iARBook: An Immersive Augmented Reality System for Education

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***Abstract*—The advancement in technology nowadays has improved learning methods that are beginning to override the traditional methods. Augmented Reality (AR) is one such technology that has seen many applications in education. This paper describes how an Immersive Augmented Reality (iAR) application in conjunction with a book, can act as a new smart learning method by engaging as many of the user's senses and human functions as possible. In addition, a survey was conducted on students and educators who have tested the application. The purpose of the survey is to study the effectiveness of the application in enhancing the user's learning experience and help to devise plans to improve the system.**

Keywords—Immersive Augmented Reality; Smart Education; Edutainment; Augmented Reality; Interactive Learning.

I. INTRODUCTION

Most AR applications targeting education nowadays are based on visuals and sounds. For an AR application to be immersive, it has to go a step further by providing stimulation for a number of other human senses and functions, not just sight and sound. One possible way of doing this is by allowing the iAR user to trigger some action using speech, touch and gesture controls. Immersive Reality with Augmented Reality is an effective way of enhancing the user's ability to learn because many of their senses work together to understand a topic. Biomedical students for example, can understand chemistry by being allowed to visualize 3D models of complex molecular structures that are superimposed on top of their chemistry textbooks. The students can then interact with these models by using certain gesture movements or speech commands. Augmented Reality on its own has been used for many purposes, even in education. The next part of this paper will bring up some pure applications of Immersive Reality, Augmented Reality, or a combination of both. A description of an iAR proof-of-concept project will then follow. This is accompanied by an evaluation of the project done through surveying students and educators who have used the application. The last part of this paper is a conclusion based on the survey results, and some discussion on the limitations of the current system, as well as the future work plans that will address these limitations.

The next section will shed light on some applications of Immersive Reality, Augmented Reality, or a combination of both Immersive and Augmented Reality.

II. RELATED WORK

A. An Immersive Dining Experience

A number of fine dining restaurants concentrate on the presentation of the dish, which often matches the theme of the restaurant. It has also become common for some restaurants to play piano music, which they believe, will allow the diners to have a better dining experience. All these methods are a form of Immersive Reality, and while seen by some as gimmicks, many people have reported that these methods do work in enhancing the taste of their dishes. To give an example, Chef Heston Blementhal supplemented an audio of recorded ocean sounds with his seafood dish, "Sounds of the Sea" [1]. The chef said that oysters tasted much stronger and saltier with the music. Another customer said: "It definitely adds to the experience – the whole thing sets your senses going."

B. Augmented Reality in Tourism

More than half of the available Augmented Reality applications on Google Play or App Store under the Travel and Tourism category [2]. Some of these Augmented Reality applications act as a virtual tour guide, where the application uses the smartphone's GPS to identify the tourist's location. Then, with the help of the smartphone's camera, the application supplements the real view of the world with markers and pointers that guide the tourist to the nearest landmark, restaurant, hotel and other places of interest [2]. Some applications can also use image processing in museums [3]. They identify the items displayed in the museum and display a textual description that is overlaid beside the actual item. Others can use image processing to identify historical landmark places supplement the real worldview with an older view of how that particular landmark used to look like in the past [4].

C. Augmented Reality in Toys and Video Games

Augmented Reality has become a notable marketing technique used by many toy companies to sell more of their products. Lego® for example, has installed an AR system consisting of a screen and a camera in some toy stores [6]. The kids can choose a Lego puzzle and show the package to the camera, which will then identify the puzzle and augment the assembled puzzle in 3D so that kids know how the toy would look like in the final stage. Another notable work that combines Immersive Reality and AR elements, and is perhaps

978-1-4799-7672-0/14/$31.00 ©2014 IEEE 08-10 December 2014, Wellington, New Zealand
2014 International Conference of Teaching, Assessment and Learning (TALE)

the closest to our work, is a video game owned by Nintendo®. The video game "Nintendogs + Cats" is a virtual pet simulation game where players could raise and care for different breeds of domestic animals [6]. The game runs on a portable device that contains a 3D camera. Its niche is its capability to utilize the handheld device's camera along with AR technology to augment a virtual pet onto an AR card. The kids can then interact with their pet using various controls and speech commands such as "sit" or "sleep". Fig. 1 shows a screenshot of the virtual pet augmented into the camera's view.

Fig. 1. Screenshot of virtual pet [6]

III. System Overview

iARBook is a research project which is part of the iCampus Initiative led by Etisalat BT Innovation Center (EBTIC) [7]. The project consists of Khalifa University's 4th issue "Reflections" newsletter [8] and a tablet or a smartphone with iARBook application installed. Therefore, the main AR system hardware comprises of an input sensor (camera), a processing unit and an output display which are all available in modern smartphones and tablets.

The software is composed of various image and target recognition components in the Unity3D engine. The system integrates Image Targets, Virtual Buttons and Cloud Recognition from Vuforia through the Unity3D extension. The architecture is shown in the block diagram in Fig. 2.

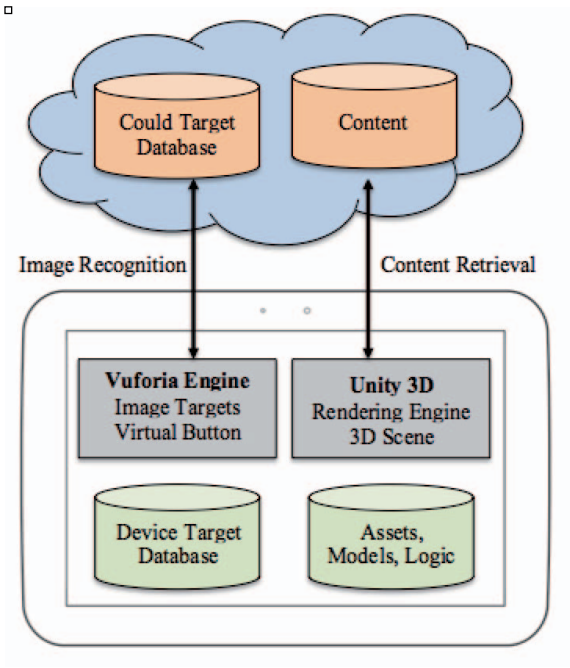

Fig. 2. System Block Diagram

The device begins capturing video input and passes it to the Vuforia engine, which in turn processes frames in real time to detect and track the images in the database. Moreover, it communicates with the cloud recognition service to recognize targets that are not defined in the device database. Once an image is recognized, the relative Unity scene is rendered over the video frame. Another interesting feature is the Virtual Button, which is a clickable area on the target that is triggered when the user places his hand on it. It is used to facilitate control options such as rotation and movement of objects in the 3D scene, allowing events to be triggered with basic natural interaction.

In Fig. 3, the newsletter is open and there is an article titled "Message From The President" with a picture of Khalifa University's president Dr. Tod Laursen. When viewed from the application, a screen is superimposed on top of the president's picture. The screen shows a video of him delivering the message.

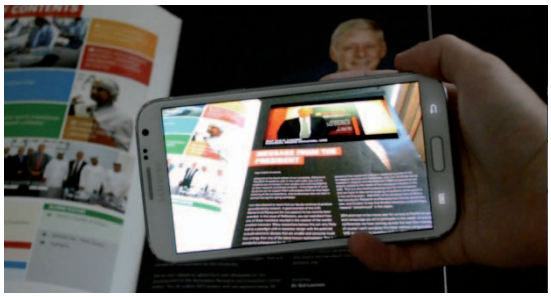

Fig. 3. Superimposed video on the newsletter page

In Fig. 4, there is an article about a training camp for kids interested in the field of medicine. When the user views the article with the application, a sound is played and a 3D DNA helix model appears along with a button. When the button is clicked, another sound is played and the DNA helix starts to spin. The user can make the DNA pause at any state by pressing the button again.

Fig. 4. Interactive Three-Dimensional DNA helix model

In Fig. 5, there is an article that speaks about historical engineering projects and there is a cartoony picture of the Leaning Pisa Tower. The app augments a 3D model of the Pisa tower that sits perpendicular to the image, leaning and implicitly prompting the user to topple it. The user can then interact with it by pushing it with their hand so that it topples and produces a crashing sound.

In Fig. 6, there is a paragraph that describes the color symbolism in the United Arab Emirates national flag. In the end of the paragraph is the source's hyperlink. When the user

clicks the hyperlink by touching the paper, the application detects that the virtual button has been covered and launches a webpage that takes the user to the source. In addition to the paragraph, there is a picture of a crowd of people standing circularly around a tall flag. When the camera detects the crowd, it superimposes a 3D jet that is colored similarly to the flag. When that happens, the UAE national anthem starts playing in the background and the jet starts performing aerial stunts. The jet's position is in the middle of the crowd, and at a good height from the picture. This gives a nice illusion that the crowd is enjoying an airshow.

Fig. 5. Leaning Tower of Pisa

Fig. 6. Interactive UAE national flag

In Fig. 7, speech functionality was implemented. The page is about a robotics competition, and there is a picture of a small robot in the corner. The app superimposes a 3D model of that robot, along with a button that prompts the user to touch it and speak something. When the user does, the robot starts moving and mimics the user's words in a robotic tune. Not only does this particular feature engage the human's speech function, it can also give information about how a particular object actually sounds like, which is something that cannot be fully described with printed text and pictures alone.

Fig. 7. Animated 3D speaking robot

Finally, the last page of the newsletter contains Facebook, Twitter, and YouTube social media icons with hyperlink of Khalifa University's account. When the user clicks on the icons on the page itself, the app takes the user to the respective social media website (See Fig. 8).

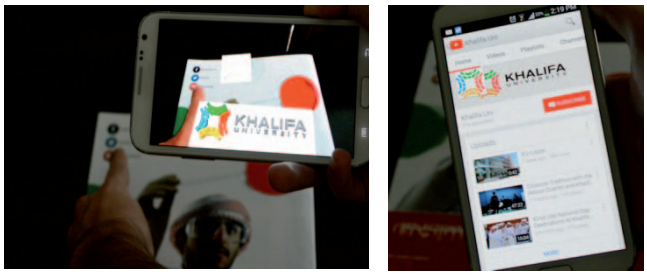

Fig. 8. Virtual Button activated social media hyperlinks

Another more immersive option for reading the newsletter is by using an immersive e-desk (shown in Fig. 9). While the desk takes away the portability trait of the system, it enables the user to use both hands for reading and interaction. Moreover, it provides an even more immersive experience with its massive curved screen, as well as surround sound as opposed to single sound source.

Fig. 9. Side view of immersive desk being used by a man

IV. Evaluation

To test the effectiveness of the system, 30 people who are either students or researchers, were invited to use the application, and were given a survey to fill afterwards. The survey consisted of a set of questionnaires that prompt the users to select whether they strongly agree (4 points), agree (3 points), are neutral (2 points), disagree (1 point) or strongly disagree (0 points) to the corresponding statement. The statements in the survey are categorized into 3 main sections. There is a pedagogical section, a user experience section and a technological section. They are discussed below.

A. The Pedagogical Section

This part of the survey focused on the pedagogy aspect. The section helps to find out if the users of the application believed that Augmented Reality technology could be useful in enhancing the traditional learning methods. It investigated if the users would be more interested in reading a book that is supplemented with iAR technology, whether this technology helps in the learning process, and whether it is more convenient to access linked resources using this technology.

B. The User Experience Section

The aim of this section is to get feedback that will help to develop that application further by improving its interactivity and making it more user-friendly. The statements in this section investigated if the users felt that the application was easy to use and navigate through.

C. The Technological Section

For this section, the primary focus was on the technological aspects of the project. Statements belonging to this section investigated whether the users felt that the application ran smoothly, was responsive to their inputs, and that the rendered visual were clearly observed, and that the sounds produced were clear and free of noise. This is important, as it will help to spot programming errors, inaccuracies in the renderer, and other minor bugs that prevent the application from functioning properly. All of these problems threaten to overshadow the iAR application's objective of developing new and entertaining pedagogical methods.

D. Overall Evaluation Summary

The overall feedback received was positive. The pedagogical section scored 77%, while the user experience and technological sections scored 83% and 82% respectively. The plot matrix in Fig. 10 shows the normalized results. Moreover, 85% of the users were satisfied with the overall experience.

Researchers mostly wrote positive and helpful comments in their surveys. One researcher commented: "Overall, I think Augmented Reality in books is an interesting idea. I would be interested to read any research you do on learner engagement or improved learning methods". Another researcher said: "Very nice idea. Great work. It would be interesting to investigate if there are prototypes with glasses in order to aid learning complex topics/ visualization".

Students who tested the system noted some interesting comments too. A senior student liked the idea and wrote down encouraging words. She said: "I highly recommend having such system distributed among the largest number of people due to its remarkable benefits". However, one student thought that the system should not be used for education. He said: "The application is fun and enjoyable but I do not think it is good for education. I was more focused on playing with the buttons and models and forgot to actually read the text".

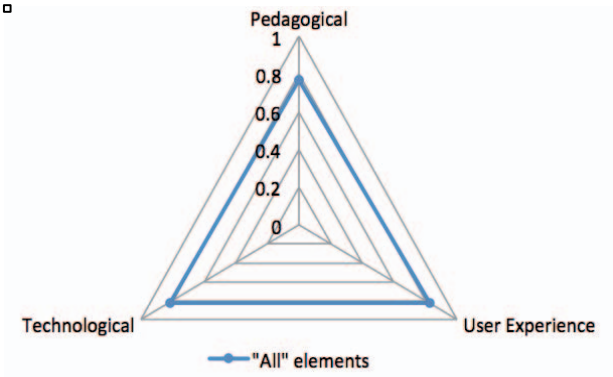

Fig 10. The Plot Matrix of the evaluation study

V. Conclusion and Future Work

This paper highlights some of the many uses of Immersive Reality, such as dining, tourism, and entertainment. The paper also introduces how the Immersive Reality technique, in combination with AR technology, can be used to enhance traditional pedagogical methods. As a proof of concept, a newsletter was taken and supplemented with animate 3D graphics, videos, sounds, gesture and speech controls, and finally the capability to access linked resources by a click of a button. It has also demonstrated how Immersive Reality can be taken a step further by using the system in conjunction with the immersive desk to get a hands-free experience. For evaluation, a group of students and teachers were invited to try the application and fill in a survey that would help in identifying whether the technology is effective or not. The results were fairly positive, and more than 85% were satisfied with the overall experience.

Some of the received comments were an eye opener for future work plans. Many have suggested that a hands-free system would function better. While the immersive desk does allow the use of both hands, it is certainly not portable and does not give the user the freedom to move the book around. To alleviate this, future revisions of iARBook may be used in conjunction with AR glasses such as Google Glass. The device is a lightweight, portable piece of hardware with a solid AR library [9]. Finally, we will try to be subtler with the design of the 3D models and animations. Otherwise, as one student noted, over exaggerating with features might defeat the purpose of the system.

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