An Educational Augmented Reality App
To Facilitate Learning Experience

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Abstract— **Augmented Reality is changing education in a dramatic way and it brings a new dimension to teaching and learning practices through amazing visualization of the real world in an interactive environment. The aim of this research is focused at developing a prototype of mobile based Augmented Reality application using Vuforia and Unity which will be helpful and valuable for students in reinforcing their learning experience. Responses from students indicate that this application is very beneficial to improve their learning curiosity and their passion to learn.**

Keywords—Augmented Reality; Unity; Vuforia; Learning experience

I. INTRODUCTION

Augmenting a real world had been unimaginable, decades back. Perhaps, the technical advancements and interventions in the field of computer science brought out one of the most fascinating concept of Augmented Reality (AR) in the recent years that allows the overlay of graphical simulations into a real environment [1]. The two categories of AR presently available to educationalists include (i) location aware based and (ii) vision based [2]. The former uses smart phone with GPS-enabled so as to get augmented physical surroundings with a relevant information. For instance, National Bank of Oman introduced an AR app enabling their customers to locate nearest bank / ATM [3]. On the other hand, vision based AR technology presents 3D visualization of 2D target images after the mobile device's camera is pointed at the image target. The proposed prototype is based on the latter technology.

Unlike Virtual Reality that replaces the real world to a virtual environment, AR just supplements reality to the real objects. AR can be conceptualized from diverse angles of characteristics including 3D visualization of objects, real-time user interaction and combine real and virtual environment [4]. Several display devices: head-mounted display, desktop, handheld devices and overhead projector are used as display metaphors for AR modeling [5]. One of the design requirements of AR is in choosing appropriate device for the display. However the selection process is based on the application intended to be developed.

AR technology is becoming ubiquitous in nature and has been found to be widely used in several areas including military, marketing, manufacturing, healthcare, banking, tourism, entertainment, social networks and so on [6]. However, this technology finds its applications in education too. AR in Curriculum Design, Classroom teaching and learning strategies, User experience design for learners and educators are becoming very popular in the current educational scenario. Current generation students who are best known as digital natives are so comfortable and ease at using technology; hence utilizing AR technology in the learning process certainly enhances enthusiasm, excitement and entertainment to their learning activities. Educational technology research confirms that AR in educational settings has several benefits: Improved motivation, satisfaction, concentration, interaction, presentation, creativity, student-centric learning, collaborative learning and retention of knowledge [7]. Outcomes of follow-up activities conducted after AR exercise reveals the immense influence of integrating AR experience in education [8].

Fig. 1.   A glimpse of 3D visualization of a 2D earth in an Encyclopedia.

II. LITERATURE REVIEW

The potential of AR in educational filed is progressing at a rapid pace: a boon for digital natives to improve learning curiosity, develop creativity and a passion for learning. AR has brought out a new dimension to the pedagogical approaches in Teaching and Learning and adds a layer to enjoy learning. This

interdisciplinary research has created innovative prospects in facilitating the quality of teaching and learning practices [9].

Fig. 2.   2D skeletal images perceived as 3D through the app in Android phone

Research conducted on educational AR is quite enormous in the recent years. A substantial improvement in students' understanding on several aspects of Geography including rotation, revolution, temperature variations had been witnessed with an AR exercise [10]. Flexibility of AR technology and its possibilities to integrate within teaching and learning contexts has been successfully demonstrated with quite a few AR based learning contents developed for an Engineering course [11].

Successful educators always look forward to adopt innovative teaching practices to improve students' learning experiences and enhance student engagement in classrooms. A summary of success stories presented is worth confirming the potential of using Mobile AR in education. This study involves Mobile AR app (based on games and simulations) developed for various topics of subjects including History, Science, Maths and Literature. The participants included elementary level, middle aged, high school, university level and students with disabilities. Overall, these studies conducted between 2006 and 2012 showed a positive impact in improving the participants' understanding on complex concepts, motivating students to make learning enjoyable, engaging students to a maximum in classrooms and obtain better results [9].

A study on the use of interactive AR for collaborative interactive learning environments is discussed in [12]. A prototype of AR system particularly for Computing courses of Higher Education has been developed incorporating several multimedia information comprising video, audio, 3D models and text to provide a better student-friendly environment.

A review presented on AR in educational field discusses its features, benefits, effectiveness, implications, trends and vision towards the opportunities of AR in educational settings. The concluding remarks drawn from the current state of the art applications amongst SSCI-indexed journals published during 2011-2016, expects high scope and better prospects in superimposing AR concepts to educational field [13].

A more systematic and extensive review has been carried out based on the publications during 2003-2016. This review not only considers answering research questions based on the factors discussed in [13] but also addresses the limitations and challenges of AR in educational settings. Moreover, the authors investigated if preferences of special needs children and adaptive / personalized processes have been considered while designing AR applications [14]. Overall the research findings presented are beneficial to proceed for further research in this educational technology field.

Has AR paved a way to make something impossible possible? It is worth to quote "Augmented Reality brings dinosaurs and planets to life" [15] proposing entire solar system in Augmented Reality or augmenting a dinosaur roaring in front of anyone through a smart phone. Very recently, Microsoft tech reveals their new launch: "Microsoft is building an Augmented Reality viewer directly into Windows 10" [16] which is expected to be released by the end of this year that allows the contents created in 3D paint to augment 3D objects by Windows 10 users, using a laptop with an integrated webcam. The publisher Pearson Education in association with a few organizations is proud to be pioneers in developing innovative and extensive pedagogical approaches in teaching and learning that gives an extremely amazing 3D visualization of objects through virtual, augmented and mixed reality thereby creating a fantastic curriculum for school and university level [16] [17]. The scope of AR technology is far beyond imagination. Undoubtedly, the next evolution of learning lies in Augmented and Mixed Reality.
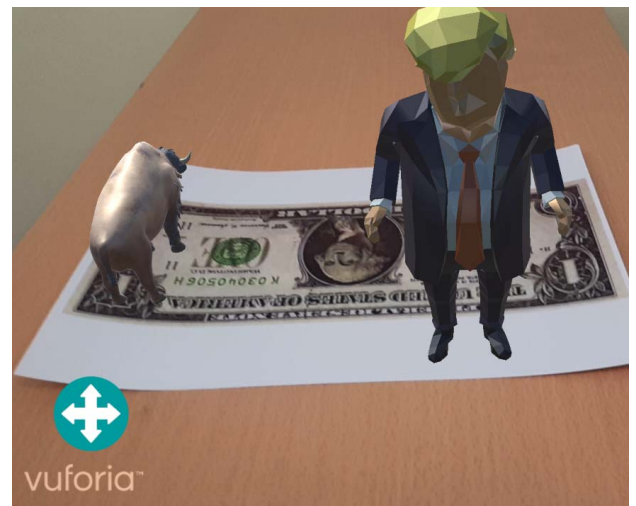

Fig. 3. 3D view of objects (Trump and Bison) related to US when 1USD is the image target

III. DESIGN METHODOLOGY

AR prototype design has to be viewed from three aspects: hardware, software and the contents [5]. With respect to the hardware, which device suits for one's prototype design is a major concern. Moreover, the choice of device is crucial as the software and contents are fully dependent on the hardware.

Android based smart phone is chosen for this prototype development. Open source software: Vuforia SDK has been used to build Android app for smart phone. App has been built

with Unity [18]. Free 3D images available in Unity and [19] are utilized in the development.

Vuforia kit comes with fabulous benefits: open source, easy to work and stunning opportunities for mobile app development in AR. Creating database and image target is an essential ingredient to create AR interface. Integrating Vuforia with Unity3D creates a new project. One of the core steps includes importing the Vuforia-Unity package and the database with target images. Necessary configuration has been done for AR animation.

In the development environment, Vuforia Smart Terrain offers an easy-to-use representation of the physical setting to the designers. It also provides surfaces analogous to a scene graph, however intended for AR model development. This dynamically created scene graph includes objects well-defined by a designer. The objects and surfaces recreated from the setting are also included in the scene graph. This facility is a real boon to developers as it provides freedom for developers to incorporate creativity, build experiences controlled by objects and interact with the environment.

Implementing the movement of objects has also been explored. This resulted in simulating a joystick to interact with the object by moving in all directions for which coding is done in C#.

The prototype of applications based on Augmented Reality has been created using Unity and Vuforia [20]. This facilitated the visualization of images from flat 2D to interactive 3D thereby learning is made fun, interesting and informative.

IV. DISCUSSION

A. Results

The opportunities and potential of Augmented Reality applications in educational field have been explored extensively. Sample outputs of the app developed are depicted in fig. 1 and fig. 2. The 3D views clearly exemplify how the app installed in the smart phone could turn a regular text book image into a 3D learning version. Moreover a unique feature integrated in our app is illustrated in fig. 3 and fig. 4. For instance, when the smartphone's camera is pointed towards 1 US Dollar through the app, objects related to United States such as Donald Trump, the President and Bison, the National animal are displayed on the image target. Similarly, Tiger, the National animal of India is displayed on the image target, 100 Rupees. This gives an unforgettable experience to students when they are expected to memorize and recollect certain facts related to an entity.

Results of an informal survey conducted among the students at secondary and higher secondary level reveal that the app supplements the learning experience in a big way. One of the participants expressed that it made him feel and conceive new ideas and would love to have it for all concepts he learns in all subjects. A teacher commented that "a perfect app for the digital natives; helps improving their imagination and understanding to a great extent".

B. Applications

The most interesting and valuable applications of this mobile app utilizing AR technology is in making the textbooks "alive" through augmenting images in real life just by pointing the objects in text books using a camera in smart phone. An AR edition of a text book with dynamic contents would be advantageous as it helps students visualize and interact with 3D models of structures/objects thereby making textbooks more user-friendly. This can be used for heterogeneous levels of study ranging from school to higher education to perform spatial engineering tasks. On the whole, AR technology facilitates students' learning experience in a rich manner. Moreover it enhances the capability to memorize, recall and organize their thoughts and ideas collectively. Game-based applications in education using AR technology is also in the forefront. AR based games have been developed as a therapy for autism disorder where the AR concepts have been utilized to improve the concentration and imagination of autistic children [21].

Fig. 4. App displaying 3D view of an object (Tiger) related to India when 100 Rupees is the image target.

C. Limitations

One of the major limitations encountered during the implementation owe to the unavailability of free 3D models; thereby creating educational contents becomes challenging. At times, the hardware configuration of the computer challenges the idea to be implemented completely. Improvement in hardware specification will definitely help creating novel applications [22].

V. CONCLUSION

A technology valuable to education that provides life long, active, creative and valuable learning experience has been explored that allows users to learn the educational contents by relating with real world more informatively. The app has been created to ensure that it is pedagogically meaningful in all aspects of learning. A traditional text book with hi-tech features is amazing with multimedia capability; enriching students' learning experience through the magical transformation of 2D pictures to a 3D perspective. In addition, the mobile app prototype provides a memorable and novel learning experience of recollecting facts associated with an entity by the unique feature incorporated in the prototype. However, it is expected that further research in Multimedia technology would help in developing a full-fledged application in future.

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