past, Envisioning the Future.” In *Proceedings of the EVA London 2014 on Electronic Visualisation and the Arts*, edited by K. Ng, J. P. Bowen and S. McDaid, 150–57. London: BCS.

D’Andrea, A., F. Niccolucci, S. Bassett, and K. Fernie. 2012. “3D-ICONS: World Heritage Sites for Europeana: Making Complex 3D Models Available to Everyone.” In *Proceedings of the 18th International Conference on Virtual Systems and Multimedia (VSMM), 2012*, edited by G. Guidi, 517–20. Milan: IEEE.

Duffy, S. 2010. “Polynomial Texture Mapping at Roughting Linn Rock Art Site.” In *International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences (ISPRS)* XXXVIII: 213–17.

Friese, S. 2014. “*Qualitative Data Analysis with ATLAS. Ti*.” London: Sage.

Gabov, A., and G. Bevan. 2011. “Recording the Weathering of Outdoor Stone Monuments Using Reflectance Transformation Imaging (RTI): The Case of the Guild of All Arts (Scarborough, Ontario).” *Journal of the Canadian Association for Conservation* 36: 3–14.

Graphics, Volume. 2016. “VGStudio Max.” Heidelberg: Volume Graphics.

Hunt, L., M. Lundberg, and B. Zuckerman. 2014. “Online Reflectance Transformational Imaging: Viewing Capabilities and Benefits in a Specialized Academic Digital Library.” *Journal of Technologies in Society* 10 (1): 57–71.

Hunter, J., and C.-H Yu. 2011. “Assessing the Value of Semantic Annotation Services for 3D Museum Artefacts.” In *Sustainable Data from Digital Research: Humanities Perspectives on Digital Scholarship*. 137-57. Melbourne: Custom Book Centre.

Jones, A. M., A. Cochrane, C. Carter, I. Dawson, M. Díaz-Guardamino, E. Kotoula, and L. Minkin. 2015. “Digital Imaging and Prehistoric Imagery: A New Analysis of the Folkton Drums.” *Antiquity* 89 (347): 1083–95.

Kim, M. H., H. Rushmeier, J. Ffrench, I. Passeri, and D. Tidmarsh. 2014. “Hyper3D: 3D Graphics Software for Examining Cultural Artifacts.” *Journal on Computing and Cultural Heritage* 7 (3): 1–19.

Kotoula, E., K. G. Akoglu, and Z. Wang. 2017. "CHER-Ob (Cultural HERitage-Object) Workshop. Computer Applications and Quantitative Methods in Archaeology Atlanta 2017." Accessed April 12, 2018. https://prezi.com/pdcbpyzqk-tk/cher-ob-cultural-heritage-object/

Malzbender, T., D. Gelb, and H. Wolters. 2001. "Polynomial Texture Maps." In *Proceedings of the 28th Annual Conference on Computer Graphics and Interactive Techniques*, edited by L. Pocock, 519–28. New York: ACM.

Manfredi, M., G. Williamson, D. Kronkright, E. Doehne, M. Jacobs, E. Marengo, and G. Bearman. 2013. "Measuring Changes in Cultural Heritage Objects with Reflectance Transformation Imaging." In *Proceedings of the 2013 Digital Heritage International Congress,* edited by C.A Madisson, L. de Luca, G. Guidi and S. Pescarin, 189–92. Marseille: IEEE.

Miles, J., M. Pitts, H. Pagi, and G. Earl. 2014. "New Applications of Photogrammetry and Reflectance Transformation Imaging to an Easter Island Statue." *Antiquity* 88 (340): 596–605.

Palma, G., M. Corsini, P. Cignoni, R. Scopigno, and M. Mudge. 2010. "Dynamic Shading Enhancement for Reflectance Transformation Imaging." *Journal on Computing and Cultural Heritage* 3 (2): 1-20.

Papadopoulos, C. 2010. "*Death Management and Virtual Pursuits: A Virtual Reconstruction of the Minoan Cemetery at Phourni, Archanes*." Oxford: Archaeopress.

Potenziani, M., M. Callieri, M. Dellepiane, M. Corsini, F. Ponchio, and R. Scopigno. 2015. "3dhop: 3d Heritage Online Presenter." *Computers & Graphics* 52: 129–41. https://doi.org/10.1016/j.cag.2015.07.001

Robinson, D., M. J. Baker, C. Bedford, J. Perry, M.e Wienhold, J. Bernard, D. Reeves, E. Kotoula, D. Gandy, and J. Miles. 2015. "Methodological Considerations of Integrating Portable Digital Technologies in the Analysis and Management of Complex Superimposed Californian Pictographs: From Spectroscopy and Spectral Imaging to 3-D Scanning." *Digital Applications in Archaeology and Cultural Heritage* 2 (2–3): 166–80. https://doi.org/10.1016/j.daach.2015.06.001

Shi, W., E. Kotoula, K. G. Akoglu, Y.Yang, and H. Rushmeier. 2016. "CHER-Ob: A Tool for Shared Analysis." In *14th EUROGRAPHICS Workshop on Graphics and Cultural Heritage*, edited by B. Falcidieno, D. W. Fellner, C. E. Catalano and L. de Luca, 187-90. Genova: Eurographics Association. http://dx.doi.org/10.2312/gch.20161404

Shi, W. 2017. "CHER-Ob open source repository." Accessed April 12, 2018. http://github.com/WeiqiJust/CHER-Ob

Wang, Z., K. G. Akoglu, and H. Rushmeier. 2017. "An Introductory Video Generator for Disseminating Cultural Heritage Projects." In *15th EUROGRAPHICS Workshop on Graphics and Cultural Heritage*, edited by T. Schreck, T. Weyrich, R. Sablatnig and B. Stular, 83-92. Graz: Eurographics Association. http://dx.doi.org/10.2312/gch.20171296

Yale Graphics Group. 2016. "CHER-Ob: An Open Source Platform for Shared Analysis in Cultural Heritage Research." Video, 2:44. https://www.youtube.com/watch?v=gl-NTAF3Z7I&t

Yale University. 2016. "CHER-Ob: An Open Source Platform for Shared Analysis in Cultural Heritage Research." Accessed December 8, 2017. http://graphics.cs.yale.edu/site/cher-ob-open-source-platform-shared-analysis-cultural-heritage-research?destination=node%2F196

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Endnotes

1 GCWA is Generalised Closed World Assumption, a type of logic that assists in database analysis.

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Future Pasts, Past Future: Or material preservation in an Increasingly digital world

Abstract

The rather problematic - yet emblematic - Smithsonian 'streets in the sky', seems to have been proven insufficient, or better inefficient, in putting Robin Hood Gardens on 'the List', joining the ever-growing fleet of English Heritage. Instead, the provocative and influential public housing scheme, designed and completed in 1972 by two of Britain's most important architectural designers and thinkers and also leading protagonists of New Brutalism, was paradoxically given the title of 'monument' and offered a place in 'PastScapes' – a repository / link in Historic England's online presence for non-listed or non-designated sites. After the failed campaign to save the historic estate and the concurrent approval of the planning application of the second phase of the 'Blackwall Regeneration Project' - which gave a conclusion to this controversial conservation case - local MP Margaret Hodge suggested that a 3D scan of the concrete complex would be enough preservation to legitimize its demolition, raising the question amoungst others, of how much a digital replica can really replace a building.

In this increasingly digital world, it seems that we are slowly starting to (if not already doing so) delegate the preservation issue to a new set of evolving technologies, that along with their incredible possibilities and fascinating/interesting capabilities, they bring to the table their own dialectics. Dialectics not quite known and certainly not yet fully determined. Dialectics that will probably once and for all change, shift, disrupt or relocate any relationship with the historical past, unmaking every established idea, notion and concept around cultural heritage, historical monuments and monumentality or even the very own idea of preservation. When everything migrates from the material to the immaterial and ultimately to the digitized computer bank or the cloud, all will be different.