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# Mobile Augmented Reality based Indoor Game for learning environment

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***Abstract - In earlier days, e-learning had a massive growth in which the learner used to sit in front of desktop to learn online compliance courses. Now a days, there has been significantly tremendous increase in the enormous usage of smart mobiles all over the world. As a result, mobile learning increased the convenience for learners to learn educational content through smart devices. But, students widely use smartphones for entertainment but won't view them as learning resources. In order to stimulate the student's interest on both learning and entertainment, augmented reality game based learning is conceived. Augmented reality is an advanced technology that can add a new dimension to the learning environment that allows the student whether in or out of the classroom to interact with educational content by leveraging their experience with the physical world. Augmented reality based Game (AR Game) is a mobile application which can leverage the user experience with real world to assess his/her intelligence on a specific topic. In this paper, we try to explain all components required for client-server architecture to develop any Augmented Reality Game as a mobile application. Augmented Reality Game is a location based application which is independent of Global positioning System (GPS) which enables the user to physically move and play around in an indoor environment. This innovative solution helps the instructor to educate, evaluate and entertain the user by authoring assessment questionnaire, changing the game play roles or objects of the game theme.***

**Keywords:** *Augmented Reality, Mobile application, Android application, education, advanced learning, e-learning, Location based application, Games, Augmented Reality Game architecture, Computer graphics.*

## I. INTRODUCTION

Nowadays, the usage of student-centric learning techniques is increasing in comparison to teacher-centric teaching. The trend shows increased student learning gains when educators follow a student-centric approach, especially in a course related to technology. Augmented Reality is one such technology, which follows student-centric learning [1]. The benefits of Augmented Reality (AR) are widely researched in the education domain. Researchers from the University of Sussex have done one such kind of study and mentioned some of the main shortcomings of the traditional educational methods are in maintaining the engagement of students into the learning process and in implementing innovative interactive learning paradigms with students [2]. But, while knowledge dissemination, the major challenge for the instructor is to engage the students and maintain their interest throughout the course. Therefore, introduction of game based learning is highly appreciated.

The main intention of game based learning is to present new approach of learning via games that would let the students acquire factual knowledge, additional skills, and gain experience, all of which they can apply in the real world [3, 4]. In this paper, the authors would like to introduce a learning tool in form of a mobile app that uses the concept of Augmented Reality along with game based learning. LeARnaround, an Augmented Reality Game is a proposed location based application which enables the user to physically move and play around in an indoor environment to collect and assess the player using MCQs.

### A. ABOUT AUGMENTED REALITY

The term Augmented Reality (AR) was first coined by Tom Caudell, a researcher at Boeing in the early 1990's to describe a digital display used by aircraft electricians that blended virtual graphics onto a physical reality [5]. Augmented Reality (AR) can be defined as a variation of Virtual Environments (VE), or Virtual Reality.VE technologies will completely immerse a user inside a virtual (computer generated) environment. The user cannot see the real world around him, while in a virtual reality environment. In contrast, AR gives an environment, where the user can see the real world, with virtual (computer generated) objects superimposed upon or composited with the real world. Augmented Reality (AR) allows an augmented content to be overlaid on an image or a video clip from the real world. So, AR supplements or augments the reality, rather than completely replacing it[6]. We can define an AR system to be having the following properties: 1) combines real and virtual objects in a real environment 2) runs interactively, and in real time 3) registers (aligns) real and virtual objects with each other [7]. The critical aspect of any Augmented Reality System is in producing consistent alignment of augmented content with the real world object [8].

The major components that enable the AR Solution are the following: a camera that captures the user's actual surroundings, a display that shows both the captured and virtual content, and an application that generates real time processing to create an exact supplementary content that will overlay the previous captured environment [5].

B. AUGMENTED REALITY IN EDUCATION

Though Augmented Reality (AR) is a new emerging technology, its popularity is significantly increasing and it is expected to become one of the prominent technologies in education in the years to come. The main reason, behind the popularity of AR despite the availability of several other immersive reality technologies such as Virtual Reality (VR) is that Augmented Reality (AR) is much simpler in comparison to similar technologies [6].

The basic requirements of any AR application includes a camera, a screen display, a memory, and a processor to render the virtual components. The recent smart phones and tablets, which are widely used by the student community meets the AR requirements unlike other technologies. On the other hand, VR needs complicated equipment such as mounted head sets and three dimension controls. In addition, AR development tools are widely available online which allows anyone with interest to develop their own AR Application [6].

Currently, AR is available in two forms for the education community. They are 1) Location-aware and 2) vision-based. In Location-aware AR Systems, the device should be enabled with GPS in order to track the location of the device and augment the media like text, graphics, audio, video or 3D models to the physical environment with navigation or academic information which is relevant to the location. In Vision-based AR systems, the learner point the device camera at an object like QR code, Proprietary markers, 2D images and augment the relevant information onto the camera view. AR Circuits, Sky View, Anatomy 4D [9] are some AR applications for educators to simulate electronic components, identifying stars, constellations and satellites, and visualization of human anatomy. In this paper we proposed a GPS Less Location based application which can identify the location of the user by counting the steps and

## II. LITERATURE SURVEY: AUGMENTED REALITY GAME (AR GAME)

The first indoor/outdoor intuitive Augmented reality / Virtual reality interfaced game was Tinmith, a context-aware wearable computer system called ARQuake[10]. In this game, a user places head mounted display on his/her head, wearable computer on his back and holds an input device called haptic gun for position and orientation information. The user's physical movement determines the position and direction of the movement of the game and hence engineered to fit and display the augmented reality information like monsters, weapons, objects of interest into the spatial context of the physical world. A mobile assisted augmented reality system with multiple interfaces was introduced in cross media Epidemic Menace [11]. Gradually researchers geared up to implement playing with small robots, curling & bowling and other collaborative activities into AR Games. AR Games also ventured into the Learning environments. ChromVille[12] is a mobile educational game app which helps students to view alive villages through mobile camera after they colored the printed chapter pages of specified villages. A mobile based AR Game PassWARG [13] is a geo-tagged treasure hunt game based on Easter egg hunt mechanic. In this game, players navigate around in the given area to find clues held by virtual characters located at Point of Interests (POIs). The player need to solve the puzzle given in the clue which reveals the password to unlock next level. Ingress [14] is a Google's augmented reality social game identifying actual physical locations using GPS and google maps set a story line and guide two different factions of agents to move around geographical locations with mobile devices to capture portals which are based on actual artifacts. In the similar way, we proposed an indoor AR Game called LeARnaround, which is a client server based game solution and the same is explained in the following section.

## III. AR GAME PROPOSED CLIENT SERVER ARCHITECTURE SOLUTION

In AR Game application, as a prior step the Instructor would interact with Game creation module framework to create and upload AR Game contents like selecting theme (virtual objects) of the game, setting difficulty level of questions, score board criteria, types of the question sets format and adding associations to AR Game application. A player/student use android Tablets / smartphones to open the AR Game application. The authenticated player can select class and subject which he/she belongs to start an AR Game client application. The next screen shown all unattempted subjects by the player. Selecting one of the subjective game, the player can start the AR Game using Augmented Reality. While the player is playing the game, as and when he is answering the AR questions prompting him in the middle, he scores with bonus points and proceed to continue the game / next level.

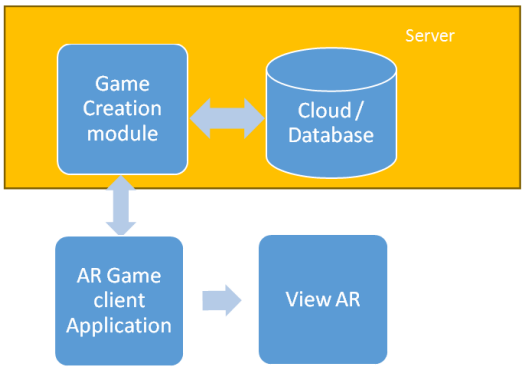


**Figure 1: General architecture of AR Game Solution**

The client server architecture solution for development of AR Game is explained as shown in the Figure 1. It consists of following modules.

1. Game creation module: This is a web application for the instructors which helps to create and maintain the Game Theme objects, MCQs class and subject wise.

2. Database server: The database server / cloud infrastructure is used to store and maintain the entire information about the AR Game solution.
3. AR Game client application: A Mobile application which drives the learner to play AR Game , educate and assess on selected subject. The theme virtual objects will be updated automatically when the user selects the class and subject.
4. View AR module: An augmented reality engine which helps to capture the real world through device camera and render the corresponding virtual objects / MCQ's onto the camera view in order continue the game play.

The major components of the proposed solution is depicted in the following Figure 2:

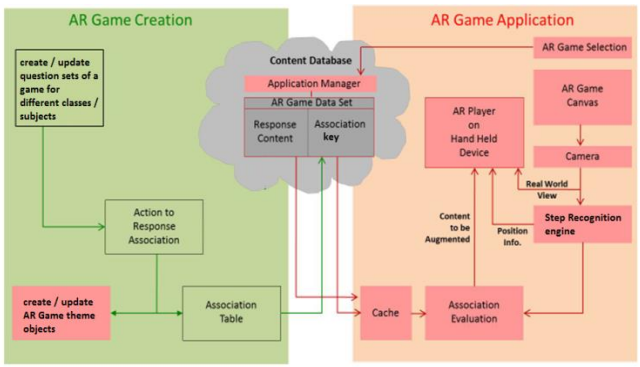


**Figure 2 : Major components of AR Game Architecture**

The AR game application is completely new approach of learning with 2D/3D animation based gameplay with learning. The students would be able to learn different concepts, as well as develop concentration. The AR game is an assessment based game with different themes and environment around it. The architecture diagram of the AR Game application as shown in Figure 2. has two major components – *the AR game creation module, and AR game application module*.

The *AR game creation module* is a web application that defines / creates / updates the question sets / virtual objects by the authenticated instructor in order of class and subject wise. The virtual objects which is in 2D / 3D need to be uploaded to this module. The complexity level of questions (MCQs) / Virtual objects vary from lower level to higher level classes. For a particular game, the question sets / virtual objects associated with the selected class and subject will be formed as association key in the association table. The same question sets/ virtual objects can be reused for different games. The association key and unique associated response contents for a particular topic are stored into a database / cloud repository.

The *AR Game Application* is a mobile application which prompts to select class and available subjects. With the user input, the virtual objects and MCQs of the selected subject and class will be downloaded from the application manager from server and make available for next attempt. When AR Game opens, the camera is ready to view the real world and virtual objects were displaying surrounding to the current device. Then the user need to collect those objects by walking. The step recognition engine counts the user walking steps and shown the current location of the user in the real view. The AR Player keeps observing the user behaviour and pops up the MCQs when the user reaches the virtual object. The Association evaluation module evaluated whether the user answers correctly and will give score of points for each question and then the virtual object will be cleared from the camera view. In the above said manner, the user need to move physically and collect all virtual objects in order to finish the game.

## IV. IMPLEMENTATION OF AR GAME APPLICATION

The realisation of using AR in game based learning is achieved by developing a mobile application AR Game called LeARnaround as shown in Figure 3. The AR game is developed on the idea of a bounty quest as depicted in Figure 4. The geographical locations in the real world environment are mapped into bounty on the app which can be seen on the screen. The learner must navigate physically to the bounty. As soon as the learner reaches the bounty, a MCQ will be displayed on to the screen as shown in Figure 5. Based on the answer provided, the learner can be evaluated and current score will be displayed as shown in the Figure 6.


**Figure 3 – AR Game app menu**

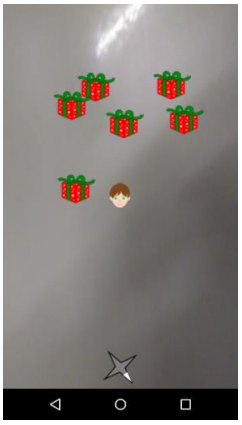

**Figure 4 – Game view**

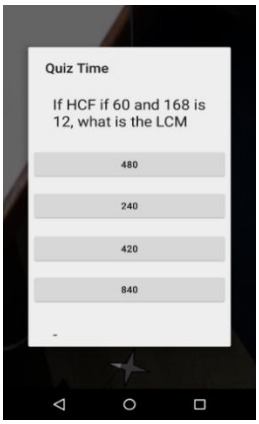


**Figure 5 – MCQ question**

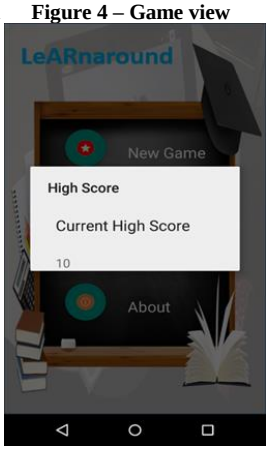


**Figure 6: Current score**

When the AR game app is started, the mobile camera opens and the real-view stream can be seen. Also, a child face which represents, the current position of the learner in the arena can be seen. As the learner will move physically, the position of the character will also change.

This game is specially meant for indoor environments, but the indoor environments are shadow regions for the GPS receiver sensor present in the phone. Therefore, the indoor location tracking through GPS is not achievable. So, in order to solve the problem of indoor location tracking, the walk detection and steps detection algorithms, along with direction retrieved from built in gyroscope sensor is used to track the movement of the learner in indoor environments.

In order to achieve indoor location tracking, a Pedestrian Dead-Reckoning (PDR) system has been built [15, 20]. The PDR system requires information, if a walk is detected and corresponding number of steps taken are calculated [15, 21]. The walk detection algorithm used, relies on the values received by the accelerometer sensor [15, 16, 18]. When a stride (two steps) is taken by the learner, a pattern in the accelerometer values are observed [19]. This pattern is cyclic in nature, and has frequency of 1-2 Hz [15, 22]. In order to make the step detection efficient, a threshold of accelerometer value is identified, to avoid any false step detections. Best results are obtained when the learner's device is close to the body [15].

To facilitate the learner for moving in a particular direction, a compass is shown on the bottom of the screen. The white coloured needle represents north direction. The accurate direction of movement of the learner in degrees is determined by the gyroscope sensor present in the smart phone, which provides the orientation of phone in the real world.

The learner must walk physically and try to grab the bounty packets shown in the screen. The physical step of the learner along with the direction of the movement received from various sensors on the phone, will be translated into the movement of the child face, on the mobile screen. As soon as the learner grabs the bounty, a MCQ question will be popped on the mobile screen. If the learner answers the question correctly, it will be awarded 5 points, and if an incorrect answer is given, the learner will be awarded -5 points.

This AR game concept can be applied with any subject by changing the question set, and asking the learner to undergo the test in the same app. For managing question sets for different subjects the above said AR Game creation module in the proposed architecture for AR game can be used. Through this setup, the question sets can be downloaded from a server and the same app can be used for evaluating the student for different subjects.

## V. EXPERIMENT STUDY

The AR Game LeARnaround is a game based learning system and has been implemented as a complete solution as a web and mobile application. The web application has been developed in Windows 7 operating system using MVC architecture. We used Node.js, express.js as web server, backbone.js as controller, mongoose schemas as models in order to communicate to mongodb database server and views as ejs files along with bootstrap. The mobile part is an android application which supports 4.2 and above version actually drives the learner to play AR Game. The REST API's created at server side helps to communicate between client and server. We experimented this Game application among few students of different classes and found that the game improved their attentiveness and deliberately engaged them in answering MCQs with mobiles than e-learning systems.

## VI. FUTURE WORK

The proposed AR enabled game based learning solution, promises to enhance learning capabilities and generate interest amongst the students through engaging content and MCQ based evaluation. Based on the architecture proposed, a mobile application has been developed to realise the AR game concept. It was found that, the AR game can be enhanced in the following ways.

1. The student engagement is the main motive of game based learning. Better student engagement can be achieved by presenting high quality multimedia content in the AR game.
2. The content can be personalized at the backend server in order to motivate the learner for further levels.
3. The complexity level of questions can be increased in various levels of the game, and virtual objects can also be changed for each level.
4. Performance analysis of the learners from each subject and level wise can be improved.
5. Predictive analysis of the learner performance can be done using data mining algorithms.
6. The step recognition engine can be improved to track minute step movements of the student, avoid obstructions and reduce the false detection, false positives and false negatives steps.
7. AR Game can be customizable to specific needs and future enhancements. And finally, the solution must be stable and scalable to cater to large number of educational organizations.

## VII. CONCLUSION

Augmented Reality (AR) is a new emerging technology and its popularity is significantly increasing year by year and ventured into education sector. We proposed a solution for creating Augmented reality game called LeARnaround which leverages the learner experience with real world to assess his/her intelligence on a specific topic. This game is a Location based application which is independent of Global positioning

System (GPS) which enables the user to physically move and play around in an indoor environment. In this paper, we explained all major components required to implement the AR game which adds a new dimension to the learning environment. The proposed architecture can be adopted by any educational institution in order to create augmented reality game and deliberately engage the learners with entertainment. This innovative solution helps the instructor to educate, evaluate and entertain the user by authoring assessment questionnaire, changing the game play roles or virtual objects of the game theme. We concluded this paper by giving the directions for future work.

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