Enhanced Interactive Learning usingAugmented Reality

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Abstract—*In the field of education, the need of combining learning with enjoyment can never be underestimated. In order to accomplish these goals, educational applications are widely being developedespecially for smart phones. Most of these applications, however provide a total virtual environment. Such an environmentlacks interactivity and providesa rigid learning experience. Augmented Reality (AR) can bridge the gap between virtual and real world thus providing a more natural and interactive learning experience. The main objective of this research work is to investigate the potential of AR to enhance the effectiveness of early learning experiences of children. Using AR technology, an interactive mobile application is developed to provide children aninnovative learning environmentfor basic concepts and skills development. The application engages children to complete simple tasks and interconnects a story with the tasks to gain and retain their interest. Currently, the tasks include English and Urdu alphabets and numeric digitsrecognition. The application, called* ***Interactive Characters****, is intended to be a platform for the further development of interactive and effective educational mobile applications with visually attractive augmented interface elements.*

I. INTRODUCTION

Augmented Reality (AR) is one of the most promising technologies which are expected to take over in the near future. Augmented reality provides realistic visualization of contents by superimposing them on the real world [1]. Itaugments user perception and interaction of the real world. The virtual elements display information that users can not directly detect with their own senses [2]. AR has inspired many applications for entertainment, education, navigation, advertisement, medical and industrial sector. Recently, AR has become very popular in the mobile application market due to widespread use of smart handheld devices [3].The most attractive aspect of AR is that the virtual content is blended or superimposed in the real world environment.AR systems allownatural and close to the real world interaction experience, taking advantage of the enhanced information storage, processing and accesscapabilitiesof the computers.

The main motivation behind this research work is to explore the educational use ofARby developing a smart phone application to help the children in learning English and Urdu alphabets and numbers. While viewing the images through the application, the children see 3D augmented content which contains the alphabet and an object related to the alphabet (e.g. Applefor alphabet A, an Insect for alphabet I etc.). An augmented button is displayed to select the correct alphabet.The application was further expanded by developing a Solar system revolving model to demonstrate the usability of ARto elaborate complexconcepts and experiments.

The next section provides a review of basic AR concepts followed by a detailed discussion of AR educational applications. Section IVdescribes the problem and highlights the research objectives, section V outlines the research methodology and application design, section VI discusses the problems encounteredduring applicationtesting and their solutions.Finally, section VII provides conclusion.

II. AUGMENTED REALITY

AR is used for overlaying virtual information on the top of real world to enhance the realism and impressiveness of an application. AR is the combination of physical spaces with digital spaces in semantically linked contexts for which the objects of associations lie in the real world [4].Besides adding objects to a real environment, AR also has the potential to remove them [5]. AR is capable of addressing the challenges of virtual reality (VR) by superimposing virtual objects onto the physical world, in which the users can interact with virtual and real objects directly [6]. Three main characteristics of ARare: it is a combination of real and virtual, it has real-time interactivity, and it has three-dimensions [7]. AR is essentially a crossover between the real and virtual world, as demonstrated by Paul Milgram's [8]well-knownReality-Virtuality (RV) continuum diagram shown below:

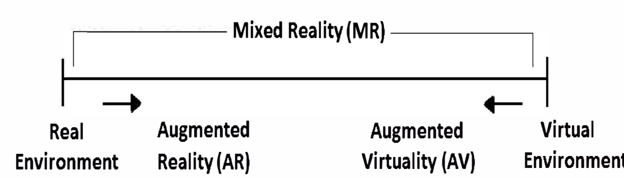

Fig.1. The RV continuum [8]

There are mainly two types of AR: Marker-less and Marker- based. Marker-less AR is further divided into Marker-less vision based and Marker-less GPS based. Marker-less vision based augmentation is used in real time applications. The augmented content is placed after image based recognition and analysis. The offside marking technology in football is one of the prominent implementations of this technique. Marker-less GPS based AR uses the Global Positioning System (GPS) or digital compass feature of mobile devices to locate and interact with surroundings. The information gathered is then

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superimposed on the camera view of the mobile device providing enhanced view of the environment to the user. Marker-based AR relies on a marker which is usually a Quick Response (QR) code. Recently, technology to deal with pictures has also been developed [9]. The device camera is used to gather information about the QR code or the picture which is then analyzed and the model or information related to it is displayed.

Augmentation is mainly used in two ways:first is to augment the user to obtain information about the physical objects, the user carries a device. Second is to augment the environment which surrounds the user and the object.In this type of augmentation neither the user nor the object is affected directly. Instead, independent devices provide and gather information from the surrounding environment, displaying information onto objects and capturing information about the user's interactions [10].

The interesting and interactive nature of AR technology makes it an attractive choice for a wide range of potential applications in the field of medicine, manufacturing, urban planning, architecture, archaeology, education and many more [11, 12]. Some of the broad domains in which effective AR applications have been implemented are discussed below:

- *Education*: AR for education has emerged to provide interactive augmented contents to the learner, and with the availability of portable devices with cameras and wireless technology this content can be easily accessed providing more in depth view of complex visualize able concepts.
- *Advertisement and Marketing*: Marker-based AR is being extensively used for presenting virtual products to the customers. In this way, the customers can get more detailed information about the product they are buying.
- *Travel and Tourism*: Location based AR services can providethe user with the information about their vicinity on the camera view of their screen. In the near future,this technology can be utilized to encapsulate everyday real world interactions [13]. Some of the other applications provide translation facilities for the written text.
- *Entertainment*: Innovation brought by the AR in field of games is revolutionary. It brings the gaming environment into the real world (out of the virtual world).
- *Medical*: The AR technology has unexploited potential in medical.It can be exploited to improve medical surgical procedures by assisting surgeons with navigation and orientation before, during, and after surgery and hence improving the safety, and efficiency. Doctors and nurses can also benefit from important information being delivered directly to their devices [14].

III. AUGMENTED REALITY EDUCATIONAL APPLICATIONS

Augmented reality can be used to teach students especially young children the concepts which are imaginary and are difficult to understand. Studies have shown that using AR for educational purposes can affect students at a deeper level by promoting both engagement and motivation [12]. Due to innovations in the mobile technology and the presence of variety of mobile platforms, it is now possible to integrateARtechnology in mobiles. The augmented learning books with 3D models, pictures and voiceovers provide a compelling learning experience. These augmented booksare highly interactive and can be played around with.In science subjects, such books can providea more visually understandable view of complex concepts as studentscan simply rotate the marker to see different views.Augmented reality in educational environment is further subdivided into following categories:

A. Training

AR training applications provide systematic instructions to guide user through completing a complex task.The virtual information helps them to identify targets and improve decision making. Most systems employ a head mounted display so that user's hands are free to perform taskssuch as the BMW workshop application [14].

B. Discovery based learning

In discovery based learning users find their own route to achieve learning objectives and enhance the learning experience by accessing virtual information at their own initiative.For example, Google'sSkyMap application[16] allows the user to discover and browse the sky by simply pointing the phone to space.

C. Augmented exploration

There are archaeological augmented reality experiences that offer user to discover the history of the landscape, buildings and environment during field trips. One such example of AR is to create situated documentaries about historic events [17].ArcheoGuide application [18] offers augmented reality tours in archaeological sites. The system allows the user to participate in personalized tours inside the cultural heritage site and provides audio-visual information on the ruins of the site.

D. Augmented books

The blending of enjoyment with learning is extremely valuable. Complex as it may be to achieve but pays of richly in user learning experience when achieved. In these books, the AR pop-up object is intended to enhance children's engagement. The learning is deepenedas AR provides an interactive and enjoyable experience. The EyeMagic children's book can be read like any 'normal' picture book, however when you look at the pages through a handheld visor, they are replaced with fully animated characters acting out the story in a virtual environment [19].

IV. PROBLEM DESCRIPTION

Most of the existing mobile educational applications are totally virtual in nature, thus, giving users a constrained learning environment.In such an environment, it is difficult to gain and maintain user interest for a long time.Most applications rely on computer graphics which provides a rigid and unrealistic experience.AR places the virtual content in the real world space rather than the digital space, in the course of action providing a realistic experience that is in the context of the user which he/she can relate to.

In order to help teachers and parents to impart basic alphabets and numbers recognition skills to children,an interactive andattractive augmented learning book is to be developed with the followingspecific learning objectives:

- Development of basic learning skills
- Teaching of English and Urdu alphabets and numbers recognition.
- Learning through realistic models of objects related to alphabets and numbers.
- Teaching children the phonicssound of alphabets.
- Verify the learning as a sequence of simple tasks.

The intended users of this application are children (aged between 3-5 years), hence, parental or teachers' assistance is required for an effective learning experience. Designing an educational mobile application for young children by blendingeducation and entertainmentis a challenging task because of the conflicting requirements of the two fields. The main design factors considered were: the application should beeasy and fun to use, the application should also be realistic so as to enhance the effectiveness and impressiveness of learning experience, moreover, the applicationneeds to be highly interactive to gain and retain young children's interest and engagement in the learning process.

V. RESEARCH METHODOLOGY

The main focus of the research is to investigate and accomplish the tasks that are the core part of any AR system which deals with marker based augmentation for the designing of an interactive learning system. These tasks include:

- Reading the target pattern through the device camera.
- Selection of correct animation/image corresponding to the target pattern.
- Presenting animation/image task to the user.
- Information retrieval from the user in the form of virtual buttons corresponding to the augmented scene.
- Displaying successful and unsuccessful information according to the user interaction.

A. System Overview

The conceptual view of application is shown in Fig. 2. The application uses the camera resource and gathers target pattern data by scanning the environment in the view of camera. The target pattern data will be used for virtual world creation which will make use of animations and virtual buttons placement databases. Virtual world creation will pass its input to the renderer to be displayed on screen. Input from the screen will then result in reconstruction of virtual world.

B. System Implementation

Device camera is used to capture the real world frames. Camera frames are then converted into pixel format which is passed to the tracker. Tracker deals with three main areas of implementation:tracking image targets, tracking multipletargets and tracking virtual buttons.After this, new target patterns are detected or already detected patterns are tracked. To handle and evaluate virtual buttons,the input from tracker is used to develop virtual world state object which uses the converted pixel frame and added virtual objects. The virtual world state object is then passed to the application and the renderer. The renderer displays the augmented virtual world on the device. The application uses the virtual world state objects to keep track of user inputs(actions).

C. Tools and Technology

Vuforia [19] platform served as the base for the augmentation in our application.Vuforia provides a complete package for mobile augmentation with libraries to detect and track image targets and to visualize the rendering in the camera view. Moreover, it also supports a variety of tools for designing,modelling and picture editing. Urdu language characters were designed using Illustrator.Mayawas used to create animations of alphabets and 3D objects. Dot net Perl was used to a run the script that converts 3D models to vertices array which are then used for rendering augmentations.

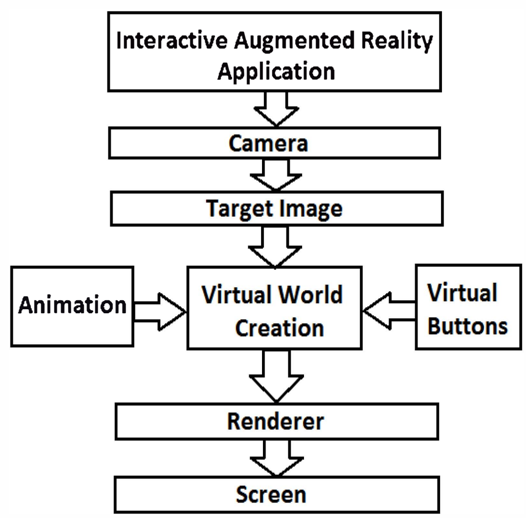

Fig. 2. The conceptual view of application

VI. DISCUSSION

The application was successfully tested on device having 1GB RAM, 8GB storage memory and 3.15MP camera to detect target images. Device was running on Android Operating v4.1.2 (Jellybeans). Some of the problems encountered during the testing phase are outlined in the following.

The system was designed to detect target images that contain only the letters and the words with a blank background. In the first testing phase, the rendered animations fluctuated as the images to be detected have large portion with no detectable features. This was countered by using different high feature backgrounds in the target images.Thisgreatly improved the stability of the rendered animations,however, it reduced the clarity of the rendered images as the augmented view of the animations was blended with the background.One possible solution of the above mentioned problems was that the images have to be designed in such a way that they provide many features using only the letters and the word so even though that a large portion will be blank, it will have enough features in the rest to render stable animation. The images designed for the final version of the system included the letters that had blank holes, prominent curves and extra edges. The final testing of the applicationdemonstrated the animations to be stable and clear due to blank space.

Also, during the initial testing phase, it was detected that if the images were changed quickly the application stops the current sound and plays the new sound corresponding to the animation.This problem was removed so that the application completes the previous sound before moving onto the next sound according to the detected image. The application was also put to stress testing by changing the images rapidly.It was found that no matter howfast the images were changed, if the images come in full view of the camera the application was able to detect and render the animation successfully.

Fig. 3 shows the main menu with three buttons: ‘Start’, ‘How to use’ and ‘Info’. Pressing the ‘start’ button begins the application to start detection of images and subsequently perform the augmentation. The ‘How to use’ button shows instructions to run the application and the ‘Info’ button shows the key functionality of the application.

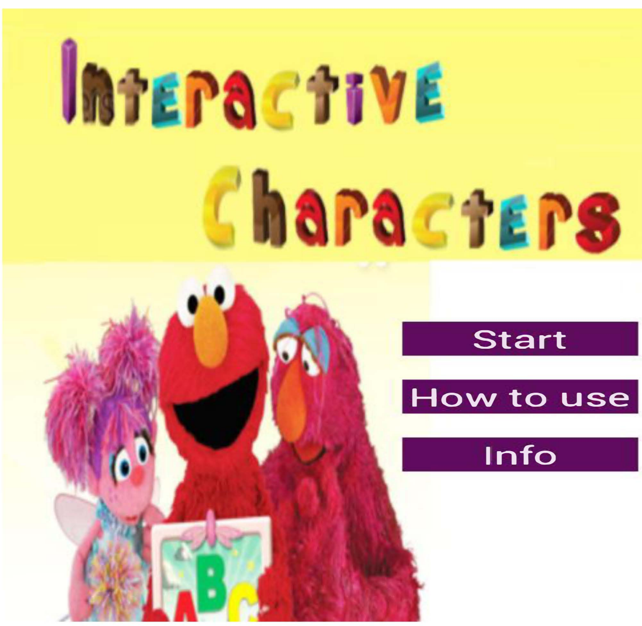

Fig. 3. Application’s main menu

Fig.4 shows the augmentation of alphabets, corresponding model and an augmented button on the target image. It demonstrates learning imparted to the children by showing augmented characters E, e, Earth and the 3D model of Earth with a button to take user to the task corresponding to the current characters. The task screen (Fig. 5) augments a task in which the children have to select the correct alphabet which has been learned. Augmented buttons are placed below each alphabet to select it as the answer.

Fig. 4. Augmented animation on target image

Fig. 5. Task augmentation

Fig. 6 shows the augmentation of image alongside 3D Urdu language characters. Fig. 7 shows the revolving augmentation of the Solar system containing the sun at the center and the nine planets revolving around it.

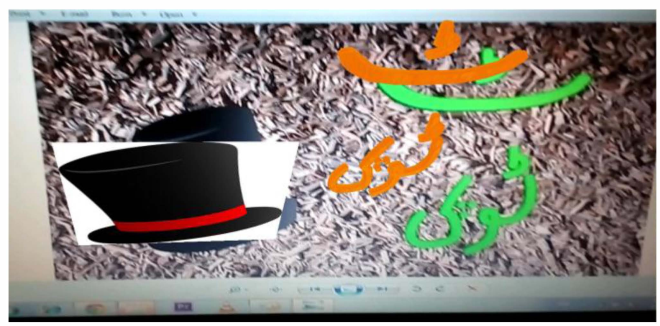
Fig. 6. Urdu alphabets with related image augmentation

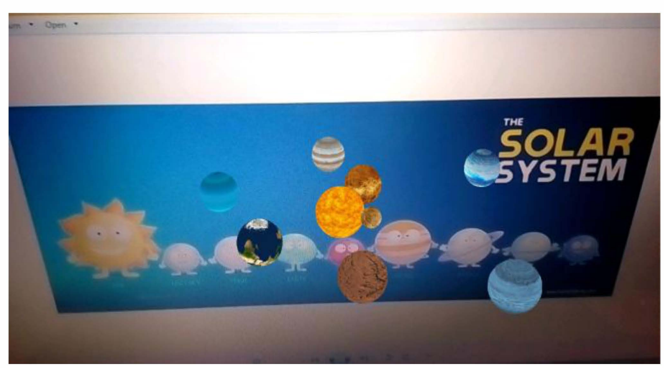

Fig. 7. Revolving Solar system augmentation

VII. CONCLUSION

AR is an interesting and exciting field with a wide range of potential applications.AR in education has a major benefit above other traditional methods of learning as it provides a more innovative and interactive learning experience.The main contribution of this study is to explore both the opportunities and challenges of integrating AR with the mobile technology to enhance early learning experience of children. This work explores the use of AR for educational purposes and describes design and implementationof aninteractive AR basedlearning book for teaching basic alphabets and numbers to children in a fun and engaging manner.Currently, the application supports English and Urdu alphabets and numeric digits recognition. In future, the application can be extended to incorporate complex concepts building capabilities. The applicationalso needs to be evaluated with the users (students and teachers) so as to understand the real potential of this new technology in practice.Furthermore, the use and implementation of AR in the higher education domain especially for science and engineering students can also be explored. Further research is also required on dynamic animation loading and retrieving models from the cloud hosted databases.

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