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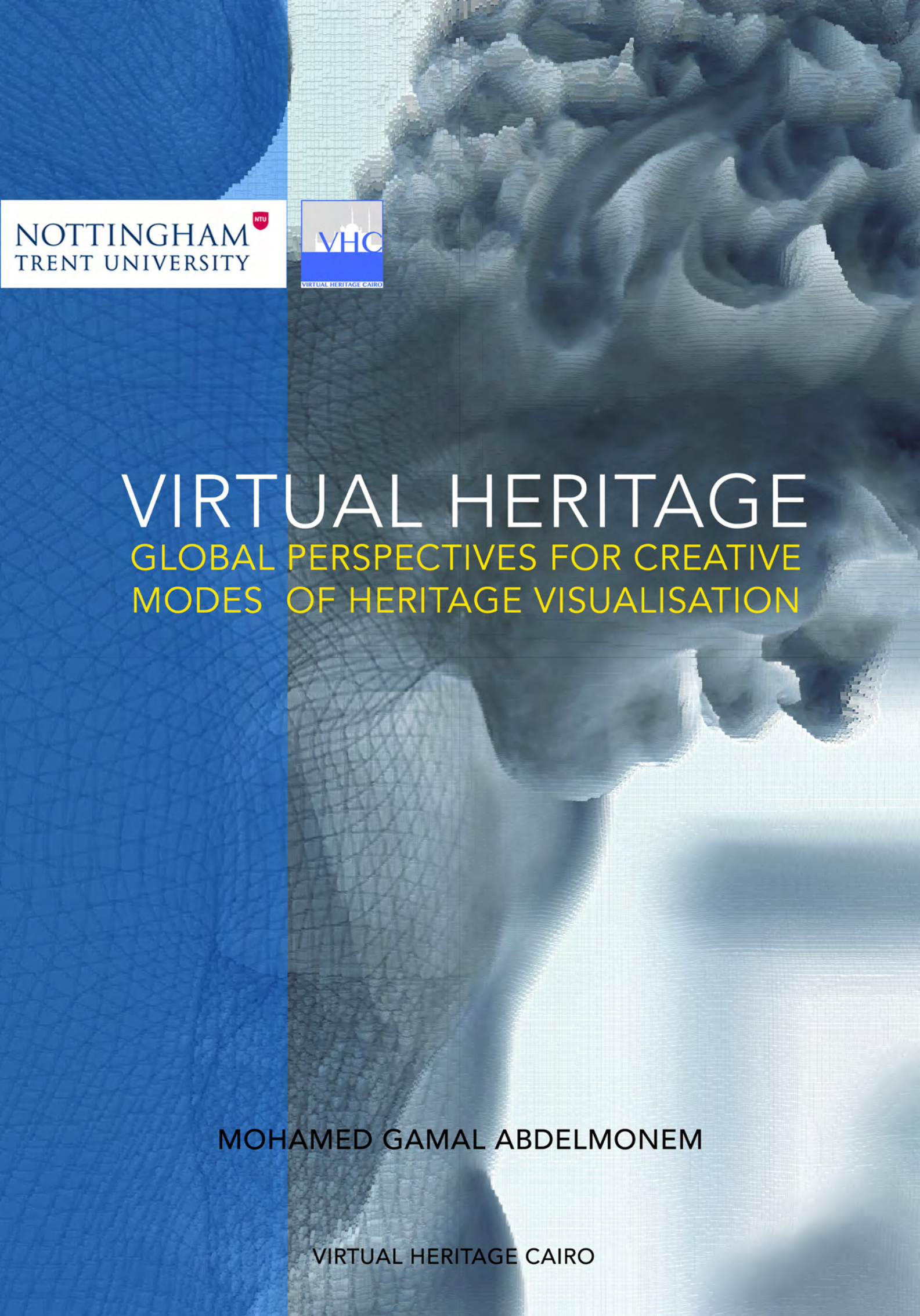

VIRTUAL HERITAGE

GLOBAL PERSPECTIVES FOR CREATIVE MODES OF HERITAGE VISUALISATION

MOHAMED GAMAL ABDELMONEM

VIRTUAL HERITAGE CAIRO

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Virtual Heritage of Medieval Culture: Collaborative Network for Cultural-*feed* of Virtual Heritage (CfVH) platforms of medieval Cairo

ARTS AND HUMANITIES RESEARCH COUNCIL (AHRC)
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FINAL RESEARCH REPORT

VIRTUAL HERITAGE

GLOBAL PERSPECTIVES FOR CREATIVE MODES OF HERITAGE VISUALISATION

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1.0 Introduction

Iconic heritage is increasingly threatened by terror, climate change, rampant commercialisation, and overexploitation by tourism; and in some cases, by significant disinvestment. Lack of responsible planning, maintenance and preservation strategies have equally caused unmitigated dereliction and irreversible damage to many heritage sites and cultural traditions in the medieval Middle East. Instability across the MENA region has prompted calls for the protection of culture and archaeological heritage as a political, economic and global challenge. With the increasing rate of destruction of heritage sites, digital preservation of historic artefacts and cultural heritage has arisen as an international priority. With tourism industry contributing 11% to Egypt's GDP, and non-governmental organisations, charity foundations and private sector enterprises dramatically growing, technical and community support to this industry has become at the forefront of sustainable economy and social welfare of local populations. Yet, there are strategies, practices, skills and technologies that can protect, develop and sustain these places in other forms of reproduction such as digital modelling, immersive virtual and augmented reality, and cinematography and Audio-visual archives.

Despite its wealth of World Heritage Sites, the production of VH in Egypt is rather limited and lacks accessibility to technology and skills, appropriate digital platforms for operation and dissemination. As many of the Cairene traditions, memories and cultural practices emerged from the enduring Medieval Cairo's historic communities (hawari; alleyways) and local markets (Abdelmonem 2016 a&b), reproducing such culturally-rich environments through VR modelling systems would be a challenge. Cairo's medieval fabric, however, would only be understood if supplemented with modes of socio-cultural interaction and traditions (Abdelmonem and Selim 2012.) These were frequently photographed, filmed and recorded in drama series and cinema productions. Virtual heritage models in this sense would offer realistic cultural experience in a living memory.

Digitisation of heritage through customs, photo archives, film footage, oral history documentaries and buildings has become central for the preservation of national identity and an effective tool in national strategies of undermining radical ideologies in marginalised communities. Virtual environments which encompass cultural heritage and are represented through digital media are often categorised as 'virtual heritage'. Modern media and technologies offer the possibility to experience virtually reconstructed historic sites as visitors, travellers, or even as a resident. Although virtual heritage possesses great potential to reconstruct our heritage and memory, critics often blame high cost, sophisticated hardware and software requirements, inaccessibility of technology and training, and high maintenance for preventing widespread dissemination and use of virtual heritage platforms.

Much of the effort in VH is directed towards accurate representation of historic objects and physical precision of ancient architecture styles but lacks the human part of city life, to which people can actually relate (Yang et al. 2006). Perfectly modelled virtual buildings and spaces only give a sense of precision, but only rituals, human attitude and cultural traditions enable them to engage with heritage visualisation (Mosaker 2001). Virtual Heritage Environments (VHE) also lack 'thematic interactivity' due to the limited cultural content and engaging modules largely used in photorealistic video gaming systems. In order to approach virtual fidelity and accurate reproduction of historic environments, this Report documents the global practices and perspective on a novel research on Cultural-feed of Virtual Heritage (CfVH). In this scope, the cultural content of Virtual Heritage focuses on the potentials of reducing technical limitations and addition of sub-grid cultural terrains to attain a degree of 'reality' and photorealism of culture as a measure for virtual environments; leading towards the amorphous nature of history.

For effective engagement with learning experiences and studies of ancient cultures or to grasp the implications of their evidence, it has become essential to introduce an interactive approach in 3D platforms. As noted by Sanders (2008), "*We understand that the past did not happen in 2D and that it cannot be effectively studied or taught as a series of disconnected static images*". Due to advanced computer hardware and high-end graphics cards, trends in virtual reality applications are motivated towards the use of immersive technology for real-time interaction with high detail. This industry has sprung into fruition over the past two decades, thanks to the breakthrough in the development of virtual reality hardware and associated software applications. But, it started from a conventional origin, museum display.

The first use of virtual heritage as a museum exhibit, and the derivation of the name 'virtual tour', was in 1994, as a museum visitor interpretation, providing a 'walk-through' of a 3D reconstruction of Dudley Castle in England as it was in 1550. This consisted of a computer controlled laserdisc-based system designed by British-based engineer Colin Johnson (Sanders 2008). It is a little-known fact that one of the first users of Virtual Heritage was Queen Elizabeth II, when she officially opened the visitor centre in June 1994. Because the Queen's officials had requested titles, descriptions and instructions of all activities, the system was named Virtual Tour, being a cross between virtual reality and Royal Tour (ibid).

Virtual heritage is considered as an important application of state-of-the-art technologies, giving scope for interdisciplinary applications for adverse fields. Virtual reality is sometimes referred to as immersive multimedia, as a computer-simulated environment that can simulate physical presence in places in the real world. Virtual, visual and digital display of lost heritage has inherent values in the education process for students in both pre-university as well as graduate education. For architecture and archaeological students, in particular, it virtually transfers them to another world and makes them feel as if they were walking at the site with its details in the past. For conservators, historians and archaeologists, it helps develop a rich library and digital archive of details, information and data necessary in restoring historical sites, as well as heritage preservation where the 3D virtual models contain accurate data and help for restoration.

In this report, we aim to uncover a conceptual framework for the development of virtual heritage platforms as a research, educational and engagement tool that brings historic spaces and buildings back to the recognition of the public eye of the ordinary user. It not

only reproduces historical scenes through physical modelling of archaeological sites or data, but, more importantly, through serial narratives where life is explored and practised in motion, and where cultural-feed brings meaning, experiences and understanding to the socio-cultural context. The report will introduce a brief and summary database of case studies of examples of virtual heritage platforms that offer a variety of methods, techniques, contexts, and outputs that are suitable to different purposes and audiences. It will finally offer a brief conclusion on how virtual heritage can provide unique and unprecedented insights into historic events that would be otherwise invisible or unimaginable through visual experience.

2.0 Goal of the Report

This report aims to introduce a series of conceptual and theoretical discussions, comparative analysis and a series of global case examples of the use of virtual platforms and media production for cultural heritage that vary in their typologies, methodologies, products and end users. It offers a summary survey and information of a series of selective best practice from North American, European and Asian cities and organisations that have produced informative, innovative and creative solutions and platforms for Virtual Heritage. They reflect different forums of research investigations, modes of recording, analysing and communicating historic contexts, heritage sites and basic research forums.

In this report, we refrained from including video gaming examples due to the largely uncritical and unverified nature of their cultural and historic content. In doing so, the research team has undertaken a comprehensive research on a variety of digital media productions used for communicating cultural heritage over the past 20 years. Those were filtered according to technology used, aspects of excellence and their relevant contexts.

In this instance the report has two principal objectives:

a. Offering an overview on the range of technologies, techniques and contexts that have been used for recording cultural heritage in virtual format
b. Identifying aspects of excellence in methodologies, research work, creative production and processes involved in each of these projects.

3.0 Research Context

The advancement of the virtual world has pervaded everyday life through multidisciplinary applications that are used in areas such as simulation for education, entertainment, medical applications, online communications, social media and gaming. Many virtual heritage projects focus on the tangible aspects of cultural heritage, for example, 3D modelling may be created automatically or manually. The manual modelling process of preparing geometric data for 3D computer graphics is similar to plastic arts such as sculpting, graphics (computer graphics include user interface design, sprite graphics, vector graphics, 3D modelling, shaders, GPU design, and computer vision) and animation or CGI animation (the process used for generating animated images). In doing so they often overlook the intangible aspects of cultural heritage associated with objects and sites, such as stories, performances and dances. The tangible aspects of cultural heritage are not inseparable

from the intangible and one method for combining them is the use of virtual heritage serious games, such as the Digital Songlines and Virtual Songlines which applies virtual reality to preserve, protect and present the cultural heritage of Australian Aborigines.

There are a number of theories attempting to address technology and virtual heritage studies which tend to be associated with the disciplines of science and technology studies (STS) and communication studies. Moreover, Descriptive theories attempt to address the definition and substance of technology, the ways it has emerged, changed and its relation to the human/social sphere. More substantively it addresses the extent to which technology is autonomous and how much force it has in determining human practice or social structure. Critical theories of technology often take a descriptive theory as their basis and articulate concerns, examining what way the relationship can be changed.

One technology that is frequently employed in virtual heritage applications is augmented reality. Augmented reality (AR) is a live direct or indirect view of a physical, real-world environment whose elements are augmented (or supplemented) by computer-generated sensory input such as sound, video, graphics or GPS data. It is related to a more general concept called mediated reality. The Hardware components for augmented reality are processor, display, sensors and input devices. Modern mobile computing devices like smartphones and tablet computers contain these elements which often include a camera and MEMS sensors such as accelerometer, GPS, and solid state compass, making them suitable AR platforms.

4.0 The Interface between Cultural and Virtual Heritage

The use of computer and digital applications for the preservation of heritage has as long history as computer science itself. Since the 1990s evolution of digital modelling, graphics, visualisation platforms and virtual environments have driven the development of new theoretical and empirical methods to approach the problems of archaeology and heritage preservations. Early methods of digital archaeology or archaeological computing were seen as methods for the elaboration of archaeological data using quantitative computing. Later versions contributed to the representation of archaeological data using cognitive procedures. Virtual Archaeology, in this context, has become a primary discipline in the analysis of the procedures of management, interpretation and representation of archaeological evidence using 3D computer graphic techniques. Its breakthrough in the digital reconstruction of historic events, lost structures or disappeared heritage enabled both theoretic and applied research to test different propositions, narratives and undertake forensic examination and analysis of archaeological remnants of the past.

However vastly developed over almost half a century, Virtual Archaeology (VA) remained a specialised platform for researchers and archaeologists for research-led activities. The public was not involved in its applications, and nor were its outputs intended for public consumption and use. More recently, the development of new communicative approaches to heritage, history and archaeological contents have progressed the use of interactive strategies that benefit broader groups of beneficiaries, stakeholders and public users. The proliferation of the use of 3D modelling techniques, nonintrusive imaging, geophysics and augmented reality cameras has offered a multiplicity of platforms to simply store, archive and communicate vast amounts of information on cultural heritage sites,

traditions and contents. There was a simultaneous necessity to experience new sustainable ways to record, store, archive and analyse ever expansive records of datasets and to create the best medium to communicate digital systems of preservation.

Cultural institutions, on the other hand, are immersed in connecting with aspects of history and tradition. Their prime purpose is to bridge time, space and experience between the past and the contemporary audience and visitors. Technology offers new frontiers that help widen both platforms of engagement and number or type of regular audience. In a recent article in the Guardian newspaper, Mia Ridge and Danny Birchall (2015) suggested that while people may no longer be missing out on all that cultural heritage has to offer online because of their lack of internet access, there may be a new "digital divide" focused on social media platforms of display. Museums and exhibition managers are therefore contemplating whether the contemporary technology-hungry younger generation, or "digital natives", are receiving appropriate content.

Many digital projects have become an increasingly core element of museums' strategy as cultural institutions face up to the challenge of bridging the gap between their capacity with technology and their aspirations to enhance audience engagement with collections. (Ridge & Birchall 2015). To achieve that, they very often make alliances with areas of digital expertise in the large and creative tech industry. There are several projects that explore culturally heritage sites and objects using digital means. For instance, museums are investigating the possibilities offered by 3D printers to examine their collections in a form where detail can be magnified and destruction is far less consequential. The Neues Museum in Berlin, for example, has collaborated with CultLab to scan and develop a virtual Model of the Nefertiti Bust to enable a larger group of audience to visualise the details of the masterpiece without exposing the invaluable artefact to damage.

Drones, 3D printing and augmented reality apps are just some of the tools being used to construct "virtual museum" experiences for real and digital visitors. Digital and virtual technologies open up new and exciting possibilities for exhibitors, archaeologists, architects and curators; they also provoke much debate in museums and user groups over real versus virtual users and the priority for investment. This instigates resistance around the issues of authenticity, ownership and value, among conventional and advocate archaeologists (Kidd, 2015.) There are currently a number of projects under way that explore how historically or culturally significant sites and objects can be presented using digital means. For instance, museums around the world are investigating the possibilities offered by 3D printers to extend and further examine their collections in a form where detail can be magnified and destruction is far less consequential.

Meanwhile, the EU's DigiArt project use drones and 3D Laser scanners, and £60 cameras to "capture" inaccessible cultural artefacts, before creating advanced 3D representations of them. DigiArt (2017) claims to provide innovative 3D capture systems, including aerial capture via drones, automatic registration and modelling techniques for post-capture processing, semantic image analysis and digital 3D representations via a "story telling engine". It uses augmented and virtual reality technologies for viewing, or interacting with the 3D models as a pathway to deeper understanding of artefacts. The 3D data captured by the scanners and drones, using techniques such as laser detection and ranging (LIDAR), are processed through robust features that cope with imperfect data. The

major output of the project is a multifaceted system to be used by museums to create such a revolutionary way of viewing and experiencing artefacts.

The networks of virtual museums are expanding with environments where immersive 3D story worlds become a genuine possibility for historical encounters with heritage sites, either existent or disappeared. The Neues Museum, the Louvre, Victoria & Albert all offer online Virtual Tours curated for public audiences and children (Kidd, 2015.) These applications for children are particularly important. Many cultural institutions, galleries and museums have developed augmented reality games that help children engage with historic sites or heritage stories through treasure hunts or collections of artefacts. It is not uncommon to find museums rendered in Minecraft, built by an invisible crowd of tech-savvy fans, as in the British Museum's Museumcraft, or Tatecraft (ibid.). In this discourse, the rhetoric of authenticity has been debated and contested as opposed to originality. Authenticity has traditionally been key to the way museum experiences are packaged and displayed to the public users. But more recently, as History itself has become subjective, so have notions and concepts such as archaeology, originality and "authenticity", as they need an authority to justify the evidence behind its identification. The history and authenticity of an artefact is no longer absolute. Its meaning is relative to the audience as it was to its creator.

But these developments have been evolving over decades. People have been talking about virtual museums for many years as ways of allowing visitors access to sites and experiences that would never otherwise be accessible to them (Ibid.) What is remarkable is how far we have come to offer realistic interactivity with historic environments, and the way in which the boundaries between virtual and physical experiences have begun to blur. Being able to test new forms of reality that no longer exist raises intriguing aspects of re-reading and reinterpreting history in the eyes of the audience, rather than the curator. Living the experience in the past venue is different from just watching still objects and images. Objects, images never exited out of context. For example, a Mummy never existed in daylight, nor the setting in which pharaonic artefacts were mostly discovered. Watching them in the tombs of Luxor or in Giza Pyramids has made them entirely more fearful than they are in the museums. Hence, virtual models of pharaonic tombs have been created to translate this experience to the virtual visitor in a way the normal museum could never offer.

5.0 Understanding Virtual Heritage & Immersive Technologies

Virtual and Digital Heritage are a body of work dealing with information and communication technologies (ICT) and their application to cultural heritage, such as virtual archaeology. According to Erik Champion, the application of virtual reality models and simulation technologies to historic knowledge and to cultural heritage content is what we generally call virtual heritage, but it has so far eluded clear and useful definitions and it has been even more difficult to evaluate. Virtual heritage aims to recreate cultural heritage environments, as well as to people them and furnish them in a historically authentic way. Its basic mission is to complement and enable rather than compete with historic research. It is designed to present historic information, context and practices as accurately, authentically and engagingly as possible.

According to Addison (2000), virtual heritage is the fusion of virtual reality technology with cultural heritage content. Champion (2016), citing Stone and Ojika (2000, p73), defined virtual heritage as: "the Use of computer-based interactive technologies to record, preserve, or create artefacts, sites and factors of historic, artistic, religious, and cultural significance and to deliver the results openly to a global audience in such a way as to provide formative educational experiences through electronic manipulations of time and space." However, the idea of cultural content is rather limited and increasingly is under representative of several intangible aspects of cultural heritage; which were summarised by Champion (2013) & Ch'ng (2013) as 'practices, representations, expressions, knowledge, skills – as the instruments, objects, artefacts and cultural spaces associated therewith – that communities, groups and in some cases, individuals recognize as part of their cultural heritage'

Whilst virtual heritage is used mainly as tools for teaching and learning about history in a visual manner, it has more recently been used to navigate, test and experiment different theories to validate historic and/or archaeological evidence. Aspects of authenticity, accuracy and realistic nature of the simulation, narratives and reproduction are intrinsic values that determine which version of history is at play. As history is increasingly contested due to different interpretations of evidence, being tangible or intangible, virtual heritage becomes accustomed to interpretation, contestation and analytical debate.

Virtual heritage and cultural heritage, in such theoretical contexts, pose different and independent meanings; cultural heritage refers to sites, monuments, buildings and objects with historical, aesthetic, archaeological, scientific, ethnological or anthropological value, whereas virtual heritage refers to instances of these within a technological domain, usually involving computer visualisation of artefacts or Virtual Reality environments. Virtualisation is, however, much more complex and multi-layered than visualisation that is to form a mental image of something incapable of being viewed or visible at a certain moment (Champion 2013). It involves the verification of not only the specific moment, site or context, but also narratives, practices and habits.

But Virtual heritage is becoming a leading sector in the diverse use of virtual reality systems and applications to engage communities, industries and technology developers with heritage. It is no longer about the short-term objective of visual representation of historic buildings. Thanks to the technological leap into a new generation of devices and supporting software, virtual heritage has become more inclusive than it was 20 years ago. While the 'London Charter' of 2009 defined computer-based visualisation as 'the process of representing information visually with the aid of computer technologies', scholars have demanded that this narrow definition is extended to include the non-visual aspects of visual experience, the haptic, auditory, olfactory and generally multi-sensory. According to Champion, it is not enough to reproduce a set of artefacts and archaeological objects as individual items separated from the story and context that give them meaningful representation.

In fact, Virtual Heritage Cairo argues that while visualisation of archaeological sites, objects and artefacts offers a detailed record of physical environments, those intangible aspects of heritage experience, namely, cultural-feed, would enable effective human interaction, understanding of the historic narratives in line with modelled objects. As we focus on cultural heritage, in contrast to archaeological preservation, we have to refer to the

human sensory experience with history. Cultural geographers, in particular, tend to associate culture with what is not seen. According to Yi-Fu Tuan (1998), perceiving the intangible is at the foundation of all human culture. Then, as cultural heritage refers to historic periods and societies that no longer exist, we face the troubled task of how to virtualise aspects that are not visible, and whose evidence of existence is scattered items, objects, spaces and series of unconnected narratives.

Here Virtual Heritage emerges as a term that reflects the ambiguous and interpretative nature of its processes. It is 'an attempt to convey not just the appearance but also the meaning and significance of cultural artefacts and the associated social agency that designed and used them through the use of interactive and immersive digital media' (Champion, 2015, p95.). While we aim in this report to bring together a series of global examples and case studies database within the framework of innovative virtual heritage, it is important to offer critical insights into the context of this emerging field and market. This would debate arguments, potentials, difficulties and risks that virtual heritage promises as an innovative and emerging discipline, research field, creative industry, important sector and market.

6.0 Economics and Management of Virtual and Digital Heritage

The conventional grant-based funds for virtual heritage are becoming increasingly rare in the current economic climate worldwide, whilst the demand for access to digital heritage is increasing among the general public, professional and amateur researchers, universities, and educators in primary and secondary schools. These realities are inspiring new economic funding models for heritage digitisation, virtual preservation and online access. In this sense, Preservation of digital heritage requires evolving technologies, and high standards of operations with the requisite policies and procedures; but critical to delivering the digital and virtual preservation service is perpetual financial sustainability (Enumerate 2015). Digital heritage has significant financial, cultural and scientific value. However, its market and economic value is still at the explorative and embryonic stage.

So far, Government grants for digitisation projects are the leading source for funding, but are always vulnerable to policy changes and austerity and budget cuts. This does not help the perpetual financial stability of a preservation repository. Not-for-profit organisations and public-private partnerships can operate efficiently and receive compensation. These include, but are not limited to, harvesting heritage assets, preserving, making accessible, repurposing for copy-on demand and curated collections, subscription services to closed collections and providing optional premium services for open collections (ibid.) Preservation institutions would need to invest excess revenue in foundations as a long-term financial strategy towards perpetual sustainability.

The eNumerate Digitisation in Cultural Heritage Report 2015 analyses data from over 1000 libraries, archives, museums and other European institutions to paint a comprehensive picture of the current digitisation landscape in Europe. The 2015 Report's survey data reveals 84% of institutions now hold a digital collection of some sort, whether purely digitised material or combined with digital elements. On average 23% of European collections have been digitised, with Museums having the highest proportion (31%), up

from 24% in the 2014 survey (eNumerate2015). The number of institutions with a predefined digitisation strategy had risen to 41% in 2015 from 36% in 2014, offering a clear indication of increased focus towards digitisation and creation of digital archives (ibid.)

Even though there has been a rise in investment, funding resources in the cultural heritage sector are still limited. The report suggests that 55% of descriptive metadata is unavailable online for general use. This implies that a large amount of records is virtually unsearchable because the associated metadata is not online. Libraries have 68% of their associated metadata available online for general use, while 51% of records are only available for staff use and 41% of data is available to archive visitors. With more data made publicly available, the market value would be expected to increase, as would the need for supporting infrastructure and metadata, as part of the digitisation efforts.

Internal and external budgets for digitisation and cultural heritage are made on an annual basis and can be funded by internal budgets and external budgets. On average the costs related to keeping digital collections are quite substantial, summing up to €276,471 (the figure was € 245,000 in 2014). (eNumerate 2015) This sum is an estimate of all the costs related to the initial creation, ongoing maintenance, enhancement and preservation of the digital collections. The cost of the staff time devoted to such activities is included in this estimate.

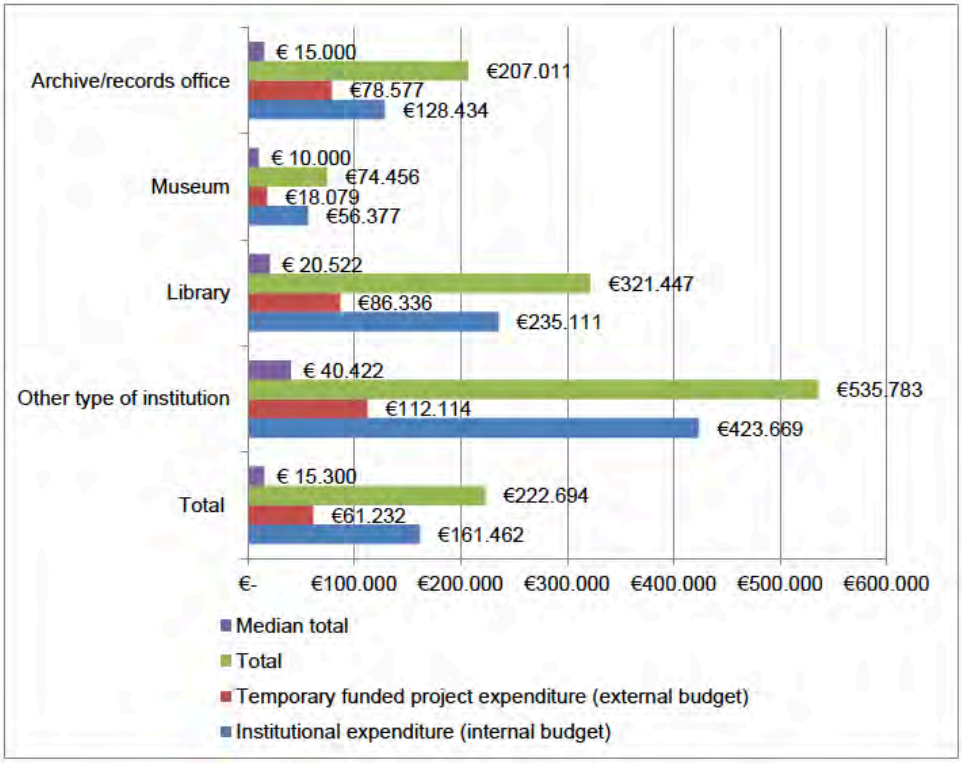


Fig.1 Estimate of Annual Expenditure for digital collections in European Institutions (n = 694) (Source: eNumerate 2015 Report)

According to Digi-Capital, investment in AR/VR technologies has exceeded a record $2 billion for the year 2016, despite the market still being in its earliest stages. Being

considered the fourth wave of platform change (after PC, online and mobile) Next-generation Virtual Reality models, economic products have evolved during 2015/2016 into a world leading hi-Tech sector with applications varying from entertainment and gaming industries to hi-end medical application in sensitive surgeries, simulation of pre-operation procedures, and virtual heritage. Predicted as the dominant technology industry for the coming three decades, Virtual Reality (VR) and Augmented Reality (AR) have opened the evolution of a wider range of subsidiary products and markets.

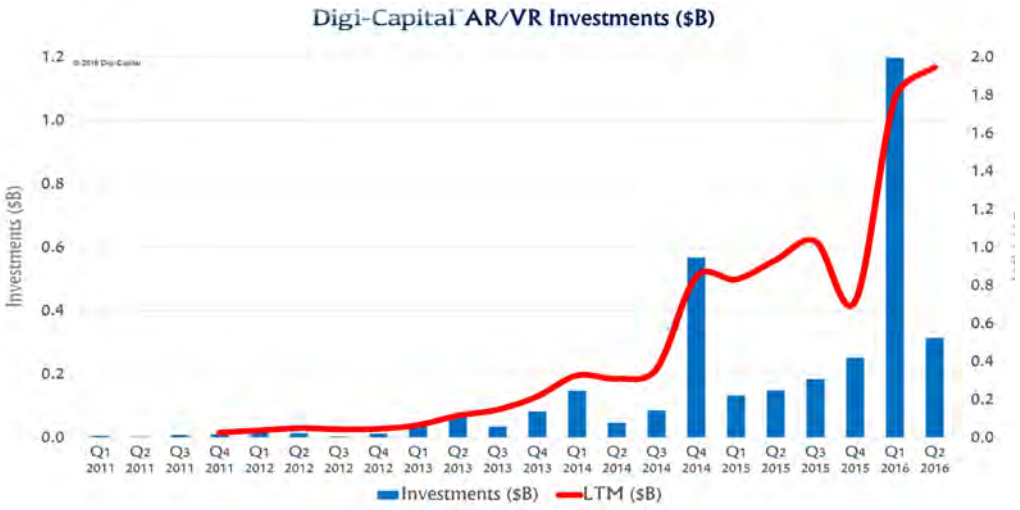


Fig. 2 Digi-Capital Statistical analysis of investments in VR/VR sector until 2nd Quarter of 2016. (Source: Digi-Capital, Feb 2017)

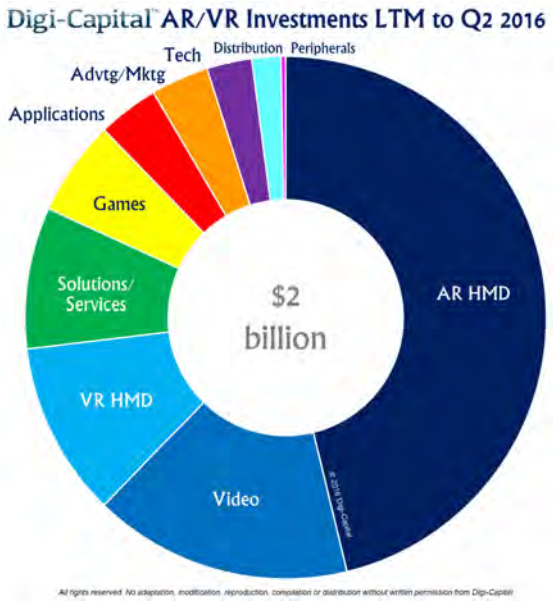


Fig. 3 Digi-Capital statistical analysis of investments in VR/VR sector for the record 2nd Quarter 2016 of $2 billion. (Source: Digi-Capital, Feb 2017)

Moviemakers are exploring opportunities for director-uncontrolled viewer perspective in VR movies. Visual effects engineers improve motion-capture techniques for inserting real-life human holograms into virtual worlds. Movie studios look to additive VR/AR "bonus content" to help market their tentpole $100 million theatrical releases. Game developers look to create ethereal escapes and immersive horror and shooter games. And concert and sporting event producers look to engage (and monetize) fans on a new and exciting event viewing medium. (Dhillon, 2016)

One example of an extensive investment programme is a series of studies, consultations and discussions run by Virtual Museums Canada (VMC) to support a virtual heritage-led Investment Program. Between 2011 and 2014, the Virtual Exhibits Program and the Community Memories Program made combined investments of $6.3 million (Canadian Dollars) in enlightening and educational digital heritage content to be developed by museums (VMC 2017). The Virtual Exhibits Program provided investment up to a maximum of $250,000 per production. The investments had led to the addition of 152 new productions to virtualmuseum.ca. These include sophisticated online productions, associated learning resources and exhibits that explore history, arts, culture, nature and science (ibid.)

Fig. 4 Digi-Capital VR/VR Industrial Sector Leaders 2015. (Source: Digi-Capital, Feb 2017)

7.0 Ethical Aspects of Virtual Heritage: Concerns and Code of Conduct

As virtual heritage develops as a mechanism for cultural heritage preservation, its equipment and gadgets such as headsets (e.g. Oculus Rift and HTC Vive) will be frequently used by millions of people and at times for long durations. VR induces strong illusions of embodiment, where two characters are at play, the real and the imaginative. It would give authority of controlling another body, which may have significant psychological, mental and physical consequences. From the other side, the way in which heritage sites are reconstructed to accommodate such remote authority may include intervention and engagement that would also offer opportunity to affect the site, vandalise it and reshape it on such an imaginative platform. While VR for heritage offers a broad range of positive and additional resources for heritage documentation, preservation and representation, it also gives space, though virtually, to vandalism, damage and abuse that may be frequent in the virtual space, but could translate into action in real life settings. Such processes and authority would involve a series of repercussions on the users and their cognitive stability.

There may be a risk of depersonalisation, especially as fully immersive experiences have a bigger and more lasting impact on people's behaviour and psychology. "We know from the rubber hand illusion that our brains can be fooled into thinking that an inanimate rubber hand is our own", Metzinger asserted (2016b). In VR environments, we can be fooled into thinking that we are our avatars. Consumers must understand that not all of the risks are known in advance. The disorientation of contextual settings is rather problematic, as we are easily swayed by our surroundings. The European Union "Virtual Embodiment and Robotic Re-embodiment project", (FP7, 2010-2015), pioneered ways to dissolve the boundary between the human body and representations of it in immersive virtual reality. It concluded that while maximising the freedom of individuals to do what they want with their own minds is a leading motive in VR development, this freedom needs to have specific processes that apply certain restrictions in an intelligent way so that the interests of others are not harmed.

With the expansion of use of Virtual Reality in general and Virtual Heritage in particular, ethical concerns have been raised by researchers, governments and the general public. According to Madary and Metzinger (2016) in their article in Frontiers in Robotics and AI, there are special concerns about the possibility of unanticipated consequences for the psychological states and self-images of users who are able to inhabit a virtual environment almost as if it is the real world.

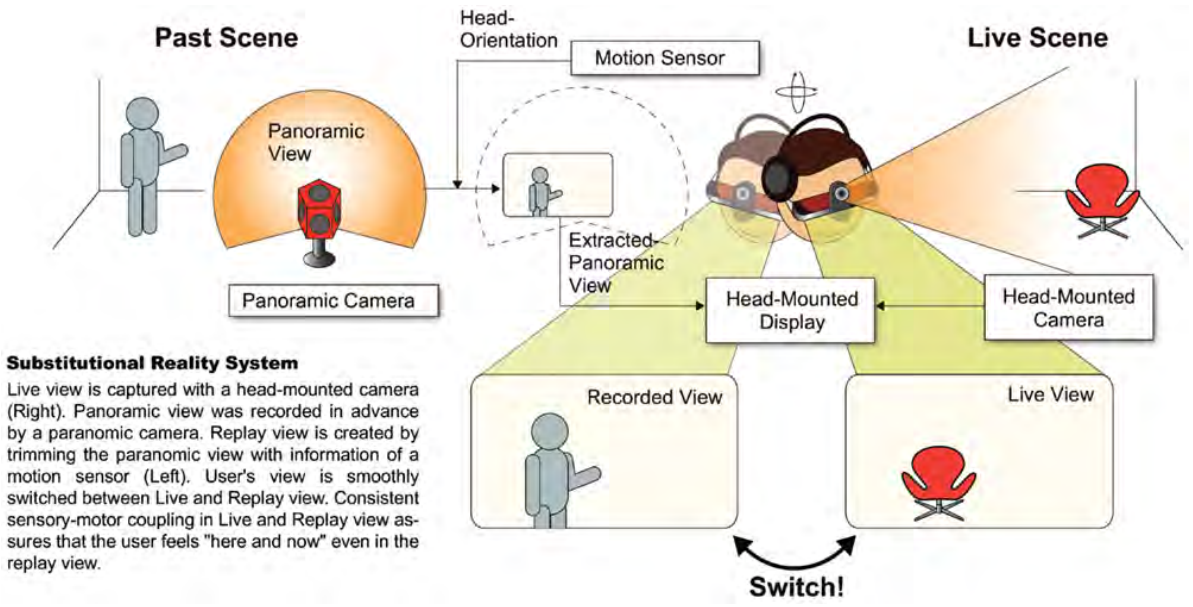


Fig 4. Diagram clarifying the substitutional reality system and its impact on the user. (Source: Madary and Metzinger, 2016)

The technological capacity for generating virtual worlds from home computers will soon be widely available to the general public, as special head-mounted displays are brought to market that create the illusion of being immersed in virtual three-dimensional worlds. The opportunities for research, education, and entertainment using VR have been much discussed in the media, but Madary and Metzinger (2016) raised the awareness about the risks that accompany these opportunities. From psychosocial philosophy's perspective, the illusions of embodiment in virtual environments impose the feeling of owning and controlling a body that is not one's own, that is known as avatar in VR. Those imaginary bodies enable navigation of spatial experience through historic buildings, spaces and negotiate movements and communications with other avatars.

The fact that VR can create these strong illusions serves as a main reason why VR brings new risks. Madary and Metzinger refer to recent studies showing that immersion in VR can cause behavioural changes that last after subjects leave the virtual environment. VR creates situations where users' bodily appearance and visual environment are determined by the host of the virtual world. Such considerations raise the possibility that VR will create vast opportunities for psychological manipulation. A code of ethical conduct, however important, can never function as a substitute for ethical reasoning of researchers. For example, in virtual heritage, researchers have the ethical responsibilities of seeking authenticity, accuracy and original references to ownership of resources and materials. Out of concern for consumers of VH, in this context, there is a call for long-term studies into the psychological effects of immersion, which for good and bad have had varying effect on involved users and/or subjects. There more discrete emphasis is placed on the need for regulations regarding ownership and individuation of avatars, regulations that should also address concerns about surveillance and data protection.

It must be clarified that, in open democratic societies, regulations that restrict certain aspects of VR practices must be based on rational arguments and available empirical

evidence, and they should be guided by a general principle of liberalism: in principle, the individual citizen's freedom and autonomy in dealing with their own brain and in choosing their own desired states of mind should be maximised. However, New technologies like VR open a vast space of potential actions which has to be constrained in a rational and evidence-based manner. It is prudent to anticipate risks involved in the use and application of virtual reality and augmented reality to heritage preservation and documentation.

Whether physical or virtual, human behaviour is situated and socially contextualised, and we are often unaware of the causal impact this fact has on learning mechanisms as well as on current behaviour. Unlike other forms of media, VR can create a situation in which the user's entire environment is determined by the creators of the virtual world, including "social hallucinations" induced by advanced avatar technology. Unlike physical environments, virtual environments can be modified quickly and easily with the goal of influencing behaviour.

To counter the alteration of behaviour of individuals so accustomed to immersive experiences in VR platforms, certain aggressive applications and offensive techniques should be closely monitored. For example, you should not be able to shoot people or destroy historic buildings or physical structures in VR, as is the norm in video gaming scenarios. Such virtual fantasies involving violence are likely to be more damaging in an immersive setting which could be used as a training ground for real life actions. Several armies already use specifically designed games to train their troops on emergency battlefield interventions. The absence of a sense of accountability in virtual experiences can easily be translated into danger of people getting used to carrying out such acts, because they are embodied in an avatar, in real life.

In the past few years, a number of studies have found a psychological influence on subjects while immersed in a virtual environment. These studies suggest that VR poses risks that are novel, that go beyond the risks of traditional psychological experiments in isolated environments, and that go beyond the risks of existing media technology for the general public. Behr et al. (2005) have emphasised that the risk of motion sickness must be minimised and that researchers ought to assist subjects as they leave the virtual environment and readjust to the real world. In general, research suggests that six principal ethical concerns surround Virtual Reality for Heritage (VH), (Madary and Metzinger 2016):

- the limits of experimental environments,
- informed consent with regard to the lasting psychological effects of VR,
- risks associated with clinical applications of VR,
- the possibility of using results of VR research for malicious purposes (dual use),
- online research using VR, and
- a general point about the inherent limitations of a code of conduct for research.

To counter these concerns, Madary and Metzinger (2016) suggested a series of discrete principles and recommendations for researchers using VR as well as ethics committees charged with evaluating the permissibility of Virtual Reality. In the context of heritage, we can see the relevance of these guidelines as benchmarks for Virtual Heritage:

- No experiment should be conducted using virtual reality with the foreseeable consequence that it will cause serious or lasting harm to a subject.
- Informed consent for VR experiments ought to include an explicit statement to the effect that immersive VR can have lasting behavioral influences on subjects, and that

some of these risks may be presently unknown.

- VR researchers aiming at new clinical applications should therefore work slowly and carefully, in close collaboration with physicians who may be better situated to make informed judgments about the suitability of particular patients for new trials.
- Overall, scientists and the media need to be clear and honest with the public about scientific progress, especially in the area of using VR for medical treatment.
- We leave the implementation details open, but urge the scientific community to take steps to avoid the abuse of informed consent with this technology, especially in the interest of preserving public trust.
- Scientists must understand that following a code of ethics is not the same as being ethical. A domain-specific ethics code, however consistent, developed, and fine grained future versions of it may be, can never function as a substitute for ethical reasoning itself.
- Longitudinal studies, further research into the psychological effects of long-term immersion.
- Focused research into the following question: What, if anything, is lost in cases of social interactions that are mediated using advanced telepresence in VR? If such losses were unnoticed, what negative effects for the human self-model could be expected?
- Avatar ownership and individuation will be an important issue for regulatory agencies to consider. There are strong reasons to place restrictions on the way in which avatars can be used, such as protecting the interests and privacy of individuals who strongly identify with their own particular avatar on social networks. On the other hand, these restrictions may prove impractical to implement and may unnecessarily limit personal creative freedom.
- Users ought to be made aware that there is evidence that advertising tactics using embodiment technology such as VR can have a powerful unconscious influence on behavior.

8.0 Technical Systems and Procedures

It took quite a few decades for software engineering to develop software packages that effectively respond to the needs of archaeologists, architectural historians to provide platforms of engagement with historic environments. To see and walk through ancient places in ways that approximate the viewpoints of the original inhabitants is a perfect tool for teaching young students or to teaching ancient cultures and buildings in the digital age. To develop these environments modelling language had to be created and modelling techniques had to reach considerable maturity. This took a good 20 years of computer graphics and modelling language to catch up. Over the past decade, the applications and use of virtual heritage environments have expanded enormously.

Interactive 3d virtual environments are usually coded using VRML (Virtual Reality Modelling Language) and experienced through multiple devices, whether specialist VR headsets, like Oculus Rift and HTC Vive which connect to computers, to smartphone-based adapted headsets using Web browser plugins (e.g., Cortona3d, FreeWRL), or built using game engines (e.g., Unity3d, Unreal) or specialty software (e.g., EonReality, Virtools)

(Charara 2017). Once the headset and power source are secured, modelling and pre-rendered models are connected to the system. The synchronisation between the body and the model operates based on head tracking, controllers, hand tracking, voice, on-device buttons or trackpads. The development of these gadgets and devices is driven by the aspiration to perfection towards total immersion in the virtual world.

More advanced and professional platforms of display exist in specialist settings such as museums, university laboratories and Virtual Suites. CAVE, the Cave Automatic Virtual Environment, is a virtual reality display platform that consists of a cube-shaped dark VR room in which the walls, floor and ceiling are synchronised 3D aspheric projection screens (ibid). The user typically wears a VR headset or head-up display (HUD) and interacts through input devices such as wands, joysticks or data gloves. Within such settings, *"The worlds can be created, dynamically revised, visited, and populated in ways that offer near first-person simulations of the ancient world"*.

3-Point Cloud Laser Scanning, on the other hand, has introduced an innovative way to accurately record each detail and feature of the archaeological sites and buildings. The laser system characterises each point on the scanned object according to its colour and location in 3-dimensional space. It scans the surface of an object using one focused laser beam comprising three different wavelengths (red, green and blue), and records the reflected light using a "charge couple device" (CHIN 2009). Each point on the object is described by 6 numeric values; positional values X, Y, and Z, and surface colour values R, G, and B. Colour intensity and texture measurements of the surface are accurate, depending on the quality of the machine, being completely independent of ambient light. The most recent and advanced laser scanners provide a scanning resolution as fine as 100 microns, recording 3D shape and colour simultaneously with high-resolution and perfect registration.

Technical applications of Virtual Heritage have expanded beyond the mere documentation and recording of individual objects. They are used in structural analysis, remote sensing, sensitive imaging and more broadly into regional conservation and planning strategies. The new and complex, yet highly accurate, LiDAR system has emerged as the leading technology in this field. LiDAR, an acronym for Light, Imaging, Detection And Ranging, is a development of the light and radar systems used for military applications. The principle behind LiDAR is simple; to shine a small light at a surface and measure the time it takes to return to its source. Light travels very fast - at about 300,000 kilometres per second, 186,000 miles per second or 0.3 metres per nanosecond, so turning a light on appears to be instantaneous.

The LiDAR instrument fires rapid pulses of laser light at a surface, some at up to 150,000 pulses per second. A sensor on the instrument measures the amount of time it takes for each pulse to bounce back. Light moves at a constant and known speed so the LiDAR instrument can calculate the distance between itself and the target with high accuracy. By repeating this in quick succession the instrument builds up a complex 'map' of the surface it is measuring (ibid). Using Professional drones, airborne LiDAR facilitates the collection of a multiplicity of data and tests them together to ensure accuracy. As the sensor is mobile and in constant movement, its height, location and orientation of the instrument must be always measured to determine the position of the laser pulse at the time of sending and the time of return. With tripod LiDAR a single GPS location and benchmark can be added for each location where the instrument is set up (CHIN ibid).

Photogrammetry, on the other hand, has emerged as the leading application for the creation of virtual archives of ancient artefacts and objectives in modern and national museums. It is the science of making measurements from photographs that translated images into 3D navigable objects. Its outputs are mostly 3D models, maps, drawings or measurements. To record archaeological sites or objects using photogrammetry, there is a need for both Aerial Photogrammetry and Close-Range Photogrammetry. In the former, the camera is mounted in an aircraft or on a drone. Multiple overlapping photos of the ground/building/ site are taken along a flight path and at specific but regular distances. These photos are processed in a stereo-plotter and then used in automated processing for Digital Elevation Model (DEM) creation. In Close-range Photogrammetry the camera is close to the subject and produces drawings, 3D models, measurements and point clouds. This type of photogrammetry (CRP for short) is also sometimes called Image-Based Modelling.

Generally, the documentation and production of heritage through virtual environments will require the integration of several of these systems along with others that are not within the scope of this document. However, the applications of technology in virtual and digital heritage are ever expanding. The above systems are a short list of closely related applications that this project endeavours to support and utilise.

9.0 Virtual Heritage Projects

BEST PRACTICE CASE STUDIES

Case Study 1

ROME REBORN

Region: Europe Country: Italy City: Rome

Year: 2013

Partners: Virtual World Heritage Laboratory of the University of Virginia (VWHL), UCLA Experiential Technology Center (ETC), Reverse Engineering Lab at the Politecnico di Milano, Ausonius Institute of the CNRS and the University of Bordeaux-3, and the University of Caen.

Website: http://romereborn.frischerconsulting.com/gallery-current.php

Brief Description

Rome Reborn is a series of 3D digital models that presents information and theories about how the city looked; the project illustrates the urban development of ancient Rome from Bronze Age (ca. 1000 B.C.) to early Middle Ages (ca. A.D. 550). 320 A.D. was chosen as the best moment in time to begin the work of modelling, because at that time, Rome had reached the peak of its population, and major Christian churches were just beginning to be built. Much of what survives of the ancient city dates to this period, making reconstruction less speculative than it must, perforce, be for earlier phases. But having started with A.D. 320, the project intends to move both backwards and forwards in time until the entire span of time has been covered. This more or less represents the height of its development as the capital of the Roman Empire.

The model has detailed information about the identification, location, and design of approximately 250 buildings, known as Class I monuments. Thirty-one of these were made at a scale of 1:1 at UCLA. The Class II buildings are very schematic and rely heavily on textures instead of geometry for architectural details. Rome Reborn 1.0 was created with a variety of software, all ultimately imported into MultiGen Creator and displayed on PCs as a real-time, interactive urban model using Open Scene Graph. The Rome Reborn team used Google Earth to georeference the archaeological documentation.

Rome Reborn 1.1 represents a conversion of version 1.0 into BVH format and runs on an IBM Cell server, generously donated to IATH. Version 1.1 brings improvements in illumination, frame rate, and resolution.

Version 2.0 uses the 32 hand-made Classes I models created at UCLA and Bordeaux and converted by IBM and the Rome Reborn team to 3D Studio Max format. Version 2.0 is greatly improved with respect to geometric detail. In versions 1.0 and 1.1, the detailing of Class II features (windows, doors, balconies, colonnades, porticoes, etc.) was provided by textures. In version 2.0, the features have been fully modelled, unlike versions 1.0 and 1.1 (which run only on a workstation). Version 2.1 of Rome Reborn includes new content and an improved file organisation. The technological improvements include organisation of all files spatially by the 14 regions of the ancient city, which have been further subdivided into three districts. All files have been converted to OBJ format. Three levels of detail are provided.

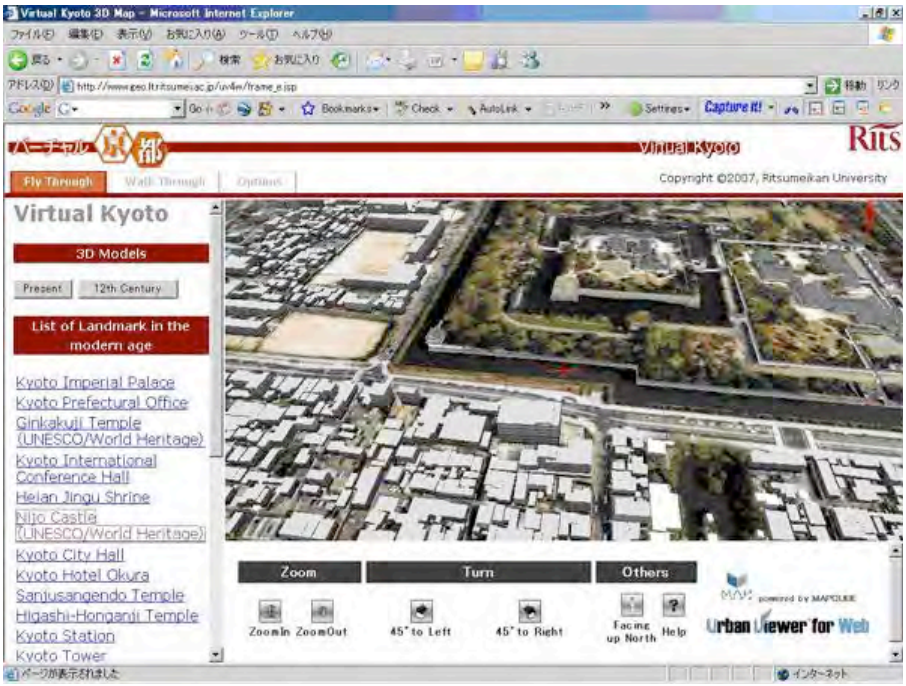
To sum up, the Rome Reborn Project has modelled 50 buildings and monuments of the ca. 200 in class I. These include the 22 buildings and monuments in the western part of the Roman Forum; the Tabularium, the Forum of Julius Caesar; the Basilica of Maxentius and Constantine; the Temple of Venus and Rome; the Arch of Titus; the Arch of Constantine; the Flavian Amphitheater; the Ludus Magnus; the Septizodium; and the Circus Maximus. These buildings have been created with the help of scientific advisory committees of experts. This means that there are still ca. 150 buildings of Class I that can be added to the model.

Aspects of Excellence

- The model represents knowledge about the urban topography of ancient Rome at various periods of time.
- The model can be used to gather data such as on built features in the city and can be used to run urban or architectural experiments, such as how well the city or the buildings within it functioned in terms of heating and ventilation, illumination, circulation of people, etc.
- In version 2.2 some animations have been added of humans going about typical business on the city streets. Addition of such animations is intended to give the model a sense of scale as well as to avoid giving the impression that the city was a ghost town.

Case Study 2

VIRTUAL KYOTO



Region: Asia Country: Japan City: Kyoto

Year: 2008

Partners: Virtual Kyoto was financially supported by the Global COE Program (Digital Humanities Center for Japanese Cultures and Arts), Academic Frontier Project (Disaster Mitigation of Urban Cultural Heritage), and MEXT KAKENHI (Grant-in-Aid for Scientific Research), collaborators with Ritsumeikan University.

Website: http://www.geo.lt.ritsumei.ac.jp/uv4w/frame_e.jsp

Brief Description

Kyoto, an old capital of Japan, which was founded more than 1,200 years ago and eluded damage from World War II, retains a great number of historical architecture such as temples, shrines, and modern heritage buildings. Kyoto has a large number of temples and shrines: approximately 1,300 temples and 350 shrines, footprint and height, across the city of Kyoto. The 3D geometry models are automatically generated by extruding building footprint data with airborne laser profiler data. The 3D model constructed a system that supports a number of new areas of geographic inquiries.

Virtual Kyoto is a project that uses the cutting edge technologies in GIS and VR (virtual reality). It has been constructed as 4D-GIS that comprises a series of 3D GISs for different eras. The 3D modelling of the city began with the present Kyoto, and has gone back to past eras, including those soon after and before World War II, the Taisho and Meiji eras, premodern Edo era, and the Heian era of the late 8th century during which the city of Kyoto was founded.

Virtual Kyoto is organised to archive geo-referenced materials such as current digital maps, old topographic maps, cadastral maps, aerial photographs, picture maps, street photographs, landscape paintings, archaeological sites data, and historical documents. In addition, the project creates a database of all existing buildings, including traditional townhouses, modern heritage buildings, shrines and temples including historical and cultural heritages; moreover, the project creates VR models of the abovementioned buildings and estimates and simulates the land use and landscape changes over the studied periods using aforementioned materials.

Virtual Kyoto creates an infrastructure in which to place a variety of digitally archived materials associated with the city, and to disseminate varieties of sophisticated styles of culture and art of Kyoto to the world over the Internet. The project provides a user interface to explore comprehensive information on culture and art of Kyoto with its historical landscapes. Virtual Kyoto plays significant roles in assisting urban landscape planning of Kyoto as well as sending rich information on Kyoto to the world through the Internet.

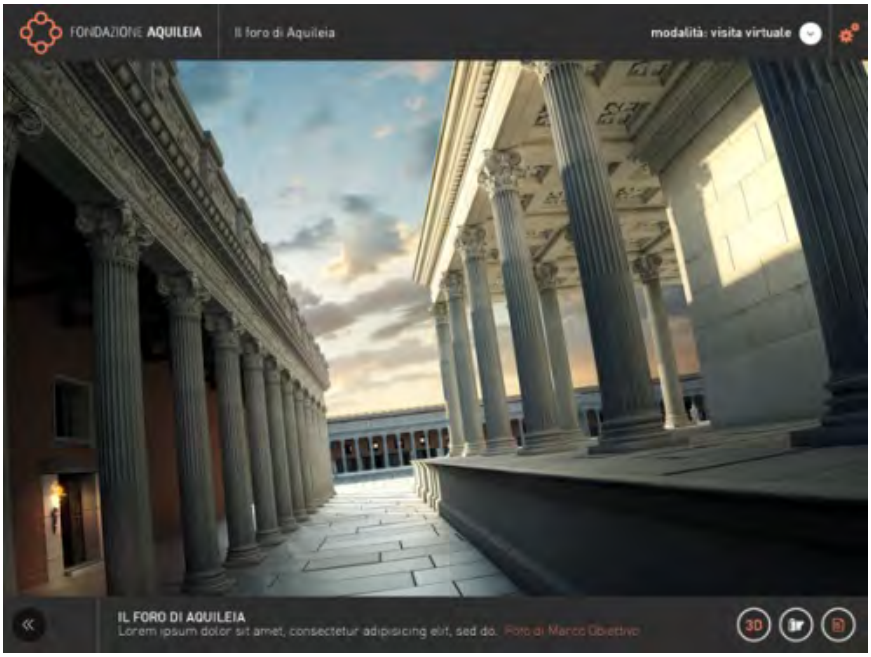
Aspects of Excellence

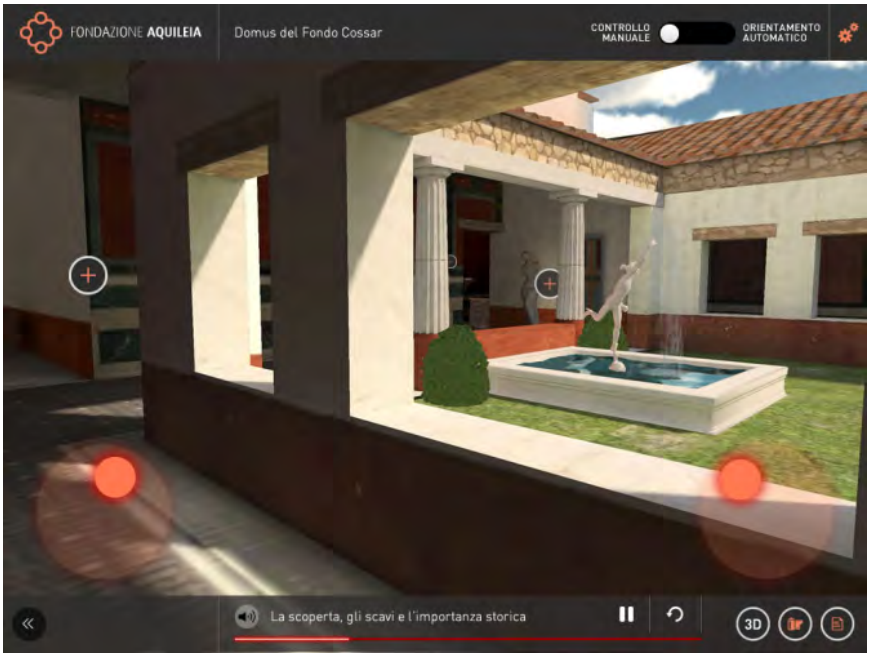
One of the most excellent aspects of Virtual Kyoto is that the project provides a platform to integrate a large collection of digital archives of arts and cultures in Kyoto.

In addition, the system provides a user-friendly interface to explore historical materials of arts and entertainments in the geographical context of Kyoto.

Case Study 3

VIRTUAL AQUILEIA





Region: Europe Country: Italy City: Aquileia

Year: 2013

Partners: Virtual Aquileia was supported by the Culture Sector and Communication & Information Sector (UNESCO), French Ministry of Culture , Conseil général des Bouches-du-Rhône , Ville de Marseille , and The Marseille Provence Chamber of Commerce and Industry(CCIMP).

Website: http://www.digitalheritage2013.org/virtual-aquileia/

Brief Description

Aquileia is a small, town in the Friuli-Venezia Giulia region of north-east Italy, in the Province of Udine. Aquileia was founded in 181BC to be a base for Roman power in this part of Europe. The town, strategically located for military and trading purposes, grew to be one of the most important cities in Roman Italy and the capital of a large area.

Virtual Aquileia is an Augmented Reality Real Time 3D app for Android and iOS tablets and smartphones. Virtual Aquileia is combining 3D images, videos and Real Time 3D models to allow people to tour information on the ancient buildings nearby and the available 3D model enables them to virtually enter the building to explore it. It can be used to gather data such as built features in the town and also to run urban or architectural experiments, such as how well the city or the buildings within it functioned in terms of heating and ventilation, illumination, circulation of people, etc.

The Virtual Aquileia app has Real Time 3D models that can be explored both on and off site (Augmented Reality, Virtual Tour), allowing people to move the mobile device around them to explore on site or use the virtual joypads on the side of the screen when off site. This app does not present a 3D walk-through but permits an exploration of the 3D Real Time reconstructed buildings using the GPS and the accelerator built into the devices, in an Augmented Reality mode, on the very spot where the original building was. Inside the 3D models there are also various hotspots with information on buildings and objects.

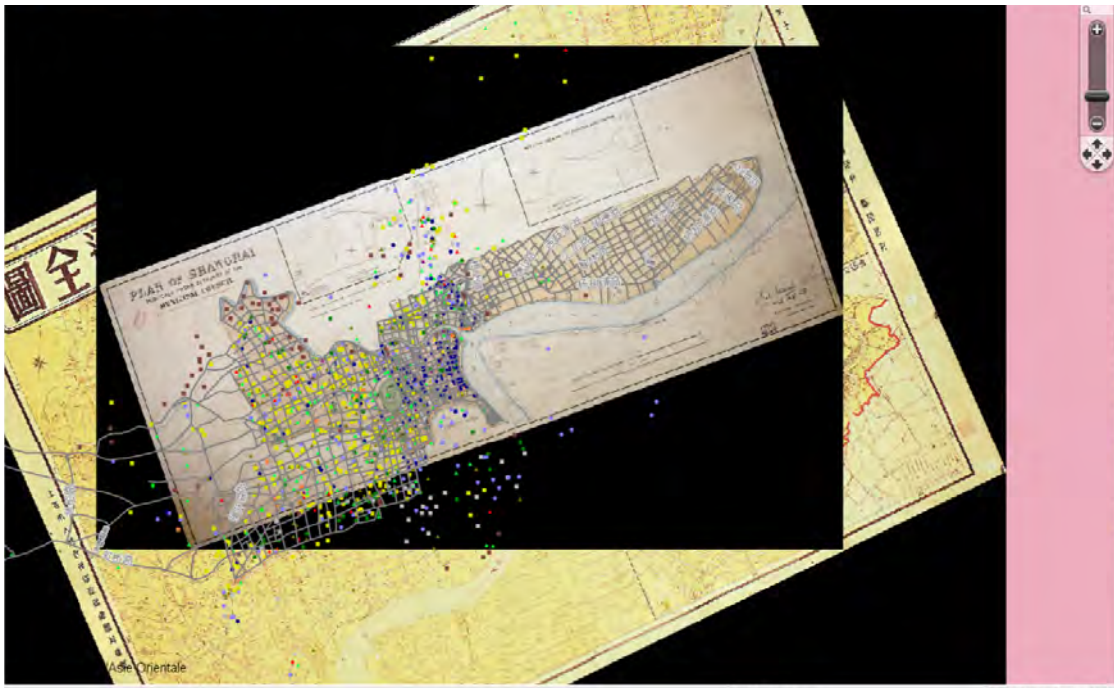
The main motivating reasons for creating Virtual Aquileia are the absence of a comprehensive study of Aquileia history and the trust and belief that the use of technology provides a powerful and effective interactive complement to books and still photography for documenting and studying urban history in a comprehensive manner. From the outset, it was apparent that the model provided an environment in which various kinds of information, both textual and visual, could be synthesised and thereby made to appeal to a broad audience with a variety of research interests

Aspects of Excellence

- One of the most excellent aspects of Virtual Aquileia is that it is easy to access, since Virtual Aquileia is an Augmented Reality Real Time 3D app for Android and iOS tablets and smartphones.

Case Study 4

VIRTUAL SHANGHAI



Region: Asia Country: China City: Shanghai

Year: 2012

Partners: Aix-Marseille University, Huma-Num Humanités numériques

Website: http://www.virtualshanghai.net/GIS/Shanghai/

Brief Description

The Virtual Shanghai Project is especially interested in collecting textual, visual, and cartographic sources related to Shanghai. It is a project about the history of Shanghai from the mid-19th century to nowadays. The project includes various sets of documents: essays, original documents, photographs, maps, quantitative data, etc. The main objective of the project is to write a history of the city through the combined mobilisation of these various types of documents. The implementation of this approach relies on the use of digital and GIS technologies. Some of the resources are original textual and visual documents, which create a powerful cartographic tool for spatial analysis and real-time mapping.

Virtual Shanghai has three main gateways. The first gateway opens the textual documents, which includes essays, original archival documents, and chronologies. It is possible to read through the texts as in a book, or to browse through topics, or move between text and related visual and cartographic documents. The second gateway offers various visual paths; the topics are suggested in the form of albums to be easy to wander around within the visual database. All items of the visual collection are related either to textual records or/and cartographic data. The third gateway opens a cartographic account of the city, including a large collection of historical maps from the earliest ones to satellite views of the city. Moreover, the GIS server presents numerous possibilities to see Shanghai at various times, under different angles, from the city level down to the block level.

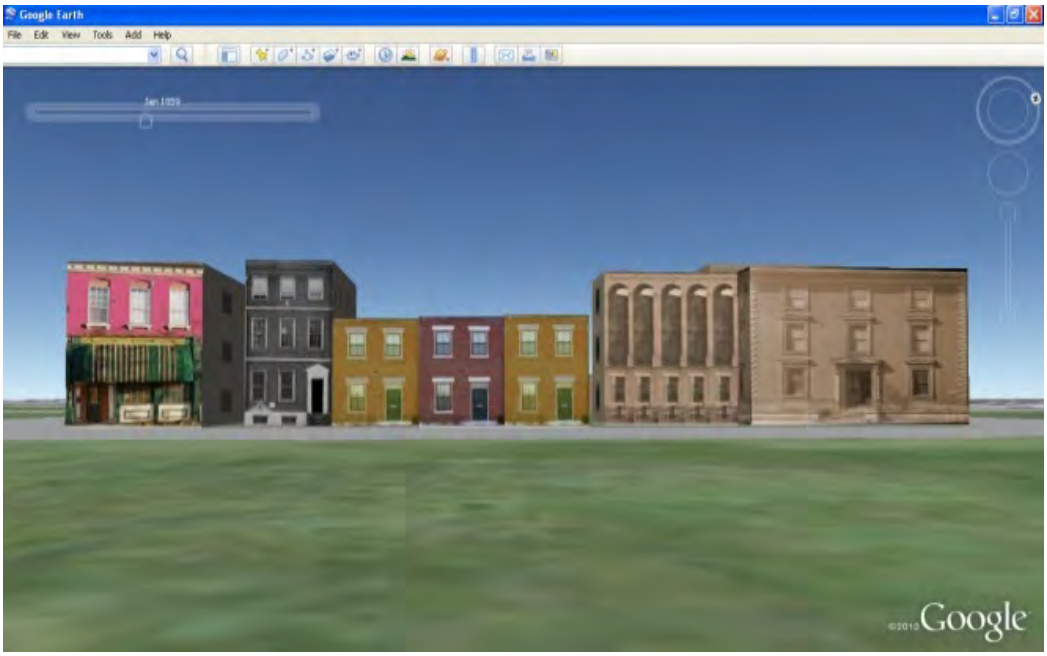
Virtual Shanghai is made up of a series of interconnected relational databases. During the three phases, phase one emphasises the construction of the photograph database, with a systematic search for photographs and research to identify the content. Then, phase two focuses on cartography, such as the digitisation of maps, their redrawing as pictorial maps and their dereferencing in GIS terms. Phase three restores the articulation of the visual database and the cartographic database around a common timeline. To sum up, the project is striving to turn original documents into digital format for long-term preservation.

Aspects of Excellence

- One of the most excellent aspects of Virtual Shanghai is that the project offers various ways to step into the history of the city and follow its course at different levels over time.
- The project represents knowledge about the urban topography of Shanghai at various periods of time.

Case Study 5

ST. LOUIS REGIONAL HISTORY PROJECT



Region: America Country: United States City: Missouri

Year: 2004

Partners: University of Missouri-St. Louis, Institute for Museum and Library Services, National Endowment for the Humanities, and Missouri State Library.

Website: http://www.umsl.edu/virtualstl/phase2/indexBAK.html

Brief Description

The St. Louis Regional History Project utilises interactive web technologies to discover the history of the City of St. Louis and the St. Louis region. The project helps to discover time on the streets of downtown St. Louis. For more than a century, from the age of the steamboat through the age of industry, the downtown district on the banks of the Mississippi River was the dynamic heart of the metropolis and the centre of urban life. Downtown was where people from all walks of life came together and interacted. Many of the most important decisions affecting the entire city were made there. As the city sorted out its problems and people sought to improve their lives, the downtown landscape evolved. High-rise office towers came to dwarf church steeples; automobiles and streetcars crowded out horse-drawn carts and carriages; derelict warehouses were demolished for new parks and monuments. By transforming the fabric of the city, the people of St. Louis worked out their history and their destiny.

At this time, the project only activates the 1850s and the 1950s decades. The Project starts with a three-dimensional, interactive model of the city ca. the 1850s, comprising such places to visit as the courthouse. In the 1850s one can explore the city and learn about the Dred Scott case. The 1950s model currently explores the themes of civil rights and consumer culture.

The website is organised into districts. Each district contains a district home page; building pages containing addresses, construction and demolition dates, as well as information about the buildings' importance in that decade; people pages for important public figures in the decade; and event pages detailing events in each building during the decade. Each event page is also linked to a perspectives page which lists primary documents from the time period. Chart a path of inquiry across space and time to discover how St. Louisans made history by reconstructing the city around them.

To use the project and begin the tour of St. Louis, simply choose a year by clicking the timeline menu bar on the left side of the main page (currently 1850 and 1950 are active). As you enter your selected decade, a three-dimensional model of downtown St. Louis will appear on the left side of your screen. By clicking on the various buildings, people and objects in the landscape, you will be able to access information about their history, which will appear on the right side of your screen. You can use your mouse or the arrow keys to help you move through the Virtual City.

Aspects of Excellence

- The project covers a long period of more than a century, from the age of the steamboat through the age of industry.
- It can be used to teach students or the general public about how the city looked.
- It is well organised and simple to use by clicking on the timeline menu bar on the left side of the main page.

Case Study 6

INSTITUTE FOR DIGITAL ARCHAEOLOGY

Region: Worldwide Country: Worldwide City: Worldwide

Year: 2012-2016

Partners: Museum of the Future Dubai, University of Oxford, UNESCO World Heritage, Harvard University, UMASS BOSTON, Classics for All, Abraham Path and other organisations.

Website: http://digitalarchaeology.org.uk/our-purpose

Brief Description

The Institute for Digital Archaeology (IDA) promotes cultural heritage preservation and a wider understanding and appreciation of the ancient world. The IDA seeks to redefine the field of archaeology by fusing traditional methods with advanced digital image capture, processing and printing technologies.

After a number of important ancient structures, including the 2000-year-old temple of Baal Shamin in Palmyra, Syria, were destroyed in 2015 by Islamic State (IS) militants, the IDA announced its plans to establish a digital record of historical sites and artefacts by creating the Million Image Database Program. Moreover, In April 2016, the Institute of Digital Archaeology unveiled a 1/3 scale reproduction of the Triumphal Arch of Palmyra in Trafalgar Square, London. The original arch was destroyed by ISIS in August 2015 in Syria.

One of the past projects of IDA (-2013-2014) involved making reflectance transformation imaging (RTI) scans of the Philae obelisk at Kingston Lacy. The team recovered significant, previously illegible Greek and Egyptian inscriptions. By using the same techniques, the IDA created RTI imaging of the Parian Marble at the Ashmolean Museum. Hellenistic in origin, the Parian Marble is the earliest Greek chronological table detailing events of historical importance, specifically from 1582 BC to 299 BC. The technique entails imaging and interactively displaying objects under varying lighting conditions.

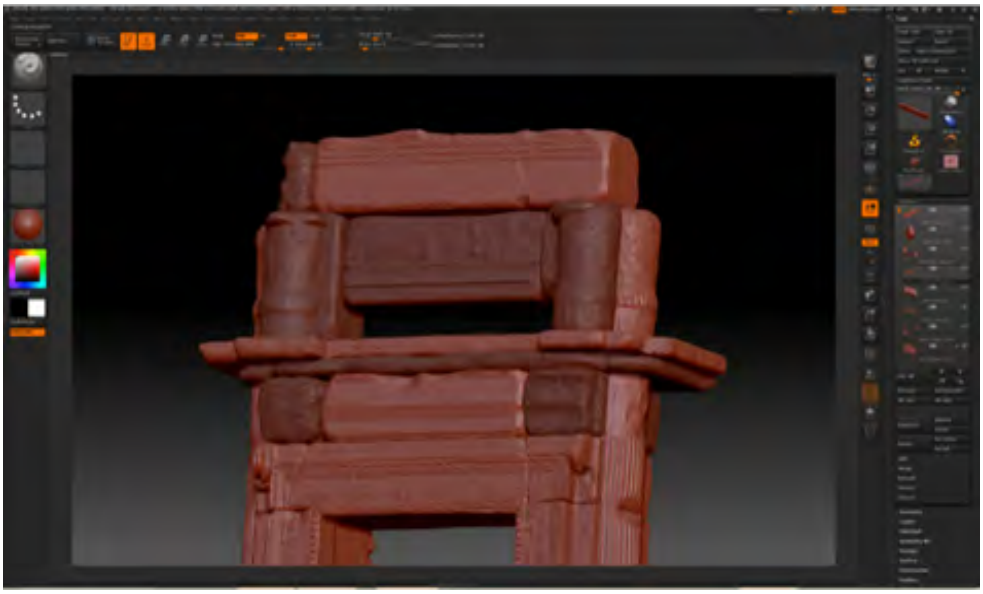
The IDA headed a project to transcribe a recently discovered, palimpsest text of Menander's lost comedy 'The Wet-Nurse' in the Vatican Library. Moreover, the IDA has also created an online database of bio bibliographies of noted deceased classical scholars from the eighteenth-century to the present (Database of Classical Scholars with University of South Carolina).

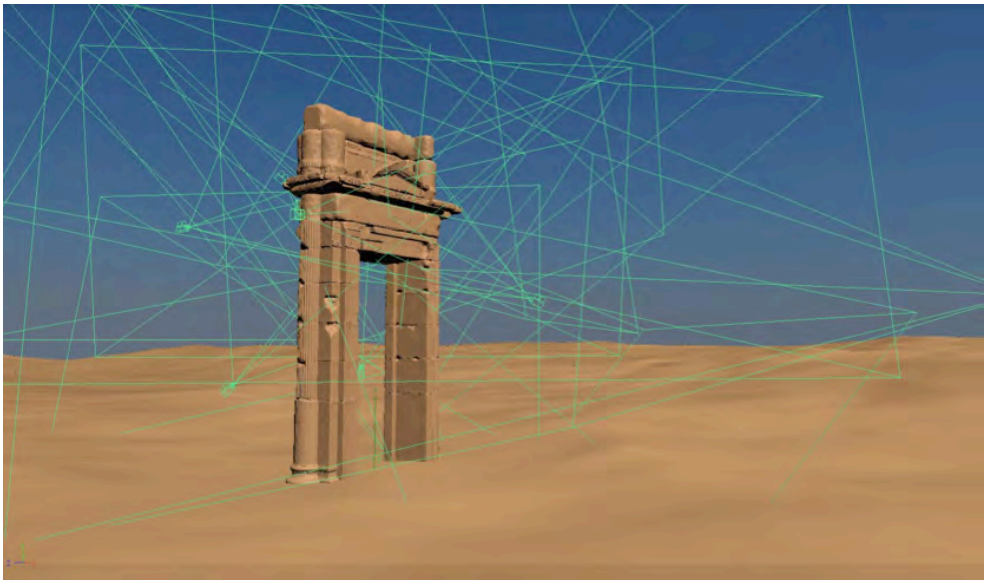
Aspects of Excellence

- One of the excellent aspects is IDA's creation of the first-ever high resolution scans of Palaeolithic paintings and inscriptions in the Marsoulas Cave in the south of France. Using RTI, the IDA was able to reveal significant, previously unknown features of this important 13,000-year-old rock art site.

Case Study 7

MILLION IMAGE DATABASE





Region: Middle East and North Africa Country: Middle East and North Africa

Year: 2016

Partners: Institute for Digital Archaeology (Museum of the Future Dubai, University of Oxford, UNESCO World Heritage, Harvard University,UMASS BOSTON, Classics for All, Abraham Path).

Website: http://www.millionimage.org.uk/

Brief Description

Million Image Database is a project aimed at preserving cultural heritage objects and architecture in the conflict zones of the Middle East and North Africa. Created by the Institute for Digital Archaeology, the project focuses specifically on heritage material objects, architecture and places rather than educational content.

The images are obtained from volunteer photographers using 3D imaging kits, digitised from paper archives, donated via social media platforms like Facebook, Instagram and Twitter, or received directly from individuals and institutions via email or snail mail. All of the images in the Million Image Database will be open-access and so available to anyone by the end of 2016. Moreover, anyone can use the navigator map to access images by location. The images will be used for research, heritage appreciation, educational programs and 3D replication including full-scale 3D replication using proprietary cement-based 3D printing techniques.

Million Image Database demonstrates the application of high-tech 3D imaging and printing in the preservation of history. The Million Image Database project started with the distribution of thousands of cameras to war zones around the region. The idea is that volunteers will capture one million images by the end of this year and 20 million images by the end of 2017. By digitising those sites and artefacts, at least some vestige of them will remain safe from terrorists and madmen.

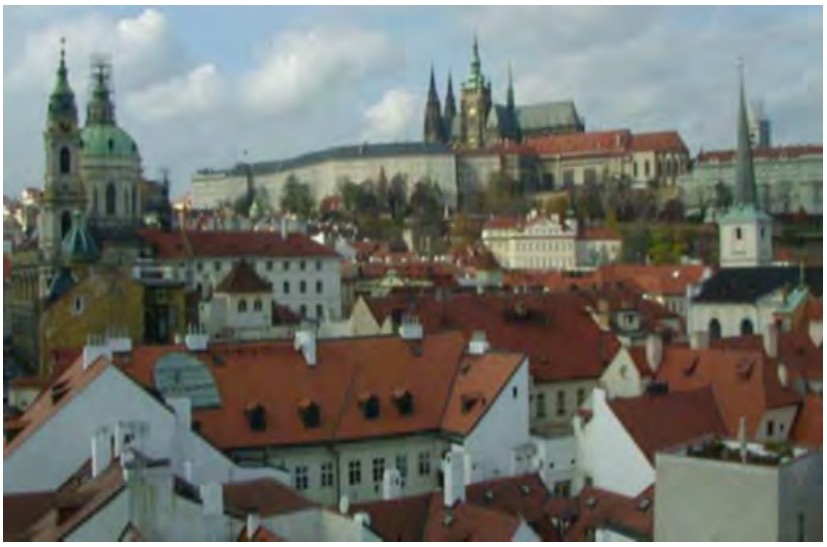
The Million Image Database team and the network of volunteers perform site surveys using a combination of conventional and stereo (3D) photography to enable accurate computer renderings to be produced. These renderings can be used to create engaging interactive virtual experiences of the respective ancient sites. The computer models can also provide the basis for the construction of full-scale replicas of architectural objects using computer-controlled 3D printing and machining techniques.

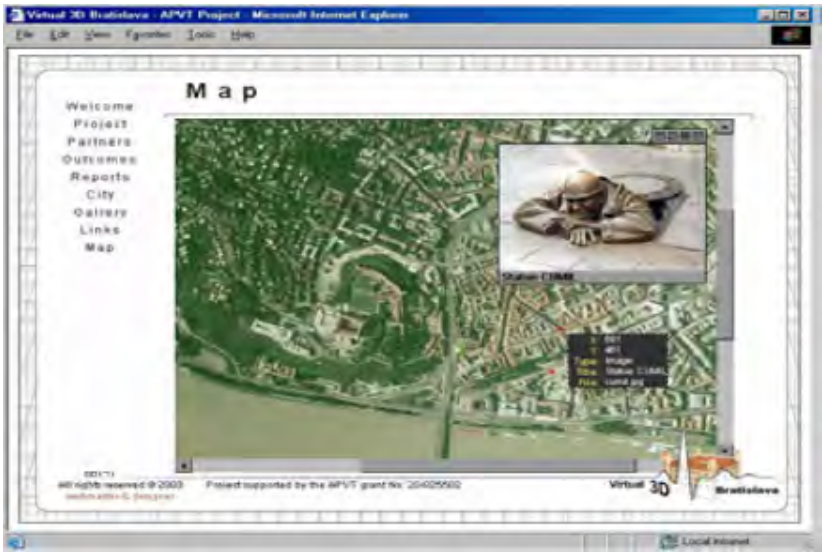
Aspects of Excellence

Through the Million Image Database project's use of 3D cameras in war-stricken places, people can scan and photograph historically significant buildings and artefacts to preserve them from politically-motivated obliteration.

Case Study 8

VIRTUAL HEART OF CENTRAL EUROPE





Region: Eastern Europe

Country: Austria, Czech Republic, Hungary, Slovakia and Slovenia

City: Prague, Graz, Maribor, and Bratislava

Year: 2004

Partners: European Commission's Culture 2000 Framework Programme, Comenius University, VRVis/AR2 Austria, CTU Prague, Univerza v Mariboru.

Website: http://www.vhce.info/

Brief Description

Virtual Heart of Central Europe presents a cultural heritage oriented project for documentation, digital preservation, and on-line dissemination of selected towers, historical places and rarities in Prague, Graz, Maribor, and Bratislava. The project enables sharing of European values in wide public and internet global village population. Thus, such a project creates the true bridge between the past and the future.

Virtual Heart of Central Europe selects the representative city verticals and embeds them into the virtual old cities, modelled at the reasonable level of precision. Also some very special local rarities have been added to preserve and publish the top quality attractions, then 3D reconstructions, models, and virtual environments have been created. The creations are static and have no inhabitants. Therefore, the creation of virtual habitat follows – navigation, exploration, and on-line co-operation support. Interactive communication with the environment, and with the virtual inhabitants – avatars. There are virtual environments with avatars and without avatars. Avatars, Digital Storytelling and tools for Immersive Experiments are the final phases of creating the reconstruction.

Virtual Heart of Central Europe proceeds in the 3D reconstruction as follows. A set of calibrated high-precision images is processed using MetropoGIS to obtain dense façade point clouds. For very special input it creates 3D models manually (3D Studio Max, PhotoModeller, Maya). An alternative of high precision panoramas has been proposed and developed; another low-cost work-flow has [Ftac04]. Output formats include VRML, QTVR, video, digital stories, animations, and even computer games. Sometimes, there are virtual guides as emphatic avatars [Stan03]. The complete look and feel is designed in Flash and the project composes the various data formats using XML and the fruitful idea of data containers.

In Virtual Heart of Central Europe project there are at least 30 unique and recognised sites in Austria, Czech Republic, Hungary, Slovakia, and Slovenia -within the former Austro-Hungarian area. Prague is known as "The city with one hundred towers", corresponding perfectly with the subtitle of the project (Towers, Wells, and Rarities), and offers choice of historical and cultural jewels from a large set of candidates. Also, Graz - capital city of the

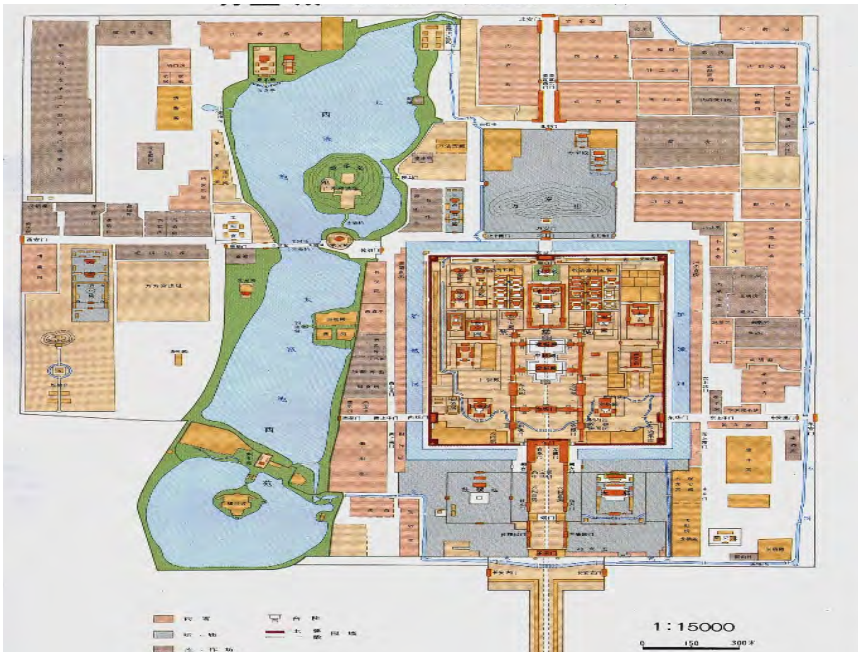
province of Styria, is Austria's second largest city, with 250.000 inhabitants. Graz has many tales to tell. To start with, the tale of its history which starts some 900 years ago and which tells of the city in its heyday as the residence of the Habsburg monarchy in medieval and Renaissance times. Although Maribor as a town goes back to medieval times, very little of its medieval architecture remains - in most cases just the foundations of buildings in the very heart of the city centre. On such remains either new buildings were erected, or old buildings totally renovated, so that their original appearance was lost, but there are still some buildings that show the basic layout of the old town. Finally, the project presents Slovakia and its capital Bratislava, to provide the urban and cultural context for six famous places.

Aspects of Excellence

One of the most excellent aspects of Virtual Heart of Central Europe is that it promotes cultural understanding throughout the world and protection of outstanding universal value.

Case Study 9

VIRTUAL BEIJING



Region: Asia Country: China City: Beijing

Year: 2008

Partners: Aix-Marseille University, Huma-Num Humanités numériques.

Website: http://beijing.virtualcities.fr/Presentation/Overview

Brief Description

Beijing is one of the four ancient cities of China, the best preserved, and famous around the world. Beijing City was established over 3,000 years ago. At the end of the Qing dynasty, World War 1 broke out. Beijing became the focus of the war, which disrupted the society. Many residences of royal families were robbed and burned down. After that, the whole country was reduced to the status of semi-colonial and semi-feudal society. It wasn't until 1949 that the People's Republic of China was founded. Beijing is known as the capital city of the prosperous new country which has flared into importance in Asia. Beijing is a historical city, the seat of power in the People's Republic of China. It is home to the Forbidden City as well as the Palace Museum. The Forbidden City was home to the emperors and their households during the Ming and Qing Dynasties.

Virtual Beijing Project places a particular emphasis on the notion of spatial history. It is an approach that initially differed from historical geography perceived as excessively focused on landscape and its transformation. It also emerged before the emergence of GIS and the drastic renewal of methods that eventually made such a distinction fade away. Virtual Beijing plans to explore further the social history of Beijing and to address its historical trajectory through case studies based on textual, visual, and spatial data.

Virtual Beijing is an exploration of the history of Beijing in the 1920s-1940s through the use of digital technologies, H-GIS, and visual sources. The main visual corpus of the Virtual Beijing project actually consists of two exceptional photographic collections in terms of quality and homogeneity. The first collection of work is focused on the population of the capital and its most underprivileged sections, and contains a unique collection of 6,000 photographs. These photographs, however, have never been used as such for systematic research. The second set collection was entrusted to the Harvard-Yenching Library at Harvard University and entirely digitised; it consists of about 5,000 pictures, a large majority of which focuses on the common people of Peking, Moreover, Virtual Beijing Project uses a wide range of photographic and pictorial materials published in China and abroad, mostly from the republican period. The materials immediately complementary to the photographs are the records of the Police and the Social Affairs Bureau of the municipality, which are an invaluable and extremely rich source.

Virtual Beijing is not a history of the city of Peking, Rather, it uses photographic material as the warp and the weft to write a story of the common people and their practices, a story of their districts and street life, a story of small crafts and the know-how of the common people.

Aspects of Excellence

- One of the most excellent aspects of Virtual Beijing is that it represents more than a geographical extension of the original digital research platform; it provides a new step forward in terms of platform design and methodological approach.

Case Study 10

SIRACUSA 3D REBORN

Region: Europe Country: Italy City: Siracusa

Year: 2013

Partners: IBAM-CNR and the Arcadia University -- TCGS.

Website: http://www.archeotour.eu/en.html

Brief Description

Syracuse is one of the most beautiful, influential and wealthy among the Greek cities of the Mediterranean basin in Italy, as the majestic temples testified; it is the birthplace of poets and thinkers such as Epicharmus and Archimedes, and was visited by such prominent figures of Greek culture as Pindar, Aeschylus and Plato.

The project has described and analysed monuments in the context of a full 3D stereoscopic representation employing techniques 01, modern cinema-industrial or explaining their historical and archaeological characteristics. Emphasis is also given to reconstruction of war mechanics and some unique inventions conceived by Archimedes, the most brilliant mind of the Greek era. 3D models have been produced and elaborated in Maxon and Cinema4D environments and rendered on a 64 core Render Farm. All the scenes have been processed in post-production with Adobe After Effects, where motion blur, colour grading and compositing of complex particles for sea foam, smoke and fire effects have been added.

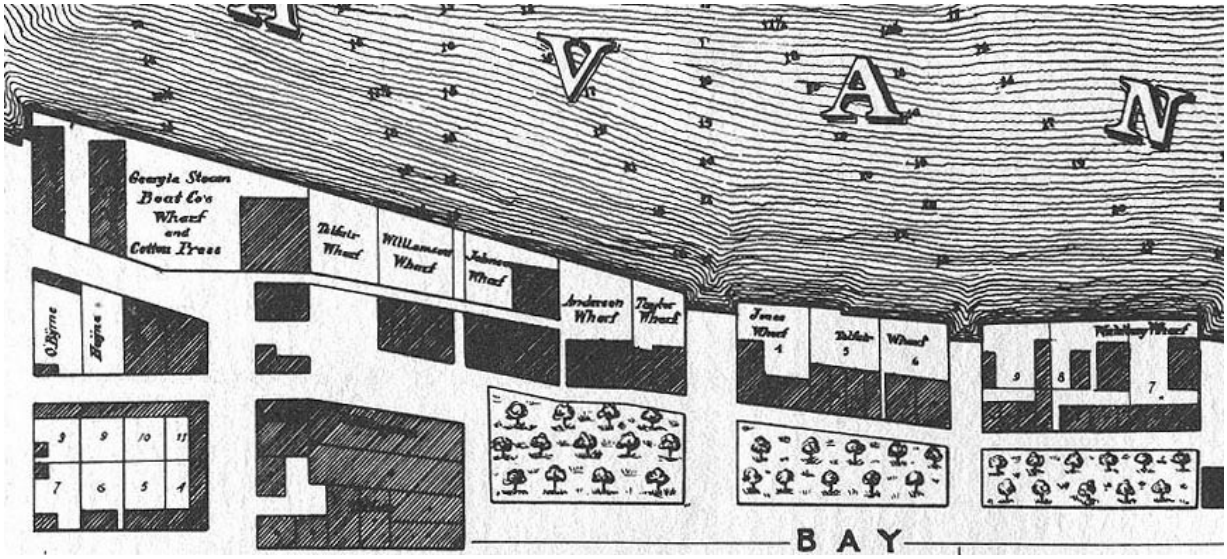
Nonetheless, Syracuse never has received the attention it deserves either in scientific literature or in the mainstream. This virtual archaeology project aims at the overall digital reconstruction of the core district of Greek Syracuse. Syracuse 3D Reborn is short, lasting only 40 minutes, so it is a great experience for young and old and gives people an opportunity to learn about history in an interesting way. The project aims to show people the concept of how cultures evolve through conquest, colonialism and other influences, also to realise how humans shape their environments to reflect their beliefs and cultural values as well as to appreciate how cultures put their unique imprint on the cities they build, to imagine past lives and appreciate how circumstances of the times influence behaviour, mores and values.

Aspects of Excellence

- The project is short, lasting only 40 minutes, so it is a great experience for young and old and gives people an opportunity to learn about history in an interesting way.

Case Study 11

VIRTUAL HISTORIC SAVANNAH PROJECT



Region: America Country: United States City: Savannah, Georgia

Year: 2004

Partners: Savannah College of Arts and design, National Endowment for the Humanities.

Website: http://vsav.scad.edu/

Brief Description

The absence of a comprehensive study of Savannah's architectural and urban history, as well as the trust that the use of computer technology provides a powerful and effective interactive complement to books were the main two motivating factors for developing the Virtual Historic Savannah Project. The project focuses on historic downtown Savannah, Georgia, which is celebrated both for the large number of historic structures and its unique urban plan. The Virtual Historic Savannah Project is combining architectural and social history research with 3D computer and database technology.

Information is provided on over two thousand and two hundred existing buildings and the people, businesses and institutions that occupied them between 1940 and 2000, as well as preliminary information on approximately three hundred buildings demolished or lost after 1970. At first, the project concentrated on developing and testing Jasper Ward. Jasper Ward was selected for its relatively central location in downtown Savannah and for its architecturally heterogeneous character. The variety and complexity of its building sizes, styles and materials, on the one hand, and the obvious succession of generations of buildings, on the other, offered a useful test bed for the conceptual and technical design of the project.

The research expanded beyond building histories to include documenting every resident of the ward in decade intervals, from 1860-2000, based on City Directories and, in 1900, on the much more detailed Census. A second version of the VHSP website was developed and the project has expanded the content from the Jasper Ward prototype to the whole downtown district.

The third version of the VHSP website was developed with a revised user interface and with the website driven by a database, made possible by such as linking objects in the 3D model to the database. The set of district-wide data layers includes for all 2,200 existing buildings in the district a low-resolution model, a new photograph and basic architectural data; data will also include lists of occupants for each building in decade intervals (2000, 1990, etc.); and lists of property owners.

Aspects of Excellence

- One of the most excellent aspects of Virtual Historic Savannah Project is its focus on compiling and analysing data on lost buildings, and expanding the architectural information on existing buildings, and compiling detailed information on people from the Census.

Case Study 12

VIRTUAL TIME TRAVEL OF PRE-REFORMATION EDINBURGH

Pre-reformation Edinburgh

Pre-reformation Edinburgh city scape

Region: Western Europe Country, Scotland, UK City: Edinburgh

Year: 2017

Developers/Partners: Dr Alan Miller & Mr Keith Millican, School of Computer Science & Smart History, University of Edinburgh

Website: http://epsrc-showcase.wp.st-andrews.ac.uk/2016/12/01/virtual-time-travel-in-pre-reformation-edinburgh-premiere/

Brief Description

The virtual reconstruction of pre-reformation Edinburgh is a project that has recently developed out of collaboration between historians and computer scientists to investigate an important layer of the city's history. Visitors and residents of Edinburgh are offered the opportunity to see the city as it was just prior to the reformation. Miller and Millican used mobile phones and the Google Day dream platform to produce an onsite dual reality experience. As visitors explore the sites of Edinburgh, they can see its historic layers using their digital time travel binoculars. The app they developed is a comprehensive reconstruction of parts of the city and allows the visitors to move along a series of houses and streets. It is mobile and orientation aware, automatically delivering the correct view with a map interface that offers an equally engaging experience for remote virtual visitors.

According to Miller and Millican, the project enables user experience to be optimised for simple and accessible technology that exists in the visitor's pocket. It makes virtual time travel a reality that is available to both local, foreign and even global audiences. This method of interacting with the past enriches the visitor experience whilst providing insights into the past that are comprehensible for the ordinary user.

The Project draws on University of St Andrews research on dual reality systems where the virtual and real worlds occupy the same space. "Position and orientation within the two worlds are synchronised enabling intuitive exploration of both worlds through movement in the real world" (Miller and Millican 2016). The designed journey offers navigation inside (St Salvators Chapel) and outside (St Andrews Cathedral) using adjusted Oculus Rift and Google Cardboard VR headsets. This led the designers to observe that users tended to look around whilst using the headsets.

Basically, the project uses high fidelity 360 photographs of a reconstructed historic model developed in the UNREAL4 Game Engine using typological designs of houses and street topography. This research was applied within the Virtual Time Binoculars (VTB) project, a £105,000 Edinburgh Digital Launchpad project funded by Innovate UK (ibid). It involves a multi-disciplinary team of Computer Scientists, Digital Designers, Digital Media producers, Historians and Museum Professionals. The team use CAA approved drone pilots, Google approved 360 photographers and historians working together to create both engaging mobile onsite experiences.

Aspects of Excellence

- The Project offers the first insight into 16th century Edinburgh based on comprehensive historic research. It is designed for ordinary users from different age groups and backgrounds.
- The team is an exemplary combination of interdisciplinary academics, historians, photographers and computer scientists.
- The Project developed out of funded academic research into a commercial spin-off enterprise that offers innovative products.

Case Study 13

JARLSHOF, SHETLAND ISLAND SCOTLAND

(Source: http://www.topofly.com)

(Source: http://www.topofly.com)

Region: Western Europe Country: Scotland, UK City: Shetland Island

Year: 2016

Jarlshof in the Shetland Islands is a short computer-generated film by Kieran Baxter that offers research-led analytical narratives of the story of settlement at the Shetland Islands' archaeological site, using speculative scenarios and built structures from different historic eras (Baxter 2014.) The project was funded by Historic Scotland, as part of PhD research at Duncan of Jordanstone College of Art and Design, University of Dundee. Baxter based his film on aerial photographs taken from a kite-suspended camera over the site, inserting and overlaying the speculative reconstructions of disappeared buildings mapped towards aerial photographs of other sites across Scotland. Using limited reconstructed elements and incorporating photographic and cinematic considerations, the interpretation of the archaeological narrative was conveyed into a visual toolkit for storytelling (ibid.)

In maximising the experiential value of visiting the site, lighting and weather conditions essentially play an active part in the narrative. The weather conditions were artificially and artistically reproduced in the animated outcome and derived from a combination of simulation and gathered imagery to reinforce the narrative by reflecting both the radical change in architectural style brought by the arrival of Norse culture, as well as the northern climate of the settler's origins. The virtual experience of the site required the use of a range of reconstructed elements to serve the aim of producing an aesthetic that would be both immersive and evocative in a speculative portrayal of lost structures. "The combination of aerial photography and computer-generated imagery used in 'Jarlshof' results in a highly technical image" (ibid.). It is important, hence, to suggest the speculative and artificial nature of the reconstructed elements while blending them into the surviving remains. Having the reconstructed structures slowly fade in and out of the scene was a helpful tool in offering layered spatial experiences of the site, while at the same time implying that the imagery had been technically manipulated.

The aerial view reveals the structure and components of the site, parts of which are difficult to grasp from ground level. According to Baxter, the low altitude aerial perspective used in 'Jarlshof' "was intended as a compromise between the relatable ground-level view and the revealing yet distancing qualities available from high altitude" (Baxter 2014). Camera movement was used to enhance the viewer's perception of depth and the 3D depth and structure of the site. This format bears no resemblance to the normal experience of moving around Jarlshof on foot. Rather, the depth of the site's structure provided by the flying motion enhances the viewer's sense of the three-dimensional space. The camera was also used to create a sense of progression through the distinct chronological phases of the site through the interesting and annotated interplay of views, camera movement and chronological display.

Aspects of Excellence

- The simple and clear narrative of the site's chronology display helps the ordinary and non-specialist audience, including children, to grasp the overall story of the site and its historic evolution including the phasing and changes in architecture.
- The speculative nature of the reconstructed elements was reiterated in a text caption that details the other sites that were used to inform the reconstruction.

10.0 Conclusions

The London Charter for the Computer-based Visualisation of Cultural Heritage developed its first draft, in 2006, as "*a means of ensuring the methodological rigour of computer-based visualization as a means of researching and communicating cultural heritage. Also sought was a means of achieving widespread recognition for this method*". (London Charter.org, 2017). The Charter introduces a set of principles which, when adopted, would ensure that digital heritage visualisation is seen to be at least as intellectually and technically rigorous as longer established cultural heritage research and communication methods (ibid). The challenge of scholarly validation of heritage visualization is similar to those facing media and art productions in that some subjects, and arguments, do not so readily lend themselves to textual description and author's work and product are inherently non-linear or synthetic. The production, be it a visualization, expressive medium of choice, reflects the author's perception as integrated in the selective production process itself, be it a static image, real-time model or printed object (Denard 2012).

The effort to address and organise the industry and practice of virtual heritage needs to address the use of visualizations through influencing not only research, academic and curatorial contexts, but also those aspects of the media and entertainment industry involving the reconstruction of architectural and cultural heritage. Computer-generated visual interpretation of history and culture plays an increasingly influential role in shaping public perceptions of the past, despite being highly selective, subjective and in many instances inaccurate. It is of considerable importance that a generation's impressions of the past should integrate the contours of historical understanding. The commercial and industrial sectors, hence, need to work on documentaries and other media productions to enable users and audience to distinguish between fact and fiction (ibid).

The past did not happen in 2D and it, therefore, cannot be effectively studied or taught as a series of disconnected and selective still images that display incomplete aspects of one coherent and missing story. The development of an interactive, 3D platform that will enable people to re-live history in a reconstructed environment is the best way for them to engage and understand how medieval cultures existed, lived or to grasp the implications of the evidence that we have (Sanders 2008). It is also true that this reconstructed world would be contested as based on different and at times disputed accounts and evidences. History after all is a subjective matter. Nevertheless, the argument-driven nature of historical evidence would be better scrutinised through examining events within 3-dimentional environments.

But the main argument to be developed is to engage with archaeologists, who are conventionally wary of technologies, to embrace it to their advantage as assistive tools to see the ancient world in realistic settings and environments. This would not only support the documentation of specific physical aspects of history, it would offer unprecedented opportunity to test theories, findings and narratives in virtual environments. It would also engage a much broader range of audience, like children, school pupils, old people and non-specialist ordinary people. The power of the moving image, animation and virtual

environment has attracted wide interest in understanding the past that was otherwise very limited.

This research report aimed at offering a comprehensive overview on global practices, theories and technologies used for the digital documentation and interpretation of architectural and cultural heritage through virtual environments. It has provided a brief history of the emergence and evolution of virtual heritage while giving an account of 12 selective and best practice case studies in the field. This report has shed light on the importance, if not dominance, of virtual documentation of endangered heritage sites over the past decade.

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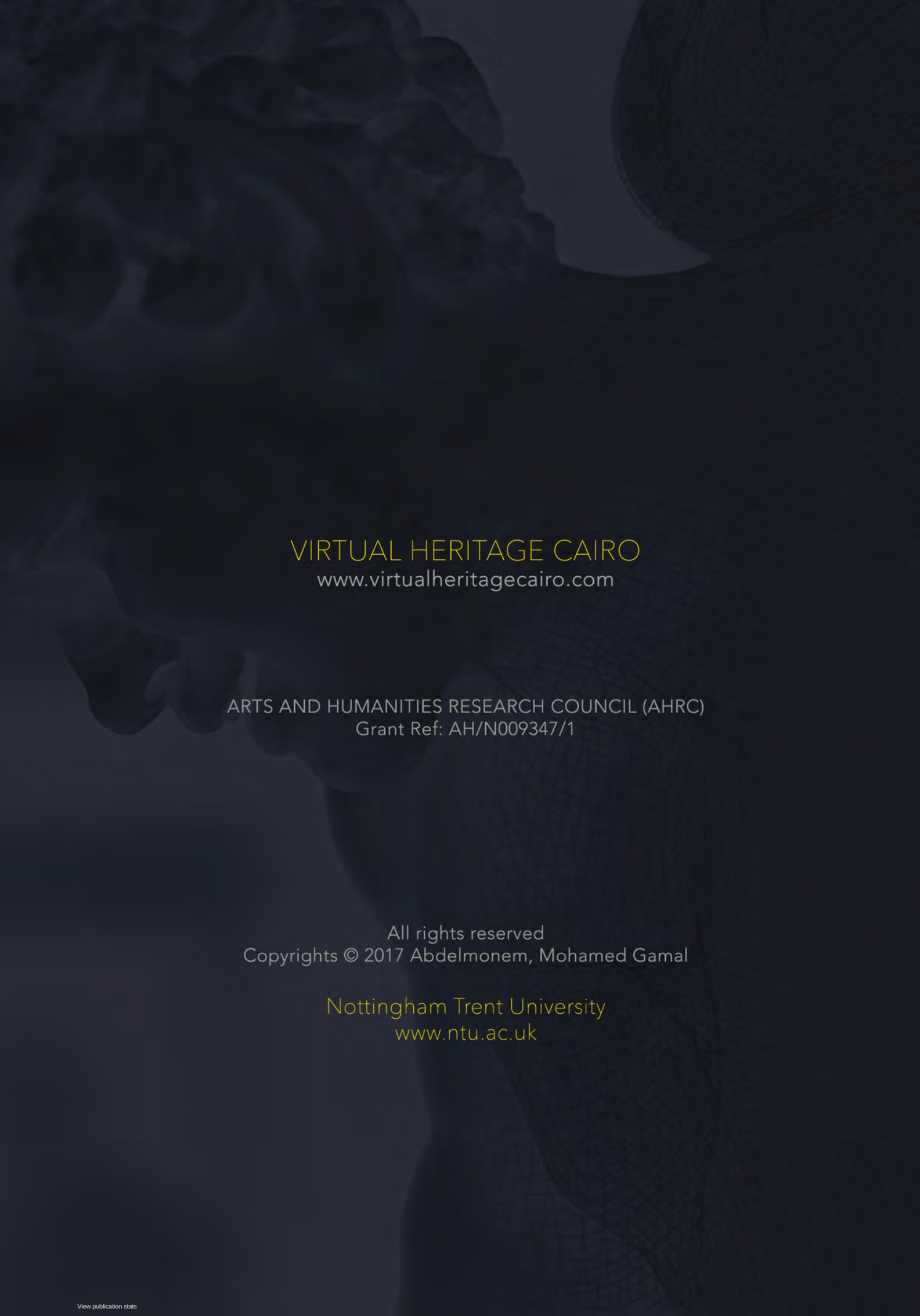

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