Visiting Heritage Sites in AR and VR

Subjects: Others

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Advances in digitization technologies have made possible the digitization of entire archaeological sites through a combination of technologies, including aerial photogrammetry, terrestrial photogrammetry, and terrestrial laser scanning. At the same time, the evolution of computer algorithms for data processing and the increased processing power made possible the combination of data from multiple scans to create a synthetic representation of large-scale sites. This route was opened by the gaming industry. In terms of research, the exploitation of these new assets in conjunction with new visual rendering technologies, such as virtual and augmented reality, can create new dimensions for education and leisure.

Keywords: augmented reality ; virtual reality ; virtual tours ; immersive experiences ; 3D digitization

1. Introduction

Making large-scale heritage sites accessible through digital technology is still a major challenge today. In this work, the challenge was providing multimodal access to the digitization of the Palace of Knossos and its peripheral sites in collaboration with the Ephorate of Antiquities of Heraklion. Knossos is best known for its monumental palace, the so-called Minos Palace [1][2][3][4], excavated by Arthur Evans [4]. The archaeological site and its peripheral sites are composed of a complex structure that has multiple internal and external sites complemented with modern additions as part of the restoration process. The digitization of the site was a great challenge by itself, which resulted in a complete set of registered and fully exploitable 3D digital assets.

The term virtual exhibition (VE) is used in the domain of digital cultural heritage (DCH) to describe a variety of technical solutions, interactions, and immersion styles. In the 2000s, the majority of VEs were web-based [5][6], and from the early 2010s, basic guidelines for creating interesting and compelling VEs were contributed [7][8][9]. In parallel, digital technology explored ways of enhancing the museum experience through on-site and mixed reality (MR) VEs [10][11][12], authoring environments for web-based virtual museums [13][14], and authoring web-based virtual environments to provide a synthetic representation of cultural heritage (CH) subjects including intangible dimensions [15][16].

2. Virtual Reality and Cultural Heritage

Using virtual reality technologies in the CH context is not new since several approaches have been proposed in the past two decades. Starting from CAVE-based virtual reality, researchers have proposed several approaches that include both immersive presentation through VR and haptic-based manipulation of heritage objects (e.g., [17][18]). The profound benefits of interacting with CH in VR gave birth to several new approaches that merged 3D reconstruction technologies with VR. By employing 3D reconstruction, realistic digital replicas of CH objects were implemented and integrated into VR experiences (e.g., [19][20]). In earlier approaches for CH presentation, digitization was not possible due to the immaturity of the technology, and technological restrictions of the rendering hardware schenes from archaeological sites were modeled from scratch in 3D (e.g., [21][22]). This, of course, resulted in lower-quality 3D models but enabled researchers to complement the reality of the heritage site (the structural remains) with digitally manufactured structures and, thus, provide a digital restoration of the monument (e.g., [23][24]). These works went even further by simulating the weather and daily life in ancient CH sites through the graphics-based rendering of nature and autonomous virtual humans. The evolution of VR devices with the emergence of commercial VR headsets and VR controllers greatly simplified the implementation of VR-based experiences (e.g., [25][26]). At the same time, 360 photography and 360 videos made possible another form of virtual reality through inexpensive VR headsets that could be mounted on smartphone devices. Such approaches were further augmented by including information points and interactive spots within 360 videos that could be activated using a more advanced interaction technology, such as an Oculus headset and controllers (e.g., [27][28][29][30]). Furthermore, studies focused on the resource-demanding task of streaming 360 videos in such headsets (e.g., [31][32]).

From a sustainability perspective, VR is proposed as an alternative means of access to endangered CH sites that, due to visiting pressure, would benefit through the redirection of visits to digital media (e.g., [33]).

3. Augmented Reality and Cultural Heritage

AR has been the subject of continuous research throughout the years, and the algorithms used have kept evolving, thus contributing to its potential. AR research provides clues that it can enhance learning as a consequence of multiple key features that are otherwise missing from common educational means [34]. In the work of Irwansyah et al. [35], it was shown that learning enhanced with AR can increase the overall experience of students in school-related subjects, such as chemistry, or even strengthen the learning experience of young children in cultural heritage sites [36]. A fascinating work by M. Claudia et al. [37] explored the value of AR for cultural heritage sites using the stakeholder approach. By conducting an exploratory study on museum stakeholders, personnel, and focus groups, they reported that there are numerous perceived value dimensions of AR within the cultural heritage tourism context for stakeholders, including economic, experiential, social, epistemic, historical and cultural, and educational value.

Mobile AR research started by integrating feature extraction algorithms into mobile phones and using camera input for the acquisition of images (e.g., [38]). Other approaches used more advanced mobile devices (that used to be called PDAs) to augment digital scenes with more advanced information including virtual humans (e.g., [39]). More recent approaches employed the increased processing power provided by modern mobile phones to provide various forms of AR, such as augmentation of the images of the mobile device camera with information (e.g., [40][41]) that includes the interpolation of 3D digitizations with the camera input (e.g., [42]). Other approaches blend the virtual and the digital by replacing the physical remains of a heritage site with a digitally enhanced version of the site at the time of its creation ([43]). Last but not least, physical objects have been used to support the visualization and interaction with archaeological artifacts in AR (e.g., [44][45]).

The wide availability of mobile devices in the context of CH has opened a new world of opportunities and expanded its usage in other contexts, such as in the domain of teaching tangible and intangible CH (e.g., [46][47][48]).

4. Mixing Augmented and Virtual Reality

In the last few years, mobile devices have been able to support larger and computationally heavy AR scenes, supporting a new trend called “AR Portals”. The concept of an AR Portal application is that, by using the currently available AR features that are supported in a mobile device such as plane detection, the user can spawn a portal (or door) to another world and, by walking through the portal, is transported into that world. After being transported, the user can roam and freely explore the world by moving and rotating the mobile device. A great application called “The Historical Figures AR” allows its users to walk through a portal and visit multiple sites of historical importance, including Albert Einstein’s lecture hall, Marie Curie’s laboratory, and others [49]. Of course, they are not historically accurate and are freely stylized for visual aesthetics, but it shows the potential of AR Portals.

Further approaches are proposed by augmenting the physical location with digital information and supporting alternative forms of interaction through the manipulation of physical objects as interactive devices exploited mainly in the context of physical museum installations rather than archaeological sites (e.g., [50]).

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