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Future Generation Education on Augmented Reality

K. Ganesh Kumar

Dept. of Computer Applications, Sadakathullah Appa College, Tirunelveli, India

Corresponding Author: ganeshkumar.tsm@gmail.com

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Abstract— Educator says that the learning process should be all about creativity and interaction. While teachers do not necessarily need to recruit all students into subject, their goal is to get them interested in a subject. Augmented Reality technology has the potential to blend both real and virtual environment to create an enhanced learning experience. Besides compared to paper-based solutions and conventional mobile applications, AR book system with scaffolding models they developed could help students to learn, particularly those with low reading ability. Objective of this paper is to highlight the applications and opportunities of research on AR applications in education.

Keywords— Augmented Reality, Education, Learning, Marker based.

I. INTRODUCTION

As we know that Traditional methods of education are becoming a thing of the past. They are becoming increasingly modernized, and being driven by technology innovations..

Several educational studies have endeavoured to explore what role Augmented Reality (AR), a technique of blending virtual information with the physical environment for presentation in real time, plays in learning. AR has an ability to render objects that are hard to imagine and turn them into 3D models. This will make easier to grasp the abstract and difficult content, which is especially good for visual learners and practically anyone to translate theoretical material into a real concept.

In AR, there are large amount of the investment undertaken by the technology industry and is indicated as one of the important developments taking place over the next few years.

This study may motivate researchers focus on future AR related applications, role and challenges of AR in the field of educations. In this paper section II concentrate on Augmented Reality and its components, section III, section IV

II.AUGMENTED REALITY

A. How does it mean?

In early 1990s before the term `augmented reality' was coined by Caudell and Mizell [37], scientists at Boeing Corporation who were developing an experimental AR system to help workers put together wiring harnesses.

On the reality-virtuality continuum by Milgram and Kishino [21], Augmented Reality (AR) is one part of the general area of mixed reality, which put together both virtual reality and augmented virtuality. In AR real objects are added to virtual ones; replace the surrounding environment by a virtual one. In contrast, AR provides local virtuality.

Fig. 1. Tthe reality-virtuality continuum by Milgram

Not just artificiality but also considering user transportation, Benford et al. [32] classify AR as separate from both VR and telepresence (see Figure 2).

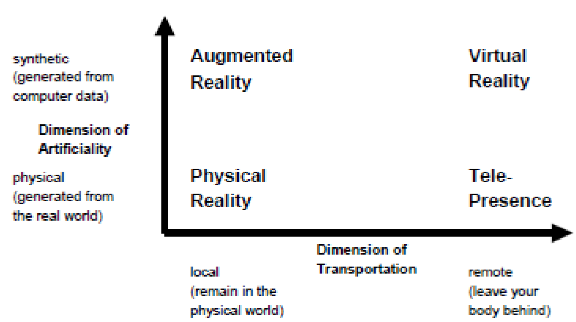

Fig.2. classification of shared space according to transportation and Artificiality

Definitions by Azuma [27, 28], AR system as follows:

- Merge real and virtual objects in a real environment;
- Register both real and virtual objects with each other
- runs interactively, in multi dimensions, and in real time.

Loomis et al. [12] developed a GPS-based outdoor system that presents navigational assistance to the visually impaired with spatial audio overlays. Rapidly computing and tracking devices became adequately powerful and small enough to support graphical overlay in mobile settings.

B. Mobile Augmented Reality

All through the last decade, Mobile Augmented Reality (MAR) attracted interest from both industry and academia. MAR enhance the real world of a mobile user with computer generated virtual contents.

Mobile technology development in sensors, computational resources, built-in cameras and mobile cloud computing have made AR possible on mobile devices.

Mobile computing, mobile cloud computing, scenery understanding, computer vision and device to device communications have enabled new user experiences that enhance the way we acquire, interact and display information within the world that surrounds us.

Through this, we are now able to blend information from our senses and mobile devices in myriad ways that were not possible before.

By considering all the definitions from Renevier et al. [23] and Karimi et al. [9], we can conclude that MAR:

- Merge real and virtual objects in a real environment;
- Register both real and virtual objects with each other
- runs interactively, in multi dimensions, and in real time.
- runs and displays the augmented view on a mobile device.

Many case specific MAR applications have been developed in the areas of tourism and culture and education while there is currently huge interest in MAR games.

Fig. 3. variants of MAR

Because of its mobile nature, most MAR applications tend to run on mobile/wearable devices, such as smart glasses, smartphones, tablets, or even in some cases laptops. A mobile application can be categorised as a MAR application if it has the following characteristics:

Input: considers the sensors of the device (such as camera, gyroscope, microphone, GPS) and any companion device.

Processing: determines the type of information to render in the screen of the mobile device and accessibility of stored locally in the device or in a remote database.

Output: projects output to the screen of the mobile device together with the current view of the user.

1) Display

a) Optical See-Through Display

Virtual contents are projected onto interface to optically mix with real scene in optical see-through display. Semi-transparent and semi-reflexive interfaces are required, so that both real and virtual scenes can be seen. Ahead tracker is used to obtain users' positions and orientations for content alignment.

Early MAR applications, Optical see-through display was used [2], which facilitates user to watch real world with their natural sense of vision without scene distortion. The major problem is that it blocks the amount of light rays from real world and reduces light. In addition it is difficult to distinguish virtual contents from real world when background environment is too bright.

b) Video See-Through Display

Head mounted display (HMD) devices replace user eyes with head mounted video cameras to capture real world scene. This video is combined with computer-generated content and then sent to HMD screen for display. User’s position and orientation are getting through a head tracker. This method is similar to optical see-through display and has been used in early MAR applications [2], [20] and [7].

The other way camera and screen in handheld devices uses the embedded cameras to capture live video and blend the video with virtual information before displaying it on the screen. This method is predominant in applications with handheld devices. The former method obtains better immersion experience at the cost of less mobility and portability. Compared to optical see-through display, mixed contents are less affected by surrounding conditions in video see-through display, but it has problems of latency and limited video resolution.

Jannick et al. [13] gave a detailed comparison of HMD-based optical and video see-through displays in terms of field of view, latency, resolution limitation and social acceptance.

Optical see-through display is not often used in recent MAR applications due to sophisticated requirement of projectors and display devices.

c) Surface Projection Display

Rather display mixed contents on a specific interface, Surface projection displays virtual contents on real object surface. Any objects surface, such as wall, paper and even human palm, can be used as interface for display. It is capable to produce impressive visual results if real surface and virtual contents are delicately arranged.

Schöning et al [14]. Mistry et al. [22] have used Pico projectors for several MAR applications. Laser projector, a various traditional projector, has been exploited for spatial AR (SAR) applications. Self-calibration, high brightness and infinite focal length are their advantages. Since virtual information is projected to any arbitrary surface, surface projection display requires additional image distortion to match real and virtual projectors for content alignment [25].

2) Tracking and Registration

The process of evaluating current pose information so as to align virtual contents with physical objects in real world is called Tracking and registration. They are classified into two types: sensor-based and vision-based.

Sensor-based methods employ inertial and electromagnetic fields, ultrasonic and radio wave to measure and calculate pose information; vision-based methods estimate gesture information from point correspondent relationships of markers and features from captured images or videos.

3) Sensor-based methods

Based on work modalities, sensor-based methods can be further divided into inertial, magnetic, electromagnetic and ultrasonic categories.

4) Vision-based methods.

Feature correspondences are the base to estimate pose information in Vision-based tracking. According to features it tracks, it can be classified into marker-based and feature-based / marker-less method.

a) Marker based

Different image used as Augmented Reality (AR) markers that can be detected by a camera and used with software as the location for virtual assets placed in a scene.

Generally markers are in black and white, though colours can be used as long as the contrast between them can be properly recognized by a camera. It can consist of one or more basic shapes made up of black squares against a white background.

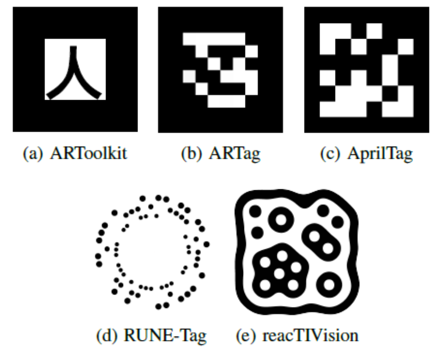

Fig. 4. Fiducial Markers

In the marker-based AR, some of the above markers are installed in the real world, and the estimation of camera pose and the registration of virtual imagery are performed based on these markers.

ARToolKit [10] and Chilitags [26] utilize 2D images as markers. This approach allows the stable camera pose tracking, and object recognition by adding information of object to the marker. Olson [6] develops AprilTag, which is a marker-based AR system with the greater robustness to occlusion, warping, and lens distortion.

Other researchers explored tracking from non-square visual markers. Cho [40] used ring shaped fiducial markers while Vogt et al. [33] designed circular shaped marker clusters with various parameters, i.e., number of markers, height, and radius with single camera tracking from its topology. Naimark and Foxlin [17] proposed a circular 2D bar-coded fiducial system for vision-inertial tracking. It existing a high information density and sub- pixel accuracy of centroid location.

Fig. 5. Fiducials with barcodes 101, 1967, 32767.

Vision-based tracking aims to associate target locations in consecutive video frames, especially when the objects are moving fast relative to the frame rate. In some cases, this can be mitigated when markers such as LEDs are allowed placed in the environment, especially in small-scale applications.

Even if maker-based tracking can enhance robustness and reduce computational requirements, they need certain maintenance and often suffer from limited range and intermittent errors because they provide location information only when markers are in sight.

Also these types of augmented reality markers that can be used are based on the software that recognizes them. It is unfeasible to deploy and maintain fiducial markers in an unknown or large outdoor environment, marker-based method is only suitable for indoor applications. It also suffers from problems of obtrusive, monotonous and view occlusion. Therefore, marker-based methods are not scalable to handle large scale navigation which may be required in an outdoor environment.

5) Nature Feature Based

In Nature feature method, tracks point and region features in image sequences are used to calculate correspondent relationships to estimate pose information. Frame-by-frame tracking helps to remove mismatches and drift errors, which most sensor-based methods suffer.

However, it suffers from deficiencies of image distortion, illumination variation and self-occlusion [38]. In order to get final result we required additional registration of image sequence with real.

This kind of methods does not require a priori information such as markers or 3D. Since that time a range of different nature feature techniques have been applied to AR such as [1][8] and [18].

The foremost problem of nature feature method is expensive in terms of computational overhead, which is especially severe for MAR applications with requirement of real time performance on mobile devices. As a result, many researches focused on GPU acceleration, computation outsourcing and algorithm improvement for performance improvement.

III. APPLICATIONS OF AR IN EDUCATION

Akçayır et al. [42], have classified the advantages of AR in education into four categories: “learner outcomes, pedagogical contributions, interaction, and other”. The majority of studies have illustrated that the use of AR in education results in “Enhancing learning achievement”, a subcategory of “Learner Outcomes”.

Blum et al. [36] used a brain-computer interface (BCI) device and gaze trackers to allow the user controlling the AR visualization. Wen et al. [29] propose a cooperative surgical system, guided by hand gestures and supported by an augmented reality based surgical field.

Mohana el at. [41] developed application that utilizing AR in medical school.

Fig. 6. Augmented reality medical school practical books from student view on phone display

And they found that Interactive Visual cognitive software for Augmented Reality for medical (I-CSDLC-ARM), radically enhance both the quality and the bandwidth of educational processes. This allows Students to read, flip pages by touching the screen of the tablet, which also give the students to walk through a human body and observing the functioning of biological system. Thus, the I-CSDLC-ARM, is design for ARM.

Gutiérrez’s [11] SMELAR (Standard Mechanical Elements Learning through Augmented Reality) for learning standard mechanical components, contains the course of an engineering graphics subject in a mechanical engineering degree of a Spanish university.

In addition to this, it also contains graphic information about standard representation, photorealistic image and a marker which allows visualization of the 3D standard element from any point of view through augmented reality using BuildAR.

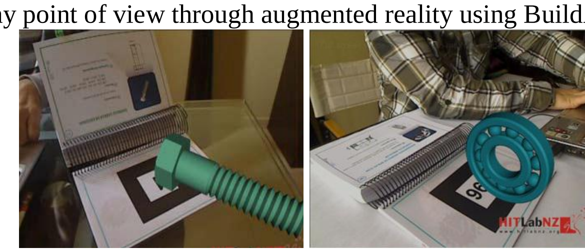

Fig. 7. Examples of hex-head screw; Examples worm gear.

Teaching anatomy, which requires a considerable amount of effort, expertise and temporal resources, is an example where AR can be used effectively to provide additional information [5].

Lu and Liu [19] have reported that students showed a satisfactory opinion towards AR learning techniques in marine education. Moreover, they have concluded that learning through playing can improve student’s learning performances. Accordingly, the use of this technology in education leads to an increase in students’ motivation to learn, and improves their imagination skill.

Alakärppä et al., [3] have developed NatureAR to study nature elements in AR mobile application, in which physical items from nature are used as AR markers.

Fig. 8. NatureAR

In their work marker-based AR approach has been used. It completely based on machine vision techniques. The natural markers (such as leaves and pinecones in a game-like nature quiz) are being detected, using the camera of a portable device, and then the AR application overlays the marker with the digital information [34].

(a) Printed marker *(b) Natural marker*

Fig. 10. Markers in NatureAR

In this project, nature and printed markers of different species were hidden in several locations of the research area. Then the tablet was pointed at a marker and this was centered on the screen, two 3D models related to that marker appeared on the display as AR content.

The work of Restivo et al. [31] with Augmented Reality involving STEM students, using markers for teaching DC circuit fundamentals, revealed very good student perceptions and satisfaction. Aims of this application is to contribute to the understanding of certain concepts, which are related to DC electrical circuits namely open/closed circuit, current direction, series/parallel components, etc. Components (battery, motor, light bulbs and switch) are integrated in the circuit by placing the respective marker in one of the free positions of the circuit that will be viewed by the webcam.

AR in education, Radu [30] noted increased in content understanding, student motivation, potential challenges of usability difficulties and ineffective classroom integration.

With the factors influencing student learning it is in particular highlighted that the content can be represented in multiple ways, i.e. as sound, visualization and animation. Moreover, by allowing the learner to physically enact the abstract educational concepts through gestures etc., their understanding is greatly increased .

IV.ETHICAL CHALLENGES

Wu et al. [39] refer to three groups of potential stakeholders when developing AR for education: teachers/ educators, researchers and ICT-designers. On the other hand, designing technology to promote learning might best be qualified by merging the perspectives of teachers with those of other stakeholder groups.

Squire and Jan [35] says, although AR can be considered an advanced and convenient tool when it is used in education, in the absence of a well-designed interface, it can be very difficult and complicated to use for students. Therefore, the design and simplicity of an AR application is of utmost importance, especially when it comes to student learning.

Krajcik & Mun [16] refer AR in education must necessarily be guided by usefulness for teachers and students in the process of teaching and learning core ideas and practices in science.

As mensioned in Babak Parviz's contact lens [4], there were suggestions from readers including "tapping the optic nerve" or "plugging in to the optic nerves and touch and smell receptors" and suggested that these would eventually be "more marketable approach" and a "much more elegant solution".

V.CONCLUSION

Change the location and timing of studying, to introduce new and additional ways and methods, augmented reality has the potential. Also it has capabilities to make classes more engaging and information more apprehendable. Besides Augmented Reality is about augmenting the real environment with virtual information; it is about augmenting people's skills and senses not replacing them.

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Authors Profile

K. Ganesh Kumar revieved B.Sc. degree from Department of Computer Science, MCA degree from Department of Computer Application, and his M.Phill. from the Department of Computer Science in 2004, 2010 and 2017 respectively. He served as an assistant professor in Kodaikanal Christian College for two years. Currently, he is working as an Assistant Professor in Sadakathullah Appa College, Tirunelveli, Tamil Nadu, India.

