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Technology for Cultural Heritage

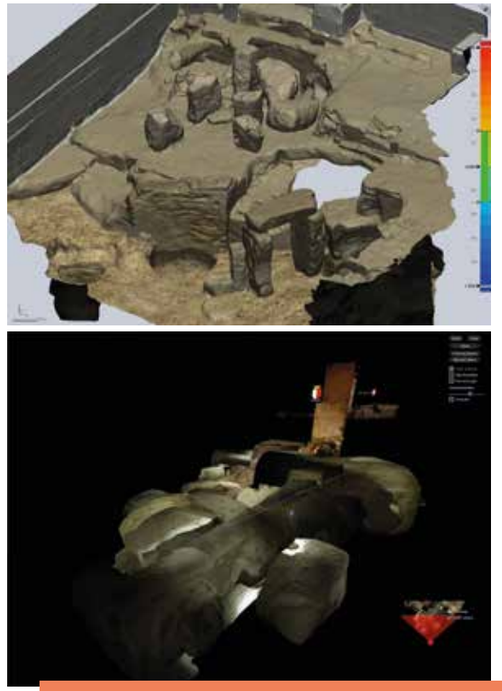
Cultural Heritage (CH) has been defined as an expression of the ways of living developed by a community and passed on from generation to generation, including customs, practices, places, objects, artistic expressions and values.[1] CH is split into two categories, namely tangible and intangible CH. The former refers to the physical artefacts of a society including built heritage, artistic creations and other physical products that are imbued with cultural elements of society. Conversely, intangible CH refers to non-physical practices, expressions, knowledge, representations and skills which are recognised as a vital component of CH[2] and that are constantly being re-evolved by communities.[3]

As technology advanced in the last decades, it has seen gradual permeation in the CH domain, namely in museums and archaeological sites. This has seen the emergence of the field of Cultural Computing (CC) which applies computer technology and scientific methods to culture, arts, and the social sciences to represent, enhance, extend, and transform creative products and processes.[4] This has allowed unprecedented ease of access to both visitors and researchers to CH which was previously inaccessible or in danger of being lost forever. Some of the most popular domains have been digitisation processes and the application of their outputs to develop mixed reality applications, together with the various projects involving artificial intelligence and video games. This article shall attempt to give a brief overview of the diverse number of major technologies enhancing the researcher's work and the user experience of CH sites.

Digitisation

The need for different forms of CH digitisation dates back several decades and has been made explicit in various EU Commission policies. These stress the need for the democratisation of goods that have value for all humanity, through digitisation, accessibility and interoperability in order to enable sharing of information and responsibilities aimed at conserving cultural identity.[5] This drive has led to projects such as Europeana, which is a digital cultural heritage platform for Europe with digitised cultural material, including a digital library, archive and museum. Europeana now provides access to some 30 million cultural objects from more than 2,500 organisations.

Digitisation has also been widely adopted in archaeology, where discovered artefacts are digitised for further study or application, for example to be used in extended reality applications. Entire sites are also scanned using photogrammetric techniques to create maps[6]



Digitised maps of the Ħal Saflieni Hypogeum and St Paul's Catacombs, courtesy: Steven Psaila

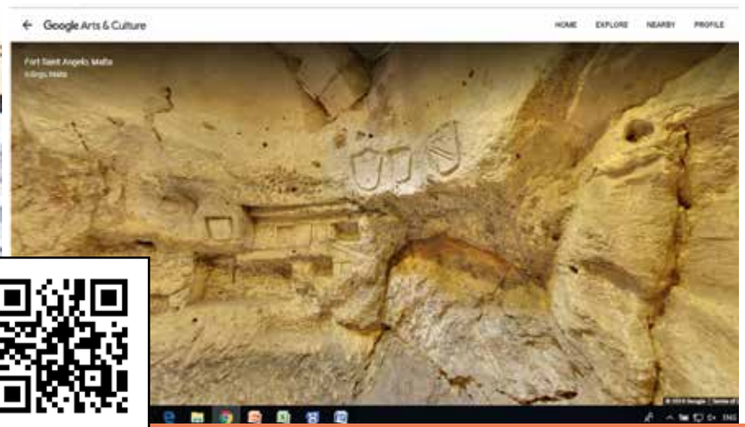
and the generating of GIS data for further study on the topology of the site.[7]

The use of extended reality

With the creation of large digitised data sets, it is no surprise that mixed reality systems have become increasingly popular in museums and CH sites. Augmented Reality (AR), Virtual Reality (VR) and Mixed Reality (MR) technologies enable a user-centred experience that makes cultural heritage digitally accessible anywhere, especially when physical access is constrained. VR enhances the users' presence through a computer generated environment which cannot be interacted with and offers no opportunity to see the real-world. On the other hand, AR superimposes virtual elements on the real world layer whilst MR blends both real and virtual environments.[8] Extended Reality (XR) refers to all real and virtual combined environments and human-machine interactions generated by computer technology and wearables. Hence, it can be seen as the umbrella term encompassing all others.

It is generally understood that museum installations that do not introduce new technologies are regarded to be less interesting and thus attract fewer visitors.[9] Experiences relying simply on textual panels and descriptions may be informative but they are not interactive.[10] Therefore, the creation of an intelligent environment responsive to the presence of visitors which adapts dynamically makes the visiting experience far more appealing.[11]

This is further attested by an experiment conducted in an art museum which involved three groups, each assigned a different guiding mode (non-guided, audio-guided and AR-guided). Results indicated that overall the learning performance of the AR-guided group was superior to that of the other two groups.



Left: A visitor experiencing VR during the launch of Wonders of Malta by Heritage Malta and Google in 2017, courtesy Steven Psaila; Above: the Guva or oubliette, a prison originally intended as a water cistern beneath Fort St Angelo, only accessible through a trapdoor, can now be experienced through Wonders of Malta with a 360º view of the graffiti carved by imprisoned knights – allegedly the most notable prisoner was Caravaggio

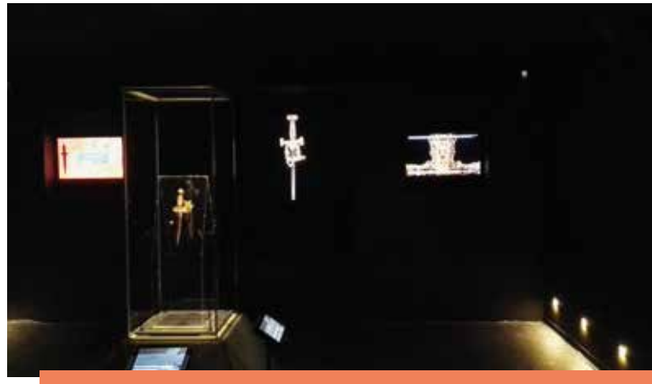
NB: Scan QR code to view graffiti

Similarly, the time spent observing a painting was highest for the AR-guided group followed by the audio-guided and non-guided group with text panels only.[12] The AR-guided group felt that the guide device provided a greater motivation to learn and was more effective in delivering the message in a "livelier and less-boring" manner, due to its extra visual commentary. In fact, the non-guided group expressed their desire to have a guide or commentary to aid them understand and appreciate the paintings, as they felt that attempting to appreciate the artworks on their own proved to be ineffective. This concluded that the AR-guiding system eliminated certain limitations of other systems such as interactive media kiosks or video players which do not offer instant comparisons with what is being exhibited, leading to a reduction in the visitor's interest and subsequently the viewing time.

Therefore, it is no surprise that mixed reality has seen a surge in applications for the CH domain. Where this is concerned, augmented, virtual and mixed reality technologies have been utilised in CH for a number of diverse applications, including education, exhibition enhancement, reconstruction of lost experiences, virtual museums and exploration. These categories may overlap depending on the application, such as a virtual museum which may be utilised as part of an exhibition.

Education is concerned with the dissemination and diffusion of the historical aspects of both tangible and intangible CH. Such playful learning improves learning outcomes since it appeals to students' curiosity and willingness to share their experiences through their eagerness to use new technologies. It also encourages a deeper immersion and interaction with the exhibition, achieved through the use of mixed reality technology.[13]

The use of mixed reality for exhibition enhancement is intended to improve the visitor's

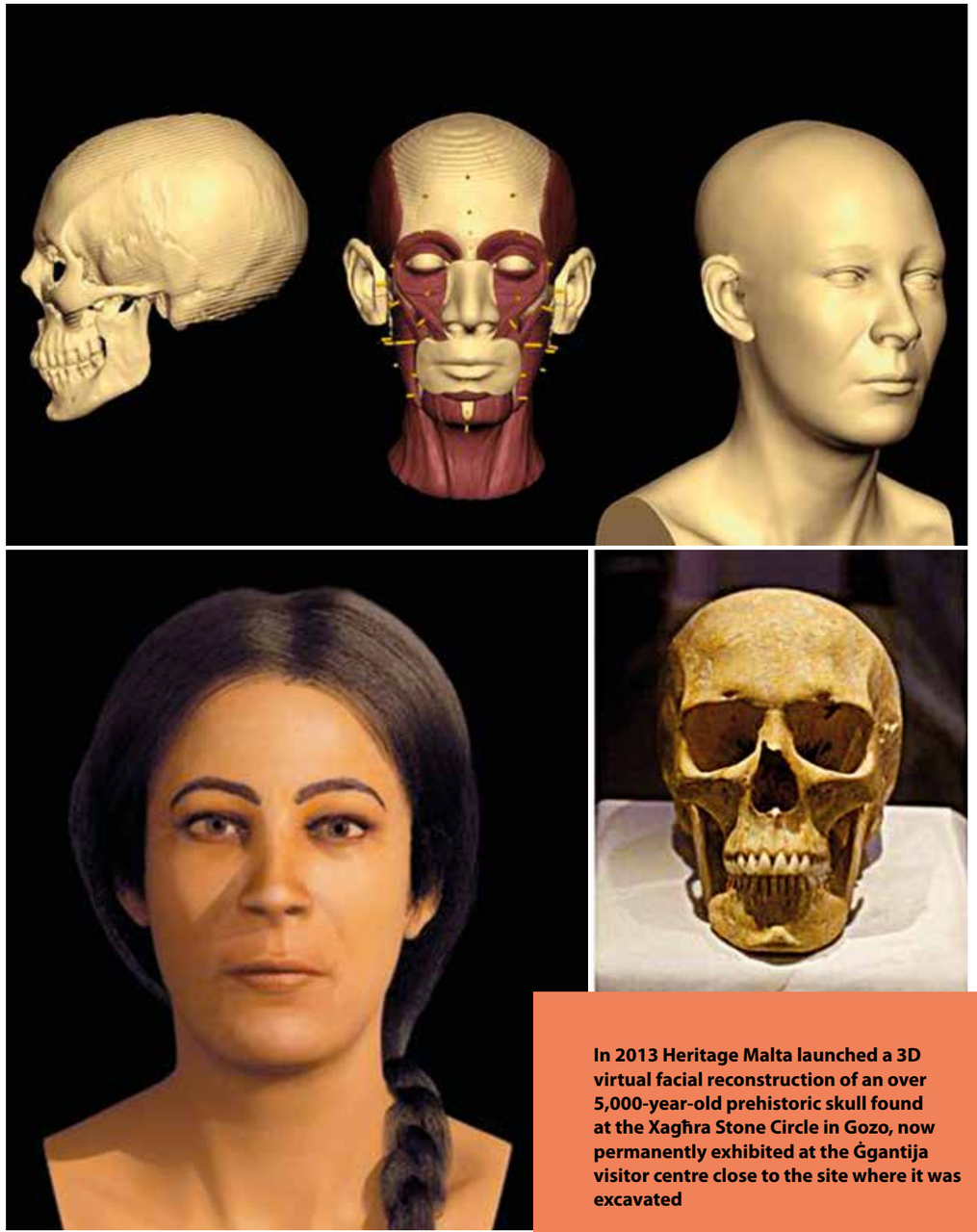


In 2017 Heritage Malta, with the cooperation of Louvre Museum-Paris, brought back the famous dagger of Grand Master Jean de Valette for a historic visit to be exhibited in Malta, after Bonaparte had kept the dagger for himself in 1798 – since the accompanying ceremonial sword was too fragile for travel, it was virtually displayed next to the dagger, courtesy: Stefania Zuccarello

experience at a physical museum or heritage site both indoors and outdoors. A virtual element such as guide maps, descriptions or virtual-human characters are superimposed on the users' real-world layer as they explore the exhibition space.[14]

Exploration supports the users in visualising and exploring historical as well as current views of CH sites in order to discover, visualise and manipulate content leading to new knowledge creation. In such contexts, the users are usually experts in their field and hence, the designers of the application can assume prior knowledge of domain-specific visualisation when developing the system. In the last two decades, archaeology has benefited greatly with the widespread availability of digitised 3D content, allowing developers to represent difficult-to-reach environments using such exploration systems.[15]

In the context of Malta, imagine utilising such systems in order to access the unreachable parts of St Paul's Catacombs, the Ħal Saflieni Hypogeum or Għar Dalam,



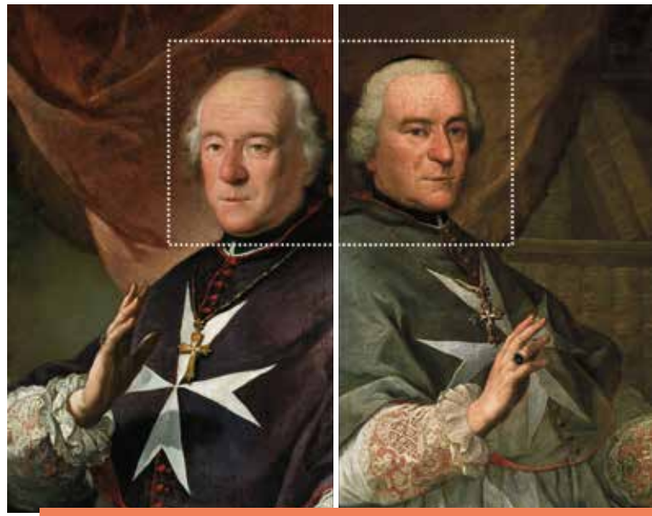
In 2013 Heritage Malta launched a 3D virtual facial reconstruction of an over 5,000-year-old prehistoric skull found at the Xagħra Stone Circle in Gozo, now permanently exhibited at the Ġgantija visitor centre close to the site where it was excavated

paving the way for further studies and new discoveries to be made possible. Similarly, reconstruction enables users to visualise and interact with reconstructed historical views of both tangible and intangible CH that existed only in the past, or only partially exist today. However, contrary to exploration, it does not solely cater for experts, and interacting with such systems does not necessarily lead to knowledge creation. AR and MR technologies can superimpose the reconstructed views over their historical location, together with an additional information overlay,[16] making them more suitable for tangible CH and a blend of both tangible and intangible CH applications.

Virtual museums simulate physical museums and CH sites with their tangible and intangible artefacts. Most of the time these artefacts are too fragile or inaccessible to the public, and therefore these are realistically simulated with great detail so that users cannot easily discern the differences between the originals and their digital replicas. Such simulations allow users to feel as if they are physically present in the actual museum or CH site. Some simulations may also go as far as including avatars of other visitors which mimic their movements and actions through sensors. This creates a hyper-realistic real-life scenario for all users who can also interact via gesture, gaze, speech, and movement.[17]

Artificial Intelligence

Artificial Intelligence (AI) has been applied to various areas of CH and has addressed topics such as the linking of museum narratives with online data sources, or other narratives and museum artefacts which may aid with interpretation and storytelling. Semantic digital archives have also been created in order to provide user-friendly, effective and efficient search with retrieval capabilities. There are also ventures in creating Natural User Interfaces (NUI) for CH in a semi-virtual environment (augmented reality) and autonomous mobile robots for monitoring archaeological sites faster, cheaper and safer.[18]



Two artworks depicting the same subject are correctly linked using a facial recognition system, source: Tabone et al., 2015

Another area of AI is computer vision (CV) which is the study of enabling machines to interpret and analyse images.[19] A particular application utilising computer vision was the linking of portraits according to similar facial characteristics[20] of works by Mattia Preti (1613-1699) and Francesco Zahra (1710-1773). Hence, portraits housed in different museums or galleries and created by the same or different artists, may be linked through a common model sitting or inspiration.

This gave rise to the idea of visitors taking selfies upon entering a museum or gallery, and discovering which portrait resembles their own face.

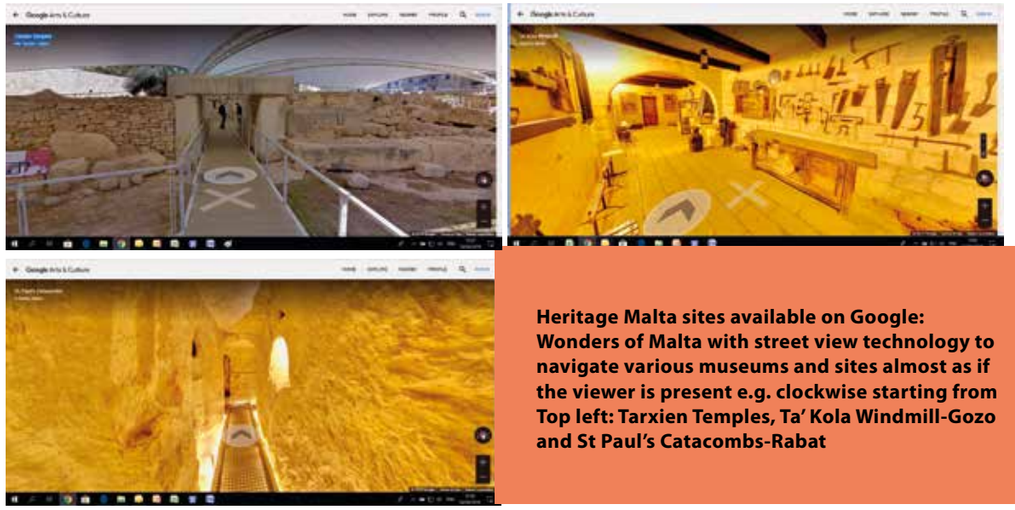
The historical character of Napoleon Bonaparte as depicted in Assassin's Creed: Unity, source: Ubisoft Montreal, 2014

Digital Games for Cultural Heritage

In the last decades, video gaming has become a major component of Western lifestyles. Video games have provided CH researchers and archaeologists with a perfect way to present their research in a media format that incorporates multiple perspectives and alternative narratives to audiences which are not normally engaged with other forms of academic literature or media regarding CH or archaeology.[21]

This is no surprise, as unlike traditional media, video games are capable to deepen the understanding of cultural heritage in a very interactive way. A number of existing commercial entertainment video games can also be used for non-leisure purposes including for presenting CH,[22] especially the so-called documentary games which realistically depict past historical events such as battles and wars.[23] Examples include *Total War: Three Kingdoms* (Creative Assembly, 2019) and *Assassin's Creed: Unity* (Ubisoft Montreal, 2014) which can be used for educational purposes through their historical accuracy and realism. For example, the latter is a 3D action adventure game set in Paris during the French Revolution (late 1700s) which has great visual and behavioural accuracy. Famous historical characters such as Napoleon Bonaparte, Louis XVI of France and the Marquis de Sade are recreated and mixed with fictitious characters. The essence and historical events of the epoch are transmitted very realistically together with recreations of locations and buildings of the real world. It also offers a great insight into the behaviours, customs and general ambiance of the era for the player.

Moreover, there are a number of serious games (SGs) also known as applied games or 'games with a purpose' which are designed with a special intent separate from pure entertainment[24]. Examples of their use in CH includes interactive virtual museums, where gaming technology is utilised for the purpose of entertaining and educating visitors[25] and usually incorporates exploration and quizzes about various elements. Examples include *Virtual Egyptian Temple* and *Walk through Ancient Olympia*. There are also prototypes and demonstrators which are games based on precise 3D virtual reconstructions from geographic data of ancient historical sites that usually provide realistic archaeological exploration. These include political, religious and artistic walk-throughs utilising historically accurate procedurally generated non-player characters (NPCs). Such examples include *Pompei: The Legend of Vesuvius* edutainment game and *Roma Nova*. An extension of these, are games specifically used for the acquisition of cultural knowledge and intangible heritage



Heritage Malta sites available on Google: Wonders of Malta with street view technology to navigate various museums and sites almost as if the viewer is present e.g. clockwise starting from Top left: Tarxien Temples, Ta' Kola Windmill-Gozo and St Paul's Catacombs-Rabat

which include intercultural skills and language training through high-fidelity 3D simulation of cultural settings. The final categories are social tagging and knowledge acquisition games. These encourage players to submit accurate information on CH artefacts with the purpose of knowledge verification and data mining so as to enhance the corpus of knowledge relating to various tangible and intangible CH elements.[26]

Looking ahead

This article demonstrates that technology has truly changed and shifted the area of CH. In this day and age, cultural artefacts from across the world are accessible to researchers and enthusiasts at the click of a button. Museums can be accessed virtually through mobile devices and carried in one's pocket. Inaccessible CH locations can now be easily explored through the use of virtuality. Artificial intelligence is paving the way to an exciting future, where breakthroughs in CH research would be possible through new tools and techniques that can handle the massive data generated. As technological advancement is fully embraced by CH researchers, a truly exciting future awaits.

Notes & References

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