Making Visits to Museums More Fun with Augmented Reality using Kinect, Drones and Games

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Abstract— Augmented Reality (AR) provides an entertaining means for displaying 3D reconstructions of ancient buildings in situ for cultural heritage. This short paper presents several AR applications that can be employed in museums or heritage sites in order to enhance the visiting experience using recent technologies such as Kinect and drones. We also give an insight to an ongoing research employing novel ideas for allowing people to make the most out of their museum visits.

Keywords— augmented reality; cultural heritage; drones; kinect

I. Introduction

AUGMENTED REALITY (AR) presents an extended version of a user's surrounding with synthetic imagery generated by computers and blended with the images acquired from the real world. Cultural Heritage applications of AR was added to the list of application types of Azuma [1] by Papagiannakis [2]. AR is an interesting topic, especially for archaeology, since it is a good approach to displaying ancient buildings to tourists in the same form as they were in the past.

This usage has another valid reason, which is the opposition of archaeologists to physical reconstruction in situ as they prefer keeping the original structures for future generations [3]. By using an AR system, no physical reconstruction is required but the computer-generated reconstructions can be overlaid on the ruins in the site.

An alternative method for this task is VR, which allows simple tours among several buildings [4] or with user interaction. Laycock et al. [5] presented an interesting application that allows users to view high-fidelity reconstructions of ancient buildings and how they changed (e.g. partial demolitions or extensions to the buildings) over time.

However, ex situ reconstructions such as models, movies or desktop applications as presented in [6] which are difficult to visualize in the context of the archaeological remains. AR reconstructions can be produced in situ with minimal physical disturbance, an attractive property, even though they may take a significant time to develop due to a number of challenges. Application of AR in cultural heritage can solve this problem by introducing reconstructions that enrich the visiting experience of a heritage site with 3D models of ancient buildings with little or no physical disturbance to the ruins or artefacts.

An important challenge here is to produce a realistic output image in which the inserted objects are coherent with the real-world scene. Locating and tracking the user accurately in the environment [7] is key to this process since the user position and orientation determine the perspective information required for augmenting the scene. The process of tracking the user position is relatively easy if the user stands in a fixed, known position in a structured environment, looking at a fixed scene. This becomes much more difficult if he or she is able to move freely in an outdoor environment where there is no limit for possible movements.

Apart from all the challenges and available applications, the main focus of this paper is to introduce ideas which can be used to add on the current state-of-the-art of AR applications in cultural heritage. Most applications today present 3D views of ancient reconstructions in indoor or outdoor museums. Our aim is to create a prototype system for a "Total Augmentation Paradigm" which is based on the fictional prototype presented in [8]. Each user carries a tracking and display device and views the reconstruction of an ancient building. Users appear augmented in a clothing appropriate for the age when the building was available to other users of the system. Games inside such a system may make it even more interesting and entertaining. In addition, each user has an individual AR agent that helps them by providing information about the history of the building.

The rest of this paper is structured as follows: Section II presents various applications of AR for both indoor and outdoor environments. Ideas on what can be done with drones will be presented in Section III, followed by Section IV which describes a sample game that can be used in a cultural heritage context. Section V presents the general architecture project that aims to create a system following the "Total Augmentation" paradigm. Finally, conclusions are drawn in Section VI.

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II. Augmented Reality

As mentioned earlier, AR blends real-world and computer generated imagery. Literature presents different tracking methods for indoor and outdoor environments [7]. Here we present applications for both types using various sensors.

Microsoft's colour and depth sensor Kinect provides depth (range using IR light, a.k.a structured light) information along with the colour image which can be used to generate a 3D point cloud as a representation of the environment.

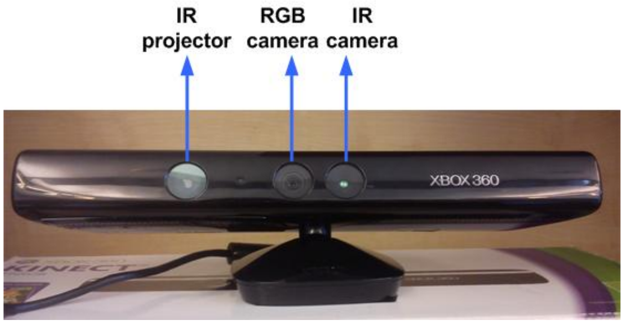

Fig. 1 Colour (RGB) and depth sensors in Kinect

A. Augmenting the Environment

An application was developed to augment rectangular regions of a specific size and aspect ratio in the Kinect imagery [9]. When the camera position and orientation had been found and the centres of suitable rectangles identified, the 3D column models described were rendered in front of them. When rectangles were found at a particular distance apart, a further model could be placed above the columns to form an arch as given in Fig. 2.

Fig. 2 Augmenting historical columns on rectangular objects

Due the brightness and shadows resulting from direct sunlight, it is not always possible to use Kinect outdoors. For this reason, use of other sensors was investigated along with the vision-based methods. For an outdoor application, a tracking system was developed using a camera, GPS and an IMU. The user wearing a helmet instrumented with sensors mentioned is shown in Figure 3.

The augmentations are displayed on the screen rather than an head-mounted display. The user can walk inside the model, experiencing the surroundings of ancient times as shown in Fig. 4.

Fig. 3 User wearing the tracking system and displaying the models

Fig. 4 Inside the State Agora of ancient Ephesus

B. Augmenting the Participants

User tracking can be accurately performed if the user is standing in front of the Kinect sensor (2.5m is given as an ideal distance) with his/her body (the upper body in particular) inside the field of view of the sensor and not occluded. Kinect's library can track 31 human joints. As each joint is recognized by the library, its position and orientation are returned. These transformations are absolute, not relative, and so can be used directly for rendering. The result of augmenting a user is depicted in Fig. 5.

Fig. 5 Augmenting the user with a toga, Roman helmet (galea) and a sword

The general effect is acceptable for toga and sword but minor registration errors are apparent for the galea model in the case of a single user.

III. Drones

Remotely piloted aerial vehicles or drones (Fig. 6) have become popular recently though the actual technology dates back to 1980's. There are several reasons behind the fact that the word 'drone' has become a catchword nowadays and reductions in the cost and weight are the main causes of this sudden popularity due to various incremental research outcomes technologies including MEMS sensors or Lithium Polymer batteries.

The developments in this technology found echoes in many applications in aerial imaging, mapping and even unmanned cargo services provided by logistics companies. It has also been quickly adapted by researchers working on cultural heritage and AR. The authors in [10] used a drone in order to capture images of buildings having a significant importance in their country's history and create documentation of these buildings.

Fig. 6 Our AR Parrot Drone 2.0 on the move

Yet another different application using drones with Kinect is given in [11]. A drone therein is controlled by the user wearing Oculus Rift using Kinect. The camera view streamed from the drone was rendered as stereo on the Rift and the user is able to control the drone using easy to learn gestures recognized by Kinect experiencing a natural feeling of flying.

IV. Games

Games are another tool that can be used in enhancing the visiting experience in museum. The work by Thon et al. [12] presented an AR game (Fig. 7) that can be played with a drone inside a museum. The aim of the game is to shoot different targets corresponding to stereotypes about museums such clichés as they are boring, dusty or only for elites. In this way, an awareness about the museum is to create an awareness via an interesting application.

We developed a different game which allows the user to collect items while moving inside an ancient model. As with previous applications, the game presents an egocentric view of the environment. The rules of the game are quite simple: the user needs to reach and collect all the reward items available as quickly as possible. When he or she reaches an item, the score is incremented by an amount that depends on the type of item encountered. The game provides three types of items: small coins, large coins and a chest, with rewards of 10, 30 and 50 points respectively.

Fig. 7 View from the AR game played on a drone (Figure courtesy of [11])

After the game is initialized with the positions of all items set, the game loop starts. The coin models use an animator and they rotate about their axes while the chest models remain static. At each frame, the position of the user is checked against the item positions by calculating the distance between them. If this distance is less than some threshold value (done so that there is some tolerance against positioning inaccuracies), then the score is updated, the item is set as 'hit' and a sound file is played. The items collected by the user simply disappear. A timer is used for two purposes. First, it is constantly updated in the display to provide feedback to the user. It is also used to decay the score for rewards mentioned above. This forces the user to collect the game tokens quickly.

The game has an interface which displays the score and time passed making the game more challenging and hence interesting. Fig. 8 shows that the game can be played with the AR reconstruction of the State Agora.

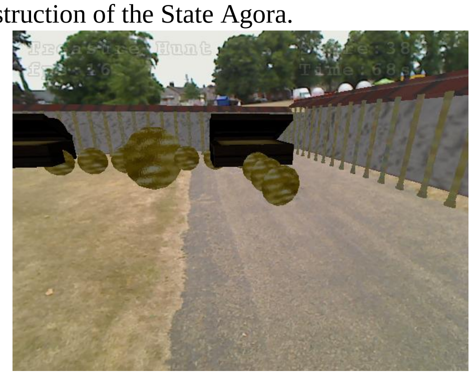

Fig. 8 A view of the game inside the agora

V. Planned Research

Considering and incorporating the ideas presented in this short paper, we are in the process of developing an AR system following the Total Augmentation paradigm described in the introduction. Fig. 9 presents the overview of the planned research in this regard

The system that will be developed will make use of mobile devices and drones along with smart glasses in order to offer the users a solid feel of presence in the ancient ages. The project will also have an educative side since information about the buildings will also be presented to the users as they walk through the reconstructions of the buildings.

Games such as the one shown in the previous section will make the user collect reward items and guide them to different parts of the site to discover. Drones controlled by the users will provide additional views of the heritage site and help the users locate themselves in the vicinity. Development of the AR helper characters is planned for the long term since this will require investigation of complex learning algorithms for providing customized feedback for each user.

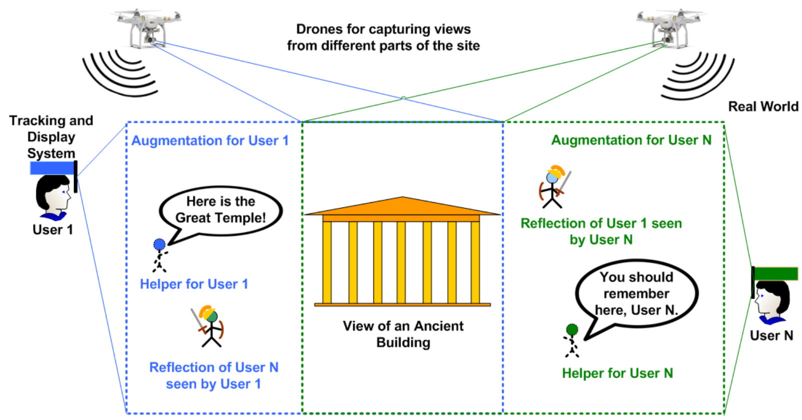

Fig. 9 Overview of the planned research

VI. Conclusion

Application of AR to cultural heritage is a fascinating research topic. It allows preserving the original building structures, already subject to wear and tear over hundreds of years, and more importantly provide an entertaining way of learning history by seeing the original building structures instead of ruins using games, interaction technologies and more.

Azuma stated in 1997 that AR tracking for outdoors in real-time with required accuracy is an open problem. Though more than a decade has passed after his statement, this problem still keeps its validity since AR requires high accuracy, low latency and low jitter. It is also known that there is a great need for a self-tracker that can be used in natural outdoor environments as well; however, a robust implementation of such a tracker was years away due to the challenges in finding robust features in natural environments.

The authors believe and work towards developing systems that using the current processing power of mobile systems or minicomputers (e.g. Raspberry Pi), techniques (e.g. multiple cores) and sophisticated algorithms making use of several sensors, and can confidently say we are much closer to seeing applications following the "Total Augmentation" paradigm.

In this regard, we are in the process of setting up a new lab in our department called SAAT (Turkish word for clock, also abbreviation for Sanal, Artırılmış ve Akıllı Teknolojiler: Virtual, Augmented and Intelligent Technologies). We are open to collaboration and welcome ideas for developing systems similar to the ones mentioned in this paper.

Acknowledgment

We have a TÜBİTAK project application under review for developing a system that will incorporate the ideas presented in this paper.

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