METHODS FOR VISUALIZING ROCK-CUT SANCTUARIES IN SOUTHWESTERN BULGARIA USING EMERGING TECHNOLOGIES

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Abstract. This paper presents different methods for virtual representation of Cultural Heritage (CH) with the support of new digital technologies. These methods could be applied on specific objects – rock-cut sanctuaries, which would benefit from the new possibilities and become more attractive for tourists. There are many rock-cut sanctuaries in Bulgaria and most of them are not easily accessible. We propose a suitable method for visualizing a rock-cut sanctuary in Southwestern Bulgaria and discuss the benefits of emerging technologies for this type of heritage sites.

Keywords: cultural heritage, emerging technologies, virtual reality, augmented reality, rock-cut sanctuaries

Introduction

Technologies have large impact on culture and arts in the last 20 years. The mix of digital technology and culture creates many new possibilities for scientists, researchers and consumers. The widespread use of computer technology in the fields of culture, arts, social sciences and cultural heritage is called Cultural Computing (Bekele, Pierdicca, Frontoni, Malinverni, & Gain, 2018; Haydar, Roussel, Maïdi, Otmane, & Mallem, 2011; Wang, 2009). This term includes special programs, technical equipment and computer specialists studying the diverse world of culture and arts.

The digitization of cultural heritage is a rapidly evolving field of science that includes many researchers in various fields – historians, archaeologists, museum workers, photographers, computer specialists, engineers and others. The joint interdisciplinary work of all of them leads to the emergence of a new scientific field – Virtual Heritage (VH). In the field of VH we can see some real practical applications – museums present virtual exhibitions and offer virtual walks in cultural monuments, computer engineers create 3D reconstructions of damaged and destroyed buildings and religious sites. The use of immersive technologies like Virtual Reality (VR), Augmented Reality (AR),

Augmented Virtuality (AV) and Mixed Reality (MxR) enriches tourists' experience and supports the spread of cultural knowledge in the field of Virtual Heritage (Bekele & Champion, 2019).

Digital technologies are used mainly in museums for preservation of museum artefacts and for creating virtual museum walks and virtual exhibitions. In Bulgaria museums work on digitizing their collections for many years but the process is slow and relies heavily on financing by the government and the European Union. Most of the digitized collections are still invisible for the public and serve only the museum professionals. Outdoor cultural heritage sites (such as the rock-cut sanctuaries) would benefit a lot from the use of immersive technologies, because they are not easily accessible and most of them are in danger of destruction.

Speaking about emerging technologies such as VR, AR and MxR, the main focus is still mostly on the technology itself not on the benefits it creates. Researchers must try to concentrate on what kind of problems the technology solves and how this helps preservation and visualization of cultural heritage.

Emerging Technologies in Cultural Heritage

There are many definitions for Emerging Technologies and a lot of researchers use the term for technologies that seem modern, new and complex for the mass audience. For the purpose of this study we are going to use the following definition of emerging technology: "fast growing and radically novel technology characterized by a certain degree of coherence persisting over time and with the potential to exert a considerable impact on the socio-economic domain" (Rotolo, Hicks, & Martin, 2015). Considerable part of this new scientific field is occupied by the Immersive Technologies which, as the name suggests, immerse the user in an alternative reality. Their role is to merge real and virtual into one. They are a powerful tool for visual presentation of tangible and intangible cultural values. They are very important in the field of cultural heritage because they attract the interest of tourists and enrich their experience in the museum or in the heritage site. The main immersive reality technologies in the virtual heritage domain are virtual

reality and augmented reality (Haydar et al., 2011; Papagiannakis et al., 2018).

Virtual reality (VR) is defined as a 3D image created in a simulated environment where users experience sensations of immersion and movement, just as in the real world (Meinhold, 2015). This technology uses devices which completely immerse a user into a virtual world (e.g., headsets) and includes 360-degree videos (Ch'ng et al., 2019); In addition, the use of peripheral hardware that replicates the natural movements of the head, such as Oculus Rift, allows increased user perception within the VR environment (Gonizzi Barsanti, Caruso, Micoli, Covarrubias Rodriguez, & Guidi, 2015).

Augmented reality (AR) superimposes or supplements the real world with 3D virtual content, generating the illusion that real and virtual coexist in the same space (Azuma, 1997). AR is the most promising technology for the future of virtual cultural heritage because of its wide possibilities and prevailing usage in VH. Devices for AR become cheaper and easier to use. Developers create more software platforms for AR applications. Visualizations become better and users feel the virtual augmentation almost like natural objects and views.

There are two other immersive technologies which are not so popular as VR and AR in the field of VH but are worth mentioning because of their hybrid nature.

Augmented Virtuality (AV) augments virtual environments with live scenes of events and elements from the real-world (Bekele & Champion, 2019). This technology is very challenging and rarely used by far in cultural heritage. It has some applications in game development.

Mixed/merged reality (MxR), is defined as the merging of real and virtual worlds to produce new environments and visualizations where physical and digital objects co-exist and interact in real time. Mixed reality takes place not only in the physical world or the virtual world, but is a mix of reality and virtual reality (McMillan, Flood, & Glaeser, 2017).

Table 1. Main Methods for Visual Representation of Cultural Heritage Sites

Methods	Purpose/Benefit	Application
Virtual Reality	- Education (Chrysanthi, Papadopoulos, Frankland, & Earl, 2014); - Virtual reconstruction (Barratt, 2018; Di Angelo, Di Stefano, Guardiani, Morabito, & Pane, 2019; Douglass, Day, Brunette, Bleed, & Scott, 2019; Guidi, Russo, & Angheleddu, 2014; Portalés, Alonso-Monasterio, & Viñals, 2017); - Exploration (Bekele et al., 2018); - Accessibility (Cassidy, Sim, Robinson, & Gandy, 2019); - Entertainment (Beraldin et al., 2005); - Archaeoastronomical research (Frischer, Zotti, Mari, & Vittozzi, 2016); - Preservation (Lee, Kim, Ahn, & Woo, 2019; Mah et al., 2019)	- Virtual museums (Gonizzi Barsanti, Caruso, Micoli, Covarrubias Rodriguez, & Guidi, 2015; Haydar et al., 2011; Pietroni, Ferdani, Forlani, Pagano, & Rufa, 2019); - Galleries (Windhager et al., 2019); - Sanctuaries (Hermon, Depalmas, Lopez, & Atzeni, 2017); - Underwater sites (Aragón, Munar, Rodríguez, & Yamafune, 2018; Balletti, Beltrame, Costa, Guerra, & Vernier, 2016; Bruno et al., 2019)
Augmented Reality	- Exhibition enhancement (Bekele et al., 2018; Breuss-Schneeweis, 2016); - Reconstruction (Bekele et al., 2018; Marto & Gonçalves, 2019; Noh, Sunar, & Pan, 2009; Petrelli, 2019); - Exploration (Bozzelli et al., 2019; Caggianese, Neroni, & Gallo, 2014; Haydar et al., 2011); - Presentation/Representation (Boev, 2015; Girão, Paulo, Garrote, & Peixoto, 2018; Pollalis et al., 2018; Quint, Sebastian, & Gorecky, 2015; Vlahakis et al., 2002); - Information (Andrade & Dias, 2020; Blanco-Pons, Carrión-Ruiz, Luis Lerma, & Villaverde, 2019; Diaz, Hincapié, & Moreno, 2015; Gutierrez, Molinero, Soto-Martín, & Medina, 2015; Thomas et al., 2014; Yovcheva, Buhalis, & Gatzidis, 2012)	- Museums (Ch'ng, Cai, Leow, & Zhang, 2019; Cranmer, 2017; Kadri, Khalloufi, & Azough, 2020; Kyriakou & Hermon, 2019; Petrelli, 2019); - Outdoor cultural heritage sites (Alkhafaji, Fallahkhair, & Cocea, 2019; Caggianese et al., 2014; Vlahakis et al., 2002); - Historical buildings (Fogliaroni, 2018)

Proposed Application of Digital Technologies on Rock-Cut Sanctuaries in Southwestern Bulgaria

Rock-cut sanctuaries are very difficult to socialize because of their location. Some of them are robbed and destroyed, others are in danger and need special care. Immersive technologies should play a key role in preservation and communication of these historical sites. We propose suitable digital methods for visualizing rock-cut sanctuaries and for illustration of our ideas we are going to virtually apply these methods on "Markov kamak" sanctuary near Tsarev Peak in the Rila Mountain, Southwestern Bulgaria.

Tsarev Peak is located in the Rila Mountain at an altitude of 2376 meters. At the southwestern foot of Tsarev Peak is situated an interesting configuration of stone blocks, the central part of which forms a rough trilith. The trilith is formed by a stone slab stuck on two adjacent rocks, thus forming an East-West oriented aperture (Markov, 2007, p. 177). There are carvings on the covering stone of the thus formed rock arch or trilith, one of which is extended, resembling a step, and from it a gutter "flows" down to the aperture of the arch (Markov, 2007, p. 178). The facility thus situated presupposes a ritual pouring of liquid from the upper stone to the aperture of the arch (Markov, 2007, p. 178). Studies show that this type of installations is an important part of the ritual reality and is a common component in the rock sanctuaries (Markov, 2007, p. 178). The sanctuary around Tsarev Peak does not exist independently, but it is part of a sacred territory (Genov, 2018, p. 171). V. Markov suggests the existence of a major cult center in the area around Tsarev Peak and the Rila Monastery, where rites of renewal of the ruler's power were practiced (Markov, 2007, pp. 179–180). These rites could be reconstructed and visualized with the support of VR and AR technologies.

Archaeoastronomical research of the site testifies, that the aperture of the trilith observed from certain areas is oriented to specific markers on the horizon, marking sunrise and sunset during the summer solstice (Stoev, Maglova, & Stefanov, 2010, pp. 72-83). At sunrise on the morning of the summer solstice, the first rays of the sun pass through the opening of the trilith to illuminate a huge egg-shaped rock altar, on the surface of which many round carvings are found (Markov, 2007, p.

178). Archaeoastronomical dating sets the period from the second half of the 1st millennium BC to the 6th century AD as a possible time for using the facility (Stoev, Maglova, & Stefanov, 2010, pp. 72-83).

The archaeoastronomical and observational data can serve as a base for creating a virtual reality visualization of the sunrise on the day of the summer solstice. The phases of creating such visualization are: 1. Capturing digital images in high resolution of the stone arch and the stone egg. 2. Creating a 3D model with the support of photogrammetry software. 3. Creating the virtual reality using Oculus SDK for the Unity development environment. 4. Testing the virtual reality with the Oculus Rift headset.

Created virtual reality content solves the main problems of the heritage site: 1. Accessibility – everyone can see the sanctuary and its solar show without travelling and climbing the mountain. 2. Preservation – virtual images can be seen by thousands of people without any harm to the stones and surrounding nature. 3. Connecting younger audience to the cultural heritage – proposed digital method seems attractive to kids and teenagers and helps them familiarize with history and culture. This VR model can also be used for education and entertainment – as a base for creating games.

Conclusion

Emerging technologies create many new possibilities in the field of cultural heritage. The use of immersive technologies like VR and AR for virtual representation of rock-cut sanctuaries can help for preservation of these megalithic monuments. The other benefits of applying new digital methods for visualizing rock sanctuaries include: making them more accessible for the mass audience, attracting younger people and helping with their education, generating value for cultural tourism and gaming industry. The research in this area will continue to grow and proposed methods will serve as a base for creating new applications in the field of virtual heritage.

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