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ScienceDirect

Procedia Computer Science 25 (2013) 231 – 235

Procedia Computer Science

2013 International Conference on Virtual and Augmented Reality in Education

Applications of Multi-Touch Augmented Reality System in Education and Presentation of Virtual Heritage

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Abstract

Applications of augmented reality have a great immersion potential for education, edutainment or cultural heritage presentations. The combination of intuitive and playful interaction with multi-faceted presentation options proved to be an effective mixture that attracts viewers to educational or cultural content. We introduce a multi-touch augmented reality system (MARS) using two display units for showing two contexts of the same object(s). One of the displays serves as primary context and hosts a multi-touch surface for user input. The second display shows a camera feed of user interacting with the primary context and replaces the primary context in real-time by the secondary context and adds the augmented reality presentation of the object(s).

Selection and peer-review under responsibility of the programme committee of the 2013 International Conference on Virtual and Augmented Reality in Education

Keywords: augmented reality; multi-touch; education; virtual heritage;

1. Introduction

Augmented reality is an effective technology for combination of more contexts. In direct way it is the combination of context of camera images and the context of rendered objects blended with the correct spatial position. We can extend this by using another context. For this purpose, we need to have more than one display device.

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Selection and peer-review under responsibility of the programme committee of the 2013 International Conference on Virtual and Augmented Reality in Education
doi:10.1016/j.procs.2013.11.028

In our work, we use a multi-touch augmented reality system developed by our company for education and presentation of virtual heritage (digitized cultural heritage objects). We can use more contexts for presenting important spatial and temporal relationships between object like maps, buildings and any other 3D objects. Our multi-touch augmented reality system is used for interactive presentation and education in cases where two contexts help the understanding of spatial and/or temporal relations. We created an application for history education which combines historical maps as the primary context with 3D representation of historical buildings in the secondary context. This proved to improve the understanding of spatiotemporal relations. The users were able to observe the changes in 3D buildings as well as changes in the historical maps. In another application, we used our system for interactive presentation of cultural heritage. The primary context displays digitized archaeological sites. The secondary context shows the digital reconstruction of 3D objects contained within the site. These two contexts are linked in terms of touch-based spatial navigation (pan, rotate, zoom) and spatial changes in one contexts are transferred in real-time to the secondary context. Users operating our system reported a better understanding of the relations between displayed objects and the site as well as between different displayed objects.

2. Related work

The combination of augmented reality and multi-touch interaction has been experimented with previously. Benko et al. [1, 2] used to create an augmented reality system and explore the options of using gestures and touch to interact with the system. Head-mounted displays were also used by Dedual et al. [3], focusing mostly on the hardware/software solution. Collaborative cooperation on a multi-touch table top extended by mobile augmented reality was presented by Na et al. [4], again exploring mostly the technology of the devices. Wei et al. [5] created a system that uses a second display as a supplement to the table top touch display. Their solution is the closest to our, however, Wei et al. focus on a specific interior design application. At the same time, we rather explore the theoretical concept of our multi-touch augmented reality set-up and its immersion potential.

3. Multi-touch augmented reality system

Our proposed system – MARS (Multi-touch augmented reality system) [6] – consists of two displays and a camera as shown in Figure 1. One of the displays is a multi-touch table top display which creates the basic frame for user interaction. The camera records the user and the table he/she works with. Similarly to Krueger’s original Videoplace [7], the video feed is then mixed in a computer with the virtual object(s) and it is projected on the augmented reality display. (This may be a projection screen or a large flat-screen display.) The registration of the camera position relative to the scene is the vital part of the augmented reality system. The camera in MARS is placed in a static position and does not move. Neither does the virtual base, which in our case is the table display. This eliminates the need for real-time spatial registration as we know if from augmented reality on mobile devices or when the augmented reality marker is being moved in front of the camera. The recorded video feed is augmented by the rendered virtual object(s) which are aligned in 3D space to a virtual extrusion of the 2D space of the table display. The one disadvantage of recording the scene from behind the user’s back is the user obstructing the view of the table display. However, we devised a way to fix this by first recording a still image of the scene without the user present and then blending it with the recorded video.

The final video contains three layers: the recorded still image serves as the background layer. Then, the virtual object is rendered in the second layer. And finally, the recorded video containing the user is alpha-blended on top of them. This creates a ghost image of the user and the virtual object is visible at the same time as the users see themselves interacting with the table.

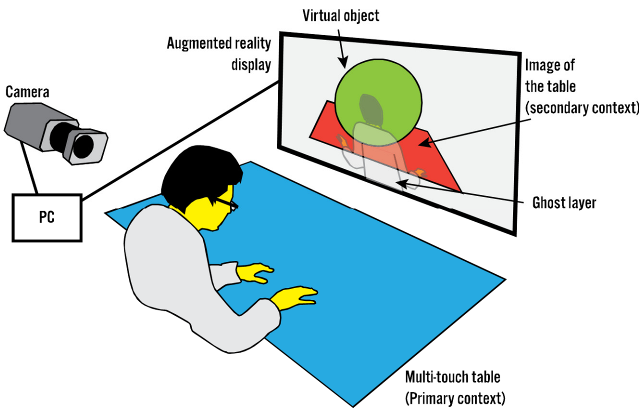

Fig. 1. Setup of Multi-touch augmented reality system

The dual-monitor set-up gives us an opportunity to present the virtual object in another context than what is displayed on the table top display. Figure 1 shows the original context in blue. The second context is displayed in the augmented reality display as a quadrilateral texture mapped to the space occupied by the original context. Figure 1 shows it in red.

4. Applications in education and presentation of cultural heritage

We use our MARS setup to enhance the quality of education process of history courses. Students have problems with finding connections between visual data like maps or images and their spatial and/or temporal relationships with the information read in text. We can help them by showing how the different maps (contexts) can be connected. In the first multi-touch display we show them actual (or historical map) and on the other display (vertical) we show them the enriched context with the 3D model. The final visualization is shown on Figure 2. In Figure 3, an example application containing basic assets for visualization of Topoľčany castle ruins is shown. This contains maps from different historical periods and the 3D model of the castle.

Fig. 2. Visualization of cultural heritage data using MARS system.
The content here is the historical old town of Bratislava.

Fig. 3. (a) Various maps for multi-touch display context, (b) real time rendered 3D model of Topoľčany castle. [8]

For the purpose of visualization of cultural heritage objects (mostly archaeological) we use another strategy. In the first context we can show to user the actual state of the object (e.g. broken vase) and in the second context we show its digital reconstruction. The advantage of this kind of visualization is that the user can manipulate with the digital objects by using natural gestures not only for basic transformations (translation, rotation, scale) and also for cutting objects or their decomposition into smaller parts (if possible).

5. Analysis and discussion

We used our solution for demonstration of the proposed methods of visualization. Our target audiences were high school students and museum professionals. We tested three various scenarios (two for each target group). The high school target group was provided with the following scenarios:

A. Maps with Topoľčany castle ruins
B. Bratislava historic monuments

Museum professionals were provided with the following scenarios:

C. 3D reconstructed vase with 360° photo
D. Bratislava historic monuments

We compared the satisfaction of the users with proposed visualization to traditional education and presentation. We used a survey with questions targeted to measure the quality of understanding of each scenario. The results of the survey were that for 85% users from target group A (high schools students) this kind of demonstration was clearer than traditional approach and they remember over 40% more information about spatial and temporal relationships compared to traditional methods. We also tested target group B (museum professionals). Their answers show that the quality of presentation of digitized objects is much clearer than the traditional approach (single screen presentation with keyboard and mouse input) and the gesture tools for object cutting and decomposition was highly recommended for future presentation of virtual 3D objects.

The biggest limitation of this kind of presentation is the hardware setup which requires appropriate space and might be costly for some. Therefore, this solution is recommended for museums or specialized educational institutions where the conditions are more suitable for this type of presentation.

6. Conclusion

We presented a presentation solution for virtual cultural heritage that uses augmented reality and a dual display setup to provide multiple contexts for the same scenario. This improves the understanding of spatio-temporal relationships and helps the students understand the topic. We tested our set-up on two sets of example data (Ruins of Topoľčany castle, Old town of Bratislava) and found out that the proposed solution is positively received by the audience.

Acknowledgements

This work was supported by the Slovak Research and Development Agency under the contract No. VMSP-II-0035-09.

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