Augmented Virtuality as an Instrument for a Better Learning of History

Dragoș Gheorghiu¹, Livia Ștefan²

(1) Doctoral School, National University of Arts, 19 Budășteanu, Bucharest, ROMANIA
(2) Vauban IT Services, 2 Oteteleșanu, Bucharest, ROMANIA
E-mail: livia.stefan[at]yahoo.com

Abstract

In this paper the authors present a research investigating methods for achieving a more efficient immersion of the visitors in a set of historical reconstructions performed in online Virtual Reality (VR) using Unity3D. The approach was centred on augmenting the virtuality by means of „reality inserts”, to enhance the veridity of the overall 3D scenes and support an immersive setting for informal history learning. The current paper will describe a case study involving two Roman-Greek reconstructions in Mangalia and Albești, within the Time Maps (PN II IDEI) project.

Keywords: Augmented Virtuality, Historic Characters, Videos, Experimental Archaeology, Unity3D

1 Introduction

Virtual reconstructions in 3D are currently a well established visualization method both in architecture and archaeology (Barceló 2001; Earl 2009; Saleeb and Dafoulas, 2011; Abbott 2012; Shanks and Webmoor 2013; Gheorghiu, 2018), representing a form of Virtual Reality (VR) which is currently more accessible to a broader public. The evolution of the 3D modelling and rendering technologies has led to the creation of 3D reconstructions of high photographic accuracy (Shanks and Webmoor 2013; Earl 2009), in which, paradoxically, the user once immersed can no longer maintain a connection to the real world.

Augmented Virtuality (AV) represents a method by which a virtual environment can be enriched with information from the real world, with the purpose of connecting the virtual to the real, and thus offering a broader cognitive context. AV was conceptualized by Milgram et al. (1994) and together with Augmented Reality (AR), defines the spectrum of a mixed reality (MR) within a reality–virtuality continuum. While AR has been experimented with in several cultural heritage and e-learning projects (Radu, 2012; Kyriakou and Hermon, 2016; Gheorghiu and Ștefan, 2012; Gheorghiu and Ștefan, 2015), AV as a mixed reality medium is less studied as a technology per se.

In AV different augmentations can be applied for the exploration of historical sites. In more complex settings, the 3D reconstructions and scenes are populated with different human characters, also reconstructed in 3D, with the purpose of reproducing a more realistic image of the past architectural spaces.

In this paper the authors present a research whose purpose was the application of methods and techniques for achieving a more efficient immersion and cognitive impact of a set of online historical reconstructions. The approach was centred on augmenting the virtuality by means of „reality inserts”, thus enhancing the veracity and complexity of the overall 3D scenes. The research goal was to create an improved immersive setting to support a better informal e-learning of history.
Two forms of augmented virtuality were tested. One was represented by videos shot within architectural fragments reconstructed in reality (as experimental archaeology) and introduced within the virtual architectural reconstructions. This method provides the visitor the opportunity to switch from a virtual to a real environment, back and forth. The second method consisted in 3D scenes populated with virtual human characters, created by 3D-scanning of real characters dressed in epoch costumes.

These methods were employed in later years within the Time Maps (PN II IDEI) project (Time Maps, 2018) of the National University of Arts (NUA) in Bucharest with excellent results in immersive and experiential e-learning (Ștefan and Gheorghiu, 2014; Gheorghiu and Ștefan, 2018).

The current paper will describe a case study using AV as an instrument of learning in two Roman-Greek reconstructions in Mangalia and Albești within the mentioned research project.

2 Literature Review

Virtuality has become a research instrument both in science and education (Goodwin et al., 2015). In the scientific literature, AV it is implemented as a form of MR. The Horizon Report (2018) defines MR as “the intersection of virtual and physical Realities” and still an “emerging environment” to be fully adopted in four or five years.

In archaeology Mixed Reality is present in recent research works (Tan and Lim., 2017). In these works, AV is not yet employed as a learning instrument but rather as a new museum practice.

In current implementations, the educational potential of the MR technology is obvious. From a user’ cognitive and engagement impact, the MR environments have proven effective but still difficult to adopt in educational practice due to the need for equipment that would mix the virtual with the real (Costanza et al., 2009; Callaghan et al., 2010; Dede et al., 2017).

3 The AV Technological Methodology

Unity3D (Unity, 2018), a very popular gaming engine among game developers and researchers, was the technology selected, due to its high performance both in online environments and mobile devices. It is for this reason that Unity3D is currently a platform of choice for both virtual reality and augmented reality (Gheorghiu and Ștefan, 2015; Kyriakou and Hermon, 2016), along with the Unreal engine (Unreal, 2018). The capability of creating very interactive 3D virtual scenes, also makes Unity3D a good platform for AV.

The 3D reconstructions were integrated as a single user application into the project’s educational website (Time Maps, 2018), using the Unity web plugin. The “first-person” mode, in which the user views the 3D scene through his/her own eyes, was employed. Thus, a complete immersion was obtained.

3.1 3D Scenes

In the Unity application, various 3D hyper realistic reconstructions of the Hellenistic architectural spaces were integrated, designed with high archaeological accuracy and focused on the details. The reconstructions were copied from existing archaeological remains or were the result of the experimental archaeological research (Gheorghiu, 2014) carried out by the first author. The built-up spaces and usual objects that furnished these spaces were reconstructed taking into account the textures and colours of each material and the diurnal and nocturnal illumination of the built space (Gheorghiu, 2018).

The illumination (Gheorghiu, 2018) took account of a specific moment of the day, thus trying to provide a more accurate (realistic) image of the site. In other experiments at the sites of Mangalia and Albești, the forms and textures of the ancient objects were scanned for a hyper-realistic representation.
3.2 3D Characters
Photogrammetry is a technique used to generate 3D models from sequences of successive photos. It is used in cultural heritage projects, to obtain models of artefacts or historic buildings (Bazzurri and Picardello, 2018), and it is a more convenient method, in terms of post-processing effort, than laser scanning. Sketchfab is an online platform that can be used to create galleries of 3D models.

In the Time Maps project, photogrammetry was used to scan young volunteer actors dressed in historical costumes as a method to create a gallery of 3D characters (Figure 1).

![Figure 1. Real Characters During Photogrammetry Sessions And The Resulted 3D Models In Sketchfab Online Gallery](image)

3.3 AV in Unity3D
To design an AV application the capabilities of Unity3D to embed hotspots linked to video films were explored. Hotspots are small regions in the 3D scene where users can interact with it by clicking on it. In Unity3D the hotspots could be seen as “game objects”. These hotspots have been inserted in the reconstructed contexts in the exact place where different technologies would have taken place in the historical time (Figure 2).

The scanned 3D characters have been post-processed and optimized in a number of polygons, due to the fact that a huge file size resulted from the generation of the 3D model, and after several iterations they were integrated in the Unity 3D scene. Even with a loss of accuracy of the resulted images, the presence of the human characters brought an important augmentation, explicating the overall historical scene and bringing to it an extra touch of “that reality”. When the 3D scenes were completed with 3D characters, the illumination effects were implemented contributing to the augmentation of the “reality” of the Past.

3.4 VR/AV as a Virtual Tour
From the Unity3D project a fully featured AV application using the
Unity3D web plugin was generated. To maintain compatibility with all the versions of browsers, a virtual tour in the first-person mode was offered as a limited VR variant of the Unity3D application. There are 2 possibilities to create a virtual tour, either using an external screen capture software, such as Fraps (2018), or using a Unity3D camera animated to make a directed tour through the 3D reconstruction. The Time Maps project employed the second method.

3.5 Discussion and Limitations
The online environment is still limited regarding the VR interactive support. This is also the case for AV. Things are also complicated by users with different browsers, different versions of the same browser, or computers with different capabilities.

Since 2016, modern browsers no longer support plugins, except for a special version of Mozilla Firefox Extended Support Release (ESR 52.8.0) as well as Google Chrome 67.0.339699, which provides backward compatibility with web plugins.

That is why, within the Time Maps project, we had to envisage solutions that would accommodate all the possible situations, such as guided virtual tours through 3D reconstructions. These videos are also compatible with mobile devices, which when detected, are redirected to the page containing the VR videos instead of the Unity3D application.

Users able to install the special version of Chrome and the Unity web plug-in received a link to the Unity VR application.

4 Pedagogical Methodologies in AV Settings
Learning “affordances” is a term introduced by the perceptual psychologist Gibson (1977), which extended the description of the graphical environments from objects and space, to specific actions performed on the objects of that environment. AV can be considered an affordance of a virtual learning setting, and can be employed as a complex instrument to study spaces and objects of the Past.

- **Video** - In the video AV method, the student does not interact with the virtual environment. The video tour of a historical reconstruction is based on the teacher's instructions that guide the student to visualize essential information in order to understand the cultural phenomenon behind the 3D historical contexts such as architectural structures, historical characters, character relationships, relationship between characters and architecture, technologies, and finally daily scenes.

- **Unity** - In AV developed as a Unity3D application, the student explores the 3D historical contexts to study, and discovers other data and meaningful relationships between characters and context that do not appear in videos and which will also generate a series of questions, thus enhancing the learning outcome and the volume of knowledge.

- **Case Study** - In these case studies we will detail the AV made with 3D inserts, real-virtual conversion and virtual insertion. Hellenistic sites on the Black Sea coast, Mangalia (Mangalia, 2018) and Albeşti (Albeşti, 2018) were selected, where various home and funerary architectural spaces were built, and populated with characters inspired by ceramics and the stone sculptures of that era.

- **Mangalia** - Characters dressed in costumes inspired from Tanagra ceramic statues were scanned and inserted in representative locations in 3D reconstructions of Hellenistic houses and of a funerary tumulus. An attempt was made to capture some daily life fragments, studying the living quarters of patio houses. A funerary scene inspired from a Greek bas-relief was also recomposed (Figure 3).
Albești - For the Albești settlement a fortified farm dating from 4th-2nd centuries BC was reconstructed in 3D. The settlement was part of the Greek town of Mangalia (Gr. Kallatis) chorai, and recalls the rural farms or pyrgoi of the Hellenistic world. The imported materials discovered constitute an index of the commercial relationships of Kallatis with the Black Sea-Aegean worlds and infer the main function of the settlement (Figure 4).

The 3D reconstruction of the pyrgoi-farm was populated with barbarians, Greek soldiers, iron-smiths and peasant women.

Conclusions and future work

The paper presents the results of an original research, consisting in the implementation of two methods of AV, applied to facilitate the understanding and study of local history in 2 locations, from the Hellenistic epoch.

These two types of augmentations of the virtual space achieved by adding „real” representations enhanced the grade of credibility of the virtual reconstructions.

Experiments with students from primary schools showed an advantage of augmenting virtual representations, compared to simple virtual ones, in order to increase knowledge and efficiency as time and volume of information transmission. AV allows the achievement of a high degree of reality of the Past, which helps to understand the cultural complexity of the discussed topics. With the help of the historical dress, facial expressions, gestures and attitudes, the historical characters could visually transmit a multitude of information about activities and daily life technologies, in a living, engaging way for students. The authors consider that the complexity of the Past can be experimented in an immersive and augmented manner, by inserting the real in the virtual, this AV allowing a visitor an enhanced experientiality derived from an enhanced veracity of the studied contexts.
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