Augmented Reality Interactive Storytelling Systems Using Tangible Cubes for Edutainment

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Abstract

Augmented Reality has been used in many areas and it has proved to be useful for storytelling. These systems are adequate for edutainment. In this paper, we present two Augmented Reality interactive storytelling systems that use tangible cubes. The first shows the story in only one face of the cube and the second presents the story in all visible faces of the cube. The progress of the story can be chosen using two different tangible interfaces. We have tested the systems with the children of the Summer School of the Technical University of Valencia. In these tests we have analysed if the use of a Head-Mounted Display or a typical monitor influence in the experience of the user. Results do not offer statistical significant differences using both visualization systems and confirm that children enjoyed playing with the systems.

1. Introduction

Augmented Reality (AR) has been used in many fields such as: military; medicine; engineering design; robotic; telerobotic; manufacturing, maintenance and repair applications; consumer design; learning; entertainment; edutainment; psychological treatments, etc. [1][2]. The term edutainment is a neologism, coined by Bob Heyman in the 60s, to point out the connections and the positive correlations between the Educational field and the Entertainment one. This term fits well with the topic of the Conference and it is where the work presented in this paper can be classified. Several works have already been presented for learning/entertainment such as: 1) Construct3D [3], an AR system for constructing 3D geometries. It was designed for learning mathematics and geometry. It was tested with students comparing traditional learning with the AR system. 2) An AR system for learning the relation between the earth and the sun for geography students has also been presented [4]. 3) Mixed Reality Lab of Singapore (www.mixedrealitylab.org) has developed several AR systems for learning and entertainment such as: an AR system for learning the sun system or an AR system for learning how the plants germinate, disperse, reproduce and perform photosynthesis. 4) Billinghurst et al. [5] presented the Magic Book as an example of application of ARToolKit. It seems like a normal book, but in the pages are markers, when the system recognizes a marker, an image is shown or a story starts. 5) Following this idea, but using a different interface, the Magic Story Cube was presented [6]. A cube is used as a tangible interface that is folded or unfolded and depending on the markers that are visible the story is different. In this case, the story of the Noah's ark was presented. With the same idea of a tangible interface using a folded/unfolded cube, we have developed the work presented in this paper.

2. Augmented Reality Interactive Storytelling systems

2.1. Hardware

The systems require a camera to capture the real world in order to determine where the virtual elements will exactly have to be drawn. We have used an USB color camera. To be exact a Logitech QuickCam Pro 4000 has been used. After processing the captured image, the systems obtain the real camera position and orientation relative to physical markers, and determine where the virtual elements have to be drawn. A Head-Mounted Display (HMD) was used as visualization system. We have used 5DT HMD (5DT Inc., 800 Hx600 V, High 40º FOV).

2.2. Software

We programmed the system using OsgART (http://www.artoolworks.com/community/osgart). It is a C++ library that allows developers to build AR applications using the rendering capabilities of Open Scene Graph (OSG) and the tracking and registration algorithms of ARToolKit.

OSG, http://www.openscenegraph.org, is a set of open source libraries that primarily provide scene management and graphics rendering optimization functionality to applications. It's written in portable ANSI C++ and uses the standard OpenGL low-level graphics API.

ARToolKit is an open source vision tracking library that enables the easy development of a wide range of AR applications. It was developed at Washington University by Kato and Billinghurst (http://www.hitl.washington.edu/artoolkit). The required elements for the application are: a USB or FireWire camera, and a marker. Markers are white squares with a black border inside of which are symbols or letter/s.

The virtual elements that appear in the system are videos of lions.

2.3. Description of the system

The system consists of an AR storytelling system for interactive stories where the children can choose how evolves the story and the end. In this system, a story based on the Lion King story was created. The story has 8 different ends and it is composed of videos of lions that allow the child to follow a modified Lion King story. The videos include audio with an invented narrative.

The system has two versions. The first version uses a typical cube where a different marker is placed over its 6 faces. In this version the story is shown over all visible faces. The way to choose the progress of the story is by using two different tangible interfaces. Both interfaces are independent to the cube. In both interfaces the selection of the progress of the story is achieved moving part of the user interface.

The second version uses a cube where the story is shown only over the front face. Moreover, the tangible interface is attached to the cube, that is, two small cubes are placed in opposite sides of the big cube. When the child has to choose one or another option (1/2), he has to raise the cube that is on the left or on the right of the big cube, respectively. Figure 1 shows an example of this second version.

Figure 1. Cube where the story is shown only in the front face. Tangible interface is attached to the cube

3. Study

The systems were tested for understanding: the degree of presence perceived by the children; the degree of involvement of the children; the perceived usefulness of the system; the application usability degree; and the usability of the related interface.

Other aspects to check are to determine which visualization system they prefer and if the order of exposure influence in their perception. In order to check these aspects the following tests were carried out.

<u>First test</u>. In this test, we checked if children prefer the HMD or if both visualization systems are perceived in a similar way. Moreover, we checked if children prefer the tangible interface or if both interaction systems (tangible interface and keyboard) are perceived in a similar way.

1. Children used a HMD as visualization system and used the tangible interface to interact with the system.
2. Children used a typical monitor as visualization system and used the computer keyboard to interact with the system.

<u>Second test</u>. In this test, in both cases, children used tangible interfaces to interact with the system, but the visualization system is different. In this test, we also checked if children prefer the HMD or if both visualization systems are perceived in a similar way. We also checked if children have similar perception of the two different tangible interfaces.

1. Children used a HMD for visualization.
2. Children used a monitor for visualization.

In the experiments, participants were counterbalanced, that is, half of the participants used first the 1) system and later the 2) and the other half used first the 2), and later the 1).

The two tests were carried out with children of the Summer School of the Technical University of Valencia. 44 children of age six to eight took part in the experiment. The children were divided into two groups of 22 participants for the two tests. The duration of the complete test was at about half an hour. After the exposure, children were asked to fill out a questionnaire. The questions used a scale of 5 (1-Completely disagree, 5-Completely Agree).

This paper only describes some characteristics of the systems and includes one question asked as example and it is the following: Q1: *Did you have fun playing with this system?*.

As it has already been said, we have checked if children prefer to use the HMD or the monitor in order to play with the system. For checking this, we took all the questions related with the HMD visualization system and with the Monitor. Results are presented in Table 1, second column where Student t (http://en.wikipedia.org/wiki/Student%27s_t-test) test was applied to the scores given to Q1. We supposed that the order in which the experience were lived had an influence over the children preferences. For checking this, children tested the application in an alternate way: twenty-two people tried first the HMD Visualization System then the Monitor and 22 people tried it in the opposite way. Results using first the HMD and later the monitor are shown in Table 1, third column. Results using first the Monitor and later the HMD are shown in Table 1, fourth column. In both cases Student t tests were applied to the scores given to Q1. The Student t tests have been performed with a confidence value of 95%.

From Table 1, it is possible to deduce that both visualization modes (HMD, monitor) have similar influence in children and the order does not affect their perception of the fun aspects of the system.

4. Conclusions

We have presented two AR interactive storytelling systems that use tangible cubes. This is an example of AR for edutainment. We have presented a playful version, but with slight modifications it can be used for learning for example the life of the lions. We have tested the systems with children of the Summer School of the Technical University of Valencia and we have presented some results. From results it is possible to deduce that children enjoyed playing with the systems and that they enjoyed the system did not matter if they were visualizing the story in the HMD or in a typical monitor. The order of exposure (HMD or monitor) did not affect the results.

Table 1. Results to Q1

	All users	HMD-Monitor	Monitor-HMD
HMD	4.9	4.9	4.9
Display	4.93	4.9	4.9
Stat t	0.39	0	0
Critical t (two leaves)	p < 1.99	p < 2.08	p < 2.08

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