Virtual Portals for a Smart Fruition of Historical and Archaeological Contexts

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Abstract. The experimentation of new effective visualization techniques provides viable technological solutions for the archaeological heritage fruition and the visitors involvement within cultural places (museums, gallery, archaeological sites).

This article discusses the feasibility of a project aimed at extending outdoor the fruition of archaeological sites, by exploiting mixed reality technology. In a previous work we focused on the development of a mobile application that exploits the Augmented Reality technology, limited to an indoor fruition. Therefore we decided to extend the app by introducing a strategy for an on-site outdoor exploration based on "virtual portals". Virtual portals are the medium that allows the transition from reality (present) to virtuality (past) and vice versa. They are located outdoor at some point of interest, so that user has the perception of passing through different space-temporal dimensions: this is actually what we want to provide as user personal experience. We considered two archaeological areas as case studies, both excavations sites of the University of Salento, as an instance of a wider network we aim to create. In this paper we give some hints about a feasible design for this project.

Keywords: Augmented reality · Mixed Reality · Cultural Heritage · Archaeology · Virtual portals

1 Introduction

In cultural heritage scenarios, visitors should never be considered as passive spectators: in order to establish a learning process with the historical contents, visitors should play an active role, in a sort of interactive learning by doing experience.

The experts talk about edutainment, a word coined by Bob Heyman in 1973 that comes from the fusion of the two words educational and entertainment [1]. Edutainment techniques often pass through the use of Information and Communications Technology (ICT). This allows the humanistic disciplines to achieve

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higher results in terms of audience engagement. In this project we would like to stimulate the user interest through an interactive learning process.

It should be taken into account that, in an archaeological context, the lack of tangible elements brings the need for "augmenting" the reality. The aim is to extend the visible by presenting a world where real and virtual objects exist simultaneously. A helpful answer to this need comes from Virtual, Augmented and Mixed Reality technologies [2]:

- Virtual Reality (VR) isolates users from the real world and immerses them in computer-generated synthetic environments;
- Augmented Reality (AR) is a technology able to extend the visible, without replacing the reality with a synthetic one, but by presenting a world where physical and digital objects co-exist;
- Mixed Reality (MR) combines elements of both AR and VR to produce new environments and visualizations enabling virtual objects to be not just overlaid on the real world but able to interact with it.

Virtual reconstructions make historical concepts more accessible to the general public. In the edutainment paradigm [3], they allow the design of game oriented environments [4,5], which provide the users with engaging multi-channel and multi-sensory experiences [6]. In addition, MR environments allow the user having his/her own personalized interactive experience.

In a previous work [7], the aim was to experiment with the use of Augmented Reality technology for the archaeological sites of the Museo Diffuso Castello di Alceste, in San Vito dei Normanni (BR) and Fondo Giuliano, in Vaste (LE), both excavations of the University of Salento. The output was a mobile application (both for Android and iOS devices) able to transmit historical-archaeological content to a wide, non-specialized audience, through virtual reconstructions of the environment displayed in AR. Indeed the user is able to visualize the 3D reconstructions by simply pointing the camera of a smartphone at some ortho photographs of the site, used as image targets.

The limit of such application is that it has been developed and optimized for an indoor fruition, for instance inside a museum that collects archaeological remains of those sites. In order to have a significant impact in terms of user experience, the extension we are going to describe concerns a possible outdoor and on-site fruition by means of Mixed Reality. The idea is to provide the user with a mobile application aimed at bringing him/her inside a virtual reconstruction of the ancient archaeological site, by means of a "virtual portal" that permits a sort of a virtual journey into the past. The visualization of a virtual door in some points of the site allows the user to move from the real environment (the present) to the virtual one (the past).

1.1 Previous Indoor Application

According to the project and development of the previous app, the idea was to enhance the understanding of Apulian ancient culture. In particular we focused on two archaeological contexts:

- Museo Diffuso Castello di Alceste in San Vito dei Normanni (BR),
- Fondo Giuliano site in Vaste (LE).

We analyzed the historical context according to the data emerged during the digs campaigns [8,9]. In this way we defined, adapted and digitally optimized the contents that are actually object of the application and that the user can visualize by using augmented reality. The accuracy of historical contents and graphic reconstructions have been an important topic: from the beginning the work has been conducted in synergy with the Department of Archaeology of the University of Salento, that has supervised the accuracy in terms of historical data.

After a preliminary context study, we passed to design a technological system for presenting archaeological sites in an interesting and appealing way. For this reason, we developed a system that allows users to visualize the 3D reconstruction of the archaeological buildings and artefacts that no longer exist. This is made possible by the augmented reality technology. The user can view historical contents (3D models, texts, audio) related to the area simply by framing a planimetric map of the location of interest with a mobile device/smartphone. Obviously, visitors can be provided with this map in the archaeological site museum, for an indoor fruition.

This version was developed by using the *Vuforia* framework [10] integrated in the *Unity 3D* environment [11]. *Vuforia* allows to associate virtual objects with 2D or 3D targets, including image targets, object target and multi target. It provides an online Target Management System to process the image target (the aerial photographs of the archaeological sites) and detect the features which will be used for the image recognition (Fig. 1).

Figure 2 shows a view of the AR section of the app: after selecting the historical period of interest, the user can view the 3D reconstructions related to the respective historical phase directly superimposed on the orthophoto. Furthermore, some information buttons provide a description for each part of the building to allow a full understanding of the history of the ancient structure. We studied also a smart interaction mode that allows the user to access to contextual specific information by simply getting closer to some point of interest (POI) with the camera of the smartphone, without tapping any button.

Through this first version of the app, the user is provided with a useful tool to contextualize the museum collection in relation to the archaeological site of provenance. Since the application has been developed for an indoor fruition, now the need is to provide an extension that allows a direct fruition on the archaeological site. It must be taken into account that not all the archaeological sites are available to be directly visited: in this case a remote fruition is recommended.

However, when the site is open to public visits, it is important to encourage the fruition directly in situ: this is one of the goal we are addressing with this new project. Finally, a tool able to make up a network of multiple archaeological contexts open to the public would be even more helpful, by defining thematic paths based on georeferenced data. This is the starting point for the proposal based on virtual portals, which we are going to describe in this paper.

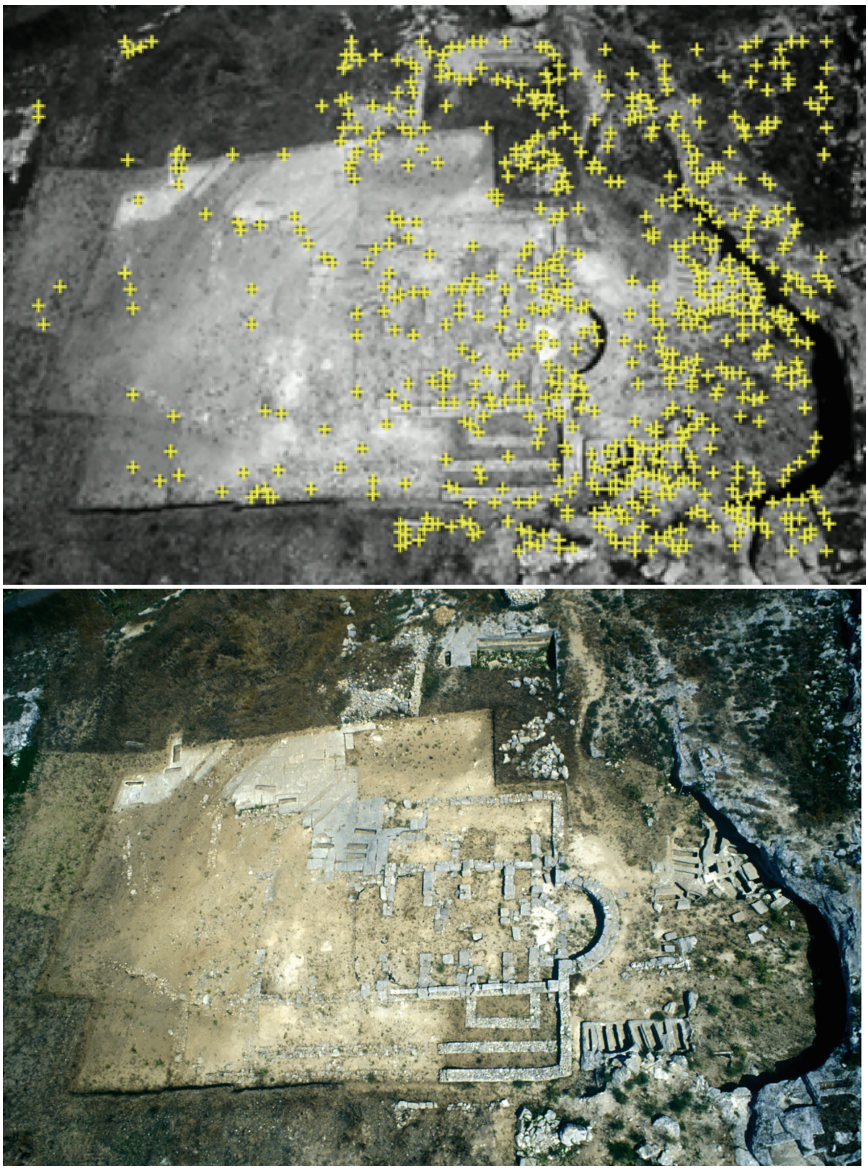

Fig. 1. Feature recognition of the image target

2 Related Works

The development of an augmented reality experience directly on site requires facing some issues related to outdoor scenarios, which are still a topic of intense research. The goal of an outdoor augmented reality system is to allow users to

Fig. 2. Augmented visualization of 3D model on the image target

move freely and without constraints in the environment, as well as to visualize and interact in real time with geo-referenced data by means of his smartphone. In particular, most of the AR outdoor applications aim at extending the visible by means of virtual reconstructions superimposed on the ruins in the real scene. This requires a great effort in terms of tracking techniques, accuracy and virtual content registration. The trend in outdoor scenarios is to exploit hybrid tracking. A fusion of various classic tracking methods can yield better results than their separate use. One of the most important and most cited instances in the archaeological domain that use hybrid tracking is ARCHEOGUIDE [12] (Augmented Reality-based Cultural Heritage Onsite GUIDE), which combines markerless tracking and Global Positioning System (GPS) to determine the viewpoint pose. It aims to develop interactive methods for accessing outdoor cultural heritage information, by providing an opportunity to visualize the 3D reconstructed damaged site.

More experimental solutions for the archaeological field have been proposed in the last years. In [13] the authors developed a location-based AR mobile application, supporting the exploration of a given archaeological site from an aerial perspective, by exploiting unmanned aerial vehicle (UAV) and augmented reality.

There are several critical issues emerging in this field, well summarized in [14], that include the need to address problems related to user mobility and the impossibility to use a marker-based tracking. The outdoor scenario is a highly dynamic and unprepared environment and generally there is the need to adopt an approach based on hybrid tracking. These critical issues have widened the gap between the accuracy of an indoor application and an outdoor one.

A different possibility for outdoor archaeological fruition is offered by the so-called virtual portals [15], which propose a jump between AR and VR. Although it does not provide a precise one-to-one correspondence between the virtual reconstruction and the archaeological remains, it leads to the possibility of opening a virtual gate connecting the present and the past.

In [16], the authors define virtual portals as three-dimensional doorways that connect one virtual location to another and can be entered by users in order to move to and come back from that place. In particular, the former is a faithful replica of the real environment that the user sees before wearing the VR viewer, while the latter is an imaginary environment.

Nevertheless, to the best of our knowledge, the use of virtual portals in the augmented reality field and, in particular, as a tool for the enhancement of archaeological sites, has not yet produced meaningful case studies in literature. By exploiting the development potential of ARkit and ARcore libraries, it becomes much easier to implement "AR Portals", allowing users to physically cross a virtual portal in the AR browser and experience different spatiotemporal realities. This makes users able to create, experience and share content-rich stories in AR. Some experimentation in this field has been conducted by Nedd [17], a French company that develops immersive experiences for brands and organizations. A first prototype combining AR, geoinformation and social networks is proposed, in order to create a highly interactive and personalized storytelling experience.

3 Work Hypothesis

As already mentioned, in this paper we want to define the hypothesis for an extension of the previous work in order to transcend traditional communication methods and propose an innovative and alternative tool for the outdoor and on-site fruition of the archaeological area. Inspired by many series or movies and 3D first-person action video games, we propose an alternative solution, as a plausible "shortcut" that performs a "time travel" by using the virtual portals concept, in order to bring the user from the real environment to the virtual one.

According to the work hypothesis, the aim is not to offer (like in the most of the outdoor AR cases) a one-to-one correspondence between the virtual reconstruction and the archaeological remains: on the contrary, we consider a simplification of the problem that only marginally deals with the tracking issues discussed above. Following our design idea, those virtual portals will be accessible through a smartphone or a mobile device: a POIs network will be provided to the user in order to discover an itinerary of geolocated virtual portals. Through these virtual gates we want to provide a "time travel", a transition between the real (the present) and the virtual (the past) environment.

4 Switching from AR to VR: Virtual Portals

In more concrete terms, the real visit experience of an archaeological site sheds light on the visit issues. Considerable difficulties arise in understanding the

chronological sequence of the site itself when the user looks at the ruins, characterized by the overlapping of different aged structures. In view of the above, virtual portals can represent a useful solution to these issues, in order to increase the understanding of these scenarios, without losing sight of the reality.

Firstly, portals are virtual objects that are properly registered in the real scenario framed by the device camera. Their alignment with the surrounding environment should give the illusion of being physically in front of a door. By means of mixed reality techniques, in which virtual objects have a spatial awareness, soil surfaces are detected to position the portal gate properly. A light estimation module will offer a higher level of realism, by setting the lighting of objects according to external lighting conditions.

Once gates are placed in the environment, users will be able to reach the virtual space by simply passing through portals. The related virtual scenario will represent a historical reconstruction of the site. The virtual space where the user will move with his/her device will be an augmented virtuality space: the portal will represent the point of return to the starting real space (consisting of the camera images).

In such approach, the portal is a door that allows a transition from the AR scenario (i.e. reality plus a portal on the virtual past) to the Augmented Virtuality (AV) scenario (i.e. the virtual world plus a portal on the real present) (Fig. 3).

We considered two archaeological areas as case studies, both excavations sites of the University of Salento, as an instance of a wider network we aim to create. The opportunity to put onto the web various archaeological contexts is granted by the use of geo-referenced maps. They exploit the device's on board sensors and GPS received to locate the user and the various portals, positioned according to the points of interest spread over the territory. In the style of a PokmonGO-like [18] location-based mobile game, the user will be provided with a map in order to navigate around the archaeological site and to explore it. When the user approaches one of the virtual portals he/she can tap on the button on the phone's screen and enable the AR visualisation. In that way, the portal will be properly placed on the AR screen as if it were in front of the user. He/she will be able to get inside the portal in order to experience a full virtual immersion into the ancient environment, although still present into the real world.

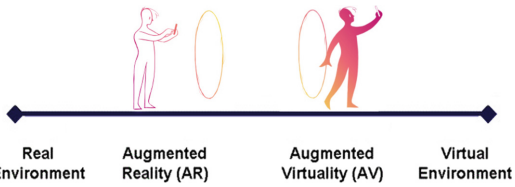

Fig. 3. Virtual portals in the virtual continuum

4.1 Implementation

While the earlier version of the application exploited an image target based tracking and used *Vuforia*, the new one needs other kind of technologies in terms of software development kit (SDK), even though the development core is still based on the *Unity 3D* environment.

The need for an AR framework that offers the possibility of developing a realistic first person game experience leads to the adoption of tools such as *ARCore* [19] for Android systems and *ARKit* [20] for iOS systems. Both the frameworks combine information coming from the device's motion sensing hardware with computer vision analysis of the scene visible to the device's camera. They can compare that information with motion sensing data and track differences in the positions of those features across video frames. The result is a high-precision model of the device's position and motion. Both the frameworks detect flat surfaces in the camera image and report their position and sizes to place virtual portals in the scene and pass through them.

5 Expected Results and Further Work

This article discussed the feasibility of a project aimed at extending outdoor the fruition of archaeological sites, by exploiting mixed reality technology.

Virtual portals are media that allow the transition from reality (present) to virtuality (past) and vice versa. They are located outdoor at some points of interest, so that the user has the perception that the travel passes through different space-temporal dimensions, and this is actually what we want to evoke as user personal experience. By identifying some paths among these portals, we aim at creating a territorial network of "smart" archaeological sites: this network would inspire and stimulate visitors in keeping this engaging experience. The main goal is to provide an interactive learning scenario in which visitors play an active role during the exploration.

The idea for the future development is to provide the user with a mobile application showing a map of the archaeological site, which keeps track of his position and displays where the virtual portals are located. These will be displayed in augmented reality when the user taps on them. For these purposes it needs to choose the tracking methodology and, consequently, the augmented reality framework for GPS support and 3D model registration in outdoor scenario; the realization of the virtual portal effect must be taken into account.

The *ARCore* framework enables devices to sense the environment, understand the world and interact with virtual content as seen through the camera. The development of 3D portals as access to a navigable virtual environment can be carried out thanks to the integration of ARcore in the Unity environment. Thanks to motion tracking, ARCore identifies some features through the phone's camera which, combined with phone's inertial sensors, determines the position and orientation of the phone. Besides key points, ARCore places the portal on top of the identified planes, by detecting the surfaces and understanding the world around them.

Another important topic concerns the 3D reconstruction of the ancient contexts: in the future development it will be necessary to evaluate the 3D modeling software as well as the reconstruction criteria and requirements for partially or totally lost contexts (through a cross-check with historical-artistic documentation).

Furthermore, after the import of 3D models, textures and lights in *Unity 3D*, we will need to properly associate 3D objects with the virtual portal, making them visible only from inside. This means that the shaders' model needs to be manipulated in order to achieve the portal effect. We need also an appropriate plugin for the design of an interactive map which displays the geolocalized points of interest. For instance, *Go Map* is suitable [21] for developing location based games and applications with Unity 3D. It is directly customizable from the Unity inspector and provides support for different types of map providers like *OpenStreetMap*, *Mapzen* and *Mapbox*.

We gave some hints about a possible design for this idea and a subsequent development of the project, as result of multidisciplinary studies. It will be also necessary to test the output, by means of some tasks provided to the user, in order to evaluate the effectiveness and usability of the product.

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