Interactive Learning Environment for Networking Topics based on Augmented Reality

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Abstract

Augmented Reality (AR) implemented on mobile devices has emerged as a prominent subject of study within the field of mobile applications and human-machine interaction. The mobile augmented reality (AR) technique integrates intelligent display, registration tracking, virtual and reality convergence, and human-computer interactions using portable devices or intelligent terminals. This enables the seamless integration of the 3D virtual object with the customer's real-life environment, thereby enhancing the perceived depth and breadth of the experience. Augmented reality has been extensively utilized across diverse domains, including the field of education. In the domain of education, augmented reality is employed to enhance the level of engagement and appeal in the learning process. Beginning with the issue of acquiring knowledge about computer networks, it is observed that the conventional approach involves the introduction of network devices, TCP/IP models, and OSI models. This research addresses the problem by creating a learning media solution that utilizes augmented reality (AR) technology. AR technology integrates two-dimensional or three-dimensional virtual objects into a real environment and displays these virtual objects in real-time. The novelty of this work implies on the design of augmented reality (AR) applications for teaching the OSI model in the field of computer networks. The aim is to enhance comprehension, stimulate motivation, and generate student interest in learning.

1. Introduction

Interactive learning projects are designed to create a medium through which users can engage in a higher level of interaction within the learning environment, as opposed to traditional learning environments. This project presents a conceptual framework for investigating the potential of Augmented Reality (AR) technology as a new type of Virtual Reality (VR) application in the field of education [1]. AR distinguishes itself from VR by enabling the seamless integration of 3D virtual objects into the real environment in real time. This capability facilitates a stronger connection between students and their physical surroundings, enhancing the learning experience by making it more engaging and captivating. AR learning provides users with interactive features such as touch screen functionality, device orientation changes, and device rotation capabilities[3]. These features enable users to engage in a novel learning experience facilitated by advanced technology.

Computers and technology are the key individuals of global contraction. By leveraging computer networks, individuals have the capability to engage in long-distance communication with others. This applies not only to general communication between people, but also extends to the educational domain, where students and teachers can effectively interact through computer networks, specifically utilising email as a means of communication. The objective is to create an augmented reality application that facilitates the learning process of the Open Systems Interconnection (OSI) Model, a conceptual framework for understanding computer network protocols [2]. By utilising a modem and computer, individuals have the ability to engage in virtual meetings with science educators who share similar interests, regardless of their geographical location, at any time of the day, throughout the year.

Typically, the majority of E-learning applications are characterised by their static nature, featuring a fixed screen layout, static text, and static images. This project was exclusively

implemented using the latest 3D concept of Augmented Reality to enhance the novelty in technological development. The application of the OSI model concept in the field of Augmented Reality (AR) has not been previously attempted. The E-learning mobile application development project has effectively demonstrated the functioning and progression of the 7 layers in the Open Systems Interconnection (OSI) model. The project incorporates both textual and audio explanations to facilitate a comprehensive understanding of the underlying concepts for the user. The user has the ability to utilise the application in any location, without the requirement of a target image, in order to render the 3D characters that are available within the application.

2. Related works

Augmented Reality (AR) is built upon the methodologies and principles established in Virtual Reality (VR). It enables users to engage with a virtual environment while maintaining a level of interconnectedness with the physical world [5]. Augmented Reality (AR) can be defined as the provision of real-time access to information encompassing text, graphics, audio, and other integrated virtual enhancements. This information is accessible to the user through real-world objects. Augmented reality (AR) technologies and applications are poised to have a crucial impact on various activities and professional competencies. Domains such as commerce, healthcare, education, and public safety are just a few examples where augmented reality will deliver substantial value [6]. According to the findings presented in reference [7], it has been determined that AR lacks inherent semantic significance. However, this concept becomes intelligible when we direct our attention towards the individual and their cognitive understanding of the surrounding environment. Therefore, it is possible to retain the term "AR" while conceptualising it as an enhanced form of reality perception.

Several recent studies in the academic literature explore the utilisation of Augmented Reality (AR) or Virtual Reality (VR) technologies to introduce novel teaching and learning methodologies.

In reference [8], the authors conduct an analysis of the challenges and potential applications of virtual reality (VR) and augmented reality (AR) in the context of primary school education. In reference [9], the investigation focuses on the impact of Augmented Reality (AR) in the field of anatomical education. A related study is discussed in reference [10], which primarily examines the application of augmented reality (AR) in the field of cardiology. Furthermore, in reference [11], the researchers present a mobile multiplayer augmented reality (AR) game designed specifically for primary school children.

The primary objective of this prototype is to enhance socialisation, communication skills, and emotional intelligence in children attending primary school. In [12], several augmented reality (AR) virtual environments are utilised for the purpose of heritage education.

In the context of the business domain, Augmented Reality (AR) presents a compelling proposition for the purpose of educating and upskilling employees in targeted subject matters or competencies. In reference [13], the author presents a comprehensive analysis of augmented reality (AR) and virtual reality (VR) as technological solutions for enhancing industrial processes and operations. In this study, the researchers reach the conclusion that the integration of augmented reality (AR) and virtual reality (VR) technologies into a platform is crucial for facilitating technical training and detailed operational procedures in emerging industries. In reference [14], the authors propose the creation of a comprehensive learning factory to facilitate the acquisition of industry 4.0 competencies in the field of industrial engineering education. In [15], a comprehensive analysis is conducted to assess the impact of Augmented Reality (AR) technology on improving situational awareness in battlefield scenarios.

The integration of technology in education has the potential to positively impact students by promoting active learning and fostering motivation, ultimately resulting in an enhanced and efficient learning experience [4]. Prior studies have indicated that the utilisation of technology may result in a passive learning experience if the technology employed fails to encourage critical thinking, significance, or meta-cognition [5]. Therefore the proposed AR model aims in

developing an interactive framework that satisfy following concepts,

- In the field of computer science education, the acquisition of practical knowledge is a fundamental requirement across a wide range of subjects.
- The proliferation of traditional classroom learning in certain subjects may lead to suboptimal comprehension within the student demographic.
- Augmented reality is employed to enhance the educational experience by addressing challenges and improving engagement and appeal within the field of education.
- To enhance the quality of education by utilising visual tools.
- Users are relieved from the burden of carrying physical books as this application offers comprehensive information on various topics.
- To satisfy the user in accessing specific information from the topics, by conveniently click on the button located at the end of the application.
- Furthermore, a significant portion of computer science topics will consist of theoretical concepts rather than visual representations. As a result, this application will seamlessly integrate virtual elements into the physical environment, enhancing its appeal and usability for the user.

3. Architecture of Proposed model

A computer-generated image is superimposed on a user's vision of the real world using augmented reality technology, creating a composite view. Due to its significance, it has been adopted in other fields including health care, transportation, education and others. Especially in the field of education, augmented reality technology plays an important role in delivering an interactive learning environment. Thus, many research endeavours concentrate on the development of E-learning with more interactive audio, video and more delicacy. AR technologies show its uniqueness from other technologies in terms of material cost and optimism, as mobile phones and processors are required to visualise the results in the real world. The overall architecture of the proposed AR model is shown in figure1. The Unity software platform offers a diverse array of options during the development process [15].

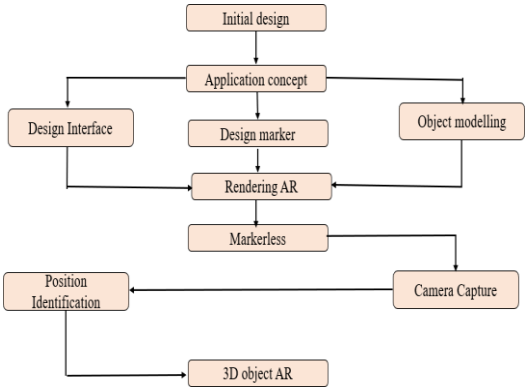

Fig. 1. Overall Architecture of the proposed E-learn based AR model

The AR application's design is structured to primarily utilise targets as the main mode of interaction. The term "targets" is used to denote a collection of real-life images that serve as the foundation for generating the three-dimensional (3D) figures within the augmented reality (AR) application. Furthermore, we utilise the human-interface technology ARToolkit [13].

To facilitate user interactions within the application, a set of buttons were implemented. These buttons enable various actions and ensure spontaneous navigation between various widgets and pages. Figure-1 shows the overall structure of the proposed E-learn model. The main engine is developed with the help of unity 3D and its corresponding development packages. A cross-platform mobile application is developed for both the Android and ios operating systems. The software is built upon IntelliJ IDEA, a Java integrated development environment (IDE), leveraging its code editing capabilities and developer tools. Design markers are a method that let users choose which object models to display on visual interfaces. After the completion of the anticipated object model, it undergoes a rendering process in order to sustain lively visual representation.

The E-learning application utilises markerless augmented reality (AR), a computer vision technique that enables the automatic incorporation of virtual three-dimensional (3D) objects into a real-world image environment. This technique operates without relying on physical markers or reference points to accurately position and anchors the virtual objects. Ultimately, the

three-dimensional (3D) entity is produced subsequent to accurately determining its spatial coordinates within the virtual environment. The sample pseudo code for developing an E-learning based AR application is described below.

Pseudo code for developing an E-learning based AR application

1 A→ left and right buttons
2 B→3D characters for each layer
3 Input (A,B)
4 Localize character position (B)
5 Generate Rendering (c) ,

a. Line-ender,
b. Click,
c. Move-Objects
d. Rotation
e. Answer-generation
f. Question Management

6 Drag (c) and map it with (B)

7 Remove camera and add AR camera

8 Generated apk file with (A, B, C)

4. E-Learn AR model design

The camera first captures the physical objects in the environment, which are then subjected to a process of converting into pixel format. This process is performed in order to establish an association between the mobile or web camera's output and the output format of the augmented reality (AR) camera application. The overall data flow is given in figure-2 which provides the working flow of the proposed E-learn AR mode for computer Network course.The AR model's primary notion is to display information of the OSI layers in computer networks, along with their protocol, application, and information flow. To accomplish this, 3 aspects including flash text, AR mode and dynamic content management are covered in 8 pages containing information regarding the OSI model. On the initial page, there is a visual representation showcasing the fundamental components of computer networking.

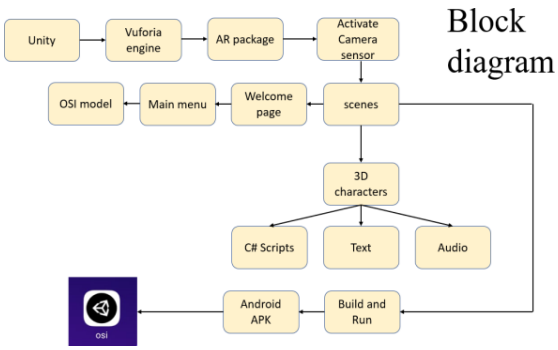

Fig. 2. Data flow diagram of the proposed E-learn based AR model

The main menu page comprises buttons that facilitate user navigation across layer pages and allow them to return from each page. The inclusion of audio background that provides explanations of activities conducted within each layer enhances the quality of the learning experience. The functionalities of incorporated in pages consist of three activities is explained below:

4.1. Flash text:

The concepts presented in the books are demonstrated by incorporating visual images alongside textual descriptions using flashcards, thereby offering an innovative way of student engagement. This component typically appears at the centre of the augmented reality (AR) screen, ensuring that it does not overlap with any other graphical displays.

4.2. Dynamic content management:

CrafterCMS is employed to facilitate a versatile, innovative, and immersive learning environment. This process instantiates the content objects that establish collaboration with real entities in the physical world.

4.3. AR mode:

Enables the application to access and utilise the rear-facing camera of the mobile device. The Vuforia engine utilises pattern recognition to accurately detect and display virtual elements that correspond to the identified target. Utility refers to a software application that facilitates the development of different modules, including the Vuforia package, AR camera, Android SDK, and C# scripts. These modules act as key in exporting the application into the Android platform.

5. Target Design

Targets are two-dimensional visual representations that possess distinct attributes and features, facilitating their identification and detection through the utilisation of the Vuforia engine. A feature refers to the distinct and well-defined characteristics present in an image, which can be used as a reference point or target. The Vuforia image analyzer visually represents the detected characteristics as small yellow crosses (+) surrounding the image.

The Vuforia Target Manager processes the uploaded image and performs an evaluation on them. Subsequently, it produces data alongside a graphical depiction of the desired characteristic. In order to simplify the recognition and tracking of the target image, the VuMark is employed. The VuMark is a localised database that is stored within the user's device. Once the target is detected, Vuforia utilises image tracking to continuously monitor the target as long as it remains within the device camera's field of view [10]. Based on the aforementioned factors, we proceed to formulate our own set of targets.

6. Results and Discussion

The incorporation of augmented reality in e-learning platforms is intended to increase the depth of the information and facilitate the teacher's quick and effective communication of concepts. In the field of computer networks, an in-depth understanding of the OSI layers plays a pivotal role in acquiring knowledge related to data transmission and the facilitation of resource sharing among interconnected devices. The augmented reality (AR) application possesses the ability to perform scans on various targets and subsequently displays the corresponding three-dimensional (3D) model over the background of the actual environment.

In Figure 3(d), the instructor can provide a dynamic explanation of the significance of the SSL protocol, which is utilised in the presentation layer, as well as its functional process. The 3D images, including the human and image in figure 3(a), were downloaded from the github repository (https://github.com/topics/3d-images) since unity supports the FDX file format.

In order to assess the effectiveness of the proposed augmented reality (AR) model, a qualitative analysis was conducted by gathering feedback from individuals aged 17-25. The analysis involved comparing the learning experiences of these individuals using traditional slide-based learning methods versus the AR model-based learning approach. A group of 63 individuals chosen randomly, including both college and high school students, are given the proposed framework and their response is collected back. Resultant AR model launched in android mobile is shown in figure 4. List of questions used for qualitative analysis is as follows,

Q1: What are the functionalities of transport, network and data link layer?

Q2: Which layer provides reliable connections?

Q3: List out the protocols used in different layers of OSI model.

Q4: Which type of messaging format is used in data link layer?

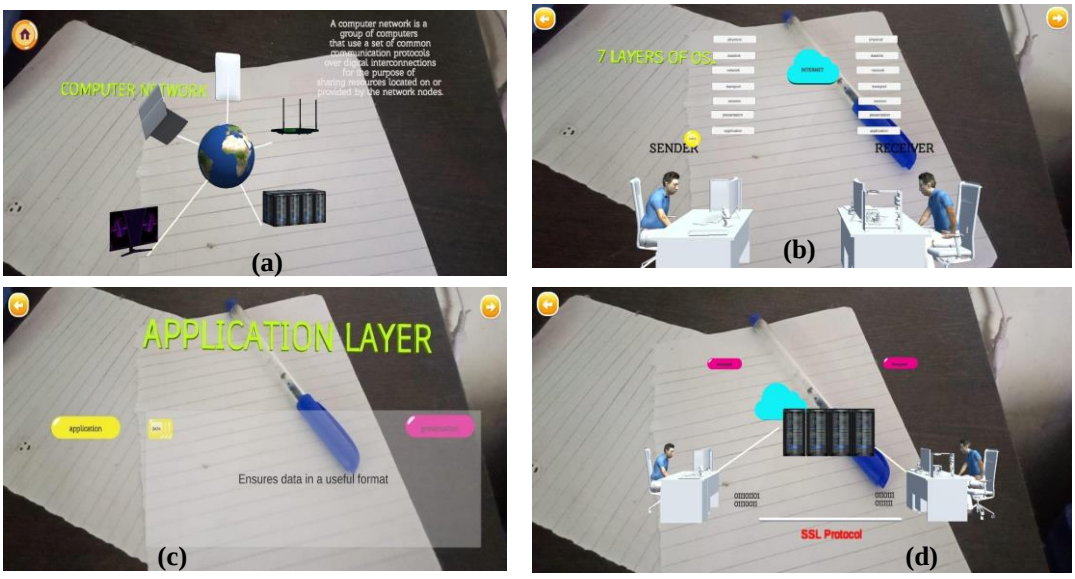

Fig.3. Graphical interface of AR application, (a) Introduction page, (b) layer options page, (c) layer definition page, (d) protocol explanation page

Fig. 4. E-learn based AR model launched in android mobile

The statistical representation of the hit percentage for each group and for each question is depicted in Figure 5. The results indicate that the implementation of the proposed Augmented Reality (AR) E-learning model facilitates the conceptualization of knowledge, leading to enhanced comprehension of the taught subjects among students.

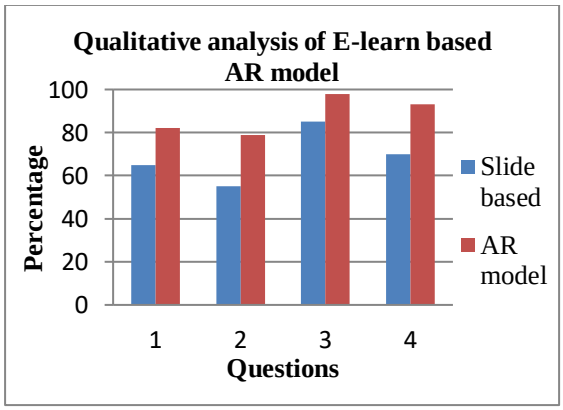

Figure 5. Statistical analysis of the proposed E-learn based AR model

The outcomes indicate that the likelihood of providing accurate responses for all four questions is greater in the context of probability compared to slide-based instructional methods. This underscores the importance of incorporating practical applications, tools, and technology in educational instruction to enhance comprehension skills, as opposed to relying solely on memorization of textual content. The book "Computer Networks: A systems Approach" served as the source for all the information needed to comprehend the OSI layers in the AR model. (https://cseweb.ucsd.edu/classes/wi19/cse124-a/courseoverview/compnetworks.pdf).

7. Conclusion

In this study, we have introduced an E-learning augmented reality (AR) model that can effectively educate individuals on the operational processes and significance of OSI layers within the field of networking. It possesses the capability to bridge the virtual world with the physical world, enabling the visualisation of tangible objects. 2D images are transformed into 3D objects, thereby diversifying the learning approach and motivating students to explore further. This includes understanding the characteristics and visual representation of a process, as well as identifying actions that resemble the original form and information from different layers within the object.

The proposed work can be enhanced in future in terms of markerless analysis. To achieve this, the technique of simultaneous localisation and mapping (SLAM) is utilised to conduct environmental scanning and generate appropriate maps for the positioning of virtual objects. The utilisation of Projection-based augmented reality (AR) technology has the potential to be implemented within various business and industrial domains. This technology enables the projection of instructional content or relevant data directly onto a specified physical space.

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