Learning Media Needs Analysis Using Augmented Reality Educational Games

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Abstract. The field of learning media constantly adapts to advancements in technology, encompassing print technology, audiovisual media, computer-based media, and the integration of print and computer technologies. Augmented Reality (AR) technology enables the integration of print and computer technologies, allowing for the combination of media in a learning environment. Augmented reality (AR) is a technology that integrates virtual elements into the real world in real-time. A computer network system consists of hardware, software, transmission media, network topology, and security. Currently, the process of teaching media to recognize network topology is still repetitive, mostly relying on visual aids such as photos, books, or other projection tools. By employing Augmented Reality technology, it becomes possible to seamlessly integrate virtual elements into the physical environment. This enables the transformation of items into three-dimensional representations, so enhancing the learning process and fostering students curiosity.

Keywords: Learning media, Educational games, Augmented reality, Learning needs.

1 Introduction

Learning is an ongoing endeavor for people, who employ diverse methods to achieve a common objective: comprehending what is being learnt. Multiple methods have been employed, such as auditory perception, textual comprehension, visual perception, direct observation, seeking advice, and other similar approaches [1]. Humans create assistive devices to support the learning process and achieve learning goals. In this context, Information and Communication Technology (ICT) plays a crucial role. ICT has become widespread in various areas, including education and teaching. Its presence facilitates access to necessary resources and simplifies the learning process [2].

The field of information and telecommunications technology is currently experiencing tremendous advancements. Similarly, the education system of today has undergone

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tremendous changes. This is evidenced by the diverse methodologies employed in the educational process to disseminate information to students. With the expectation that the information provided can be readily understood.

With the rapid development of technology, the use of information technology and telecommunications has become increasingly prevalent in education [3]. By incorporating these tools into teaching and learning, educators are embracing innovative methods that are expected to significantly improve the quality of education. This shift aligns with the ongoing technological advancements, ensuring that educational practices remain relevant and effective for today's students.

The progression of learning media has always mirrored technological advancements, evolving from print to audio-visual formats, and then to computer-based and hybrid print-computer technologies. Today, the convergence of print and digital media is exemplified using Augmented Reality (AR) technology [4]. AR integrates digital elements with the real world in real time, utilizing real-world data to adapt seamlessly to the environment. This technology is accessible on mobile devices and, although it has been in development for nearly forty years alongside Virtual Reality (VR), AR is now widely recognized and utilized across various fields. AR's applications are diverse, spanning sectors such as entertainment, advertising, healthcare, military, and education, with significant advancements expected soon.

Augmented Reality (AR) technology offers a novel approach to enhancing printed promotional materials by linking them to video-based advertising content. This system is designed to recognize specific markers and display videos that are accessed via a URL [5]. In a study conducted by Mukhlis, animations were developed using Blender, and the AR content was created with Qualcomm Augmented Reality (QCAR). These animations were then displayed on an Android smartphone, effectively illustrating the network topology. The application can showcase various topology such as bus, ring, mesh, star, peer to peer, linier, hybrid, and WLAN. This innovation holds significant potential as an educational multimedia tool [6].

The current teaching and learning activities, particularly in computer network system, still rely on traditional resources such as books, workbooks, and practical props. During the current learning process, the lecturer engages in writing and explaining while the pupils take notes on the content provided by the lecturer. There is only one prop available, although there are around 25 students in the class. Undoubtedly, this will generate an adverse ambience for students throughout the teaching and learning procedure, so hindering their comprehension and proficiency in the subject matter. By employing Augmented Reality technology, the virtual world can be seamlessly integrated with the real world, transforming objects into three-dimensional representations [7]. This innovative approach to learning prevents monotony and motivates users to explore further, enabling them to identify the network topology.

2 Literature Review

2.1. Learning Media Needs Analysis

Learning Media Needs Analysis focuses on the importance of understanding student needs in an educational context and how learning media can be designed to meet those needs [8].

According to Maslow, individuals must satisfy their basic needs, such as security and self-esteem, before they can focus on higher self-actualization, which in an educational context is related to academic achievement [9]. Fulfilling these needs creates a conducive learning environment where students can fully engage in the learning process and achieve optimal results.

In addition, Malcolm Knowles' theory of andragogy emphasizes the importance of relevant and problem-solving-oriented learning, especially for adult learners or more mature students [10]. In needs analysis, this approach demands that learning media should not only convey information, but also be relevant to students' real-life context. This relevance increases learning motivation and ensures that what students learn can be directly applied in practical situations, which in turn increases the effectiveness of the learning process.

In the development of learning media, constructivism theory plays an important role by emphasizing that effective learning occurs when students actively construct their knowledge through direct experience and interaction with media [11]. Learning media that are interactive and designed to encourage student engagement can help them understand complex concepts better. The ADDIE model, which is a systematic approach to learning media development, places needs analysis as an essential first step. This analysis stage not only helps in formulating clear learning objectives, but also in identifying student characteristics and existing knowledge gaps, so that the developed media can effectively address the identified needs.

The importance of needs analysis in learning media development cannot be ignored [12]. This analysis ensures that the media developed is in line with specific educational objectives and relevant to students' needs. In addition, in an era of ever-evolving technology, needs analysis also includes consideration of technological accessibility and the integration of digital media in the learning process. Thus, the resulting media not only meet high pedagogical standards but are also responsive to changing student needs and preferences, ensuring that the learning process can take place more effectively and efficiently in various educational contexts.

2.2. Augmented Reality (AR) Educational Game

Augmented Reality is the endeavour to integrate the physical world with the virtual world using computers, resulting in minimal distinction between the two [13]. Augmented Reality (AR) is a form of Virtual Environment (VE) that is more commonly referred to as Virtual Reality (VR). Virtual reality refers to a scenario in which the user is fully immersed in a simulated environment [14]. Within that particular setting, the user is unable to perceive the actual physical surroundings. Unlike AR, which allows for the simultaneous perception of the actual world and virtual objects, where the virtual objects are only projected onto the real environment [15].

Augmented Reality (AR) Educational Game can be built from several basic concepts that connect AR technology with the principles of learning and educational game development. First, constructivism learning theory is very relevant in this context. Constructivism, pioneered by Jean Piaget and Lev Vygotsky, states that students construct their knowledge through interaction with their environment [16]. In the context of AR, this technology allows students to interact with digital elements that are integrated with the real world, creating a more immersive and meaningful learning experience. AR can transform the learning

environment into an interactive space, where students can explore, experiment and learn through hands-on experience, in line with the principles of constructivism.

The integration of AR in educational games can also be explained through learning motivation theories. Educational games using AR have the potential to increase students' intrinsic motivation by making learning more fun and challenging. Game elements such as achievements, rewards and challenges in AR can trigger curiosity and desire to learn, while the visual and interactive aspects of AR increase student engagement. This is important as high motivation is often directly related to better learning outcomes.

Third, in terms of educational game design, Mihaly Csikszentmihalyi's Flow theory is very useful [17]. Flow theory explains how individuals can be fully engaged in an activity when the challenges provided are balanced with their skills. In the context of AR Educational Games, the game design should ensure that the challenges provided in the AR environment match the students' abilities. This helps create a state of "flow," where students are fully immersed in the learning activity without feeling bored or overwhelmed. This state allows learning to occur in the most natural and effective way, as students feel challenged and encouraged to achieve their goals in the game.

The application of AR in educational games can also be analyzed through media and communication theories, such as Richard Mayer's Cognitive Theory of Multimedia Learning model [18]. Mayer suggests that multimedia learning is more effective when text, images and sound are combined in a complementary way. In AR, the integration of these elements into one cohesive experience can improve understanding and retention of information. AR enables the presentation of complex information in a way that is easier to understand, through 3D visualization, animation, and interactivity. Thus, AR Educational Game not only enriches the learning experience but also increases the effectiveness of learning by utilizing the power of multimedia media in the most optimal way.

Augmented reality enhances the viewer's viewpoint by presenting virtual things in the real world, creating the illusion that these objects are integrated into the actual surroundings. Augmented reality is a fusion of the physical and digital realms [6]. Figure 1 displays an illustrated diagram of augmented reality.

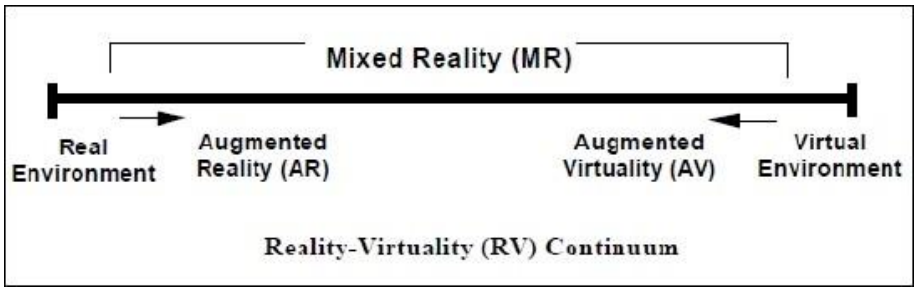

Fig 1. Augmented Reality Illustration Diagram

2.3. Markerless Augmented Reality

One technique of Augmented Reality is Markerless Augmented Reality, where users are not required to use a physical marker to display digital objects [19]. The development of markerless augmented reality technology in Android devices is anticipated to enhance the efficiency, practicality, and attractiveness of implementing augmented reality. This technology allows for its use in any location and at any time, without the requirement of printing markers [20].

2.4. Learning Media

Learning media is a fundamental instrument used in the process of teaching and learning. Anything that can be employed to provoke cognitive, perceptual, emotional, and cognitive faculties of the learner, hence fostering the process of acquiring knowledge or engaging in educational endeavours. The constraints of learning media encompass a wide range of factors, such as sources, individuals, the environment, and the methods employed to achieve learning or training goals [21].

2.5. Multimedia

Multimedia refers to the integration of text, art, sound images, animation, and video, which are transmitted by computers or digitally changed [22]. This content can be provided and managed interactively, as seen in Figure 2. There exist three distinct categories of multimedia, which are: (1) Interactive multimedia allows users to have control over the delivery and presentation of multimedia elements, enabling them to determine what content is presented and when it is presented. (2) Interactive multimedia: This form of multimedia consists of interconnected pieces that can be controlled by the user. This sort of multimedia is characterised by numerous interconnections that bind various multimedia elements together. (3) Linear multimedia: Users passively engage with multimedia content, experiencing it in a sequential manner from beginning to end.

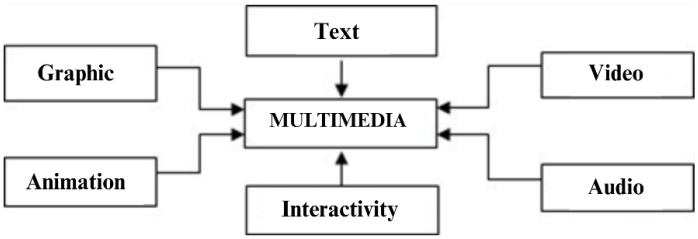

Fig 2. Multimedia Definition Overview

3 Research Methodology

The development of learning media to recognise network topology using augmented reality technology follows a process that comprises four primary stages: (1) The initial phase is the planning stage, during which preparation, literature study, and issue formulation are conducted. (2) The second step involves gathering data using methods like as observation, interviews, questionnaires, and documentation. The collected data is then processed for analysis. (3) The third step, referred to as the analysis and discussion stage, involves doing system analysis, system design, coding, implementation, and testing and evaluation of the

applied system. The documentation stage is the fourth phase where the research results are recorded and documented.

4 Discussion

4.1. Data Collection Results

The findings from data searches utilising observations, questionnaire interviews, and documentation specifically conducted for students and lecturers regarding supporting media for teaching and learning activities indicate a requirement for innovative supporting media that can be delivered through ICT. These media should offer convenience in teaching and learning, as they can be accessed and utilised effortlessly from any location.

The data collected serves as the foundation for creating a novel, imaginative, and inventive learning medium that effectively enhances teaching and learning experiences for both students and lecturers. The media is developed utilising mobile-based Augmented Reality technology, specifically designed for Android devices, to facilitate learning. The use of media on Android smartphones is influenced by the growing number of Android users, encompassing various operating system versions from Froyo to Jelly Bean, as well as diverse smartphone types and brands.

The decision to computer network system material as the subject of study was made due to the belief that network topology require a medium for observation, as they are challenging or even impossible to observe directly. Therefore, a medium is needed to display and visualise these objects in a form that closely resembles their original state. The utilisation and depiction of items via three-dimensional media. It offers an alternative to the ability to display network topology in a state that closely resembles their original shape.

4.2. System Analysis

Software needs analysis is a process that seeks to determine the specific software requirements necessary for the development of a system. The production of learning media for the identification of network topology is achieved by the utilisation of augmented reality technology, specifically using Vuforia and Unity 3D Engine.

Vuforia is an application specifically designed to facilitate the development of Augmented Reality. Vuforia, designed as a software development kit (SDK), possesses the capability to execute image recognition during the process of image recognition development. Developers have the option to choose between two types of database-based workflows: Cloud Database and Device Database (Figure 3).

The Unity Game Engine is a software application utilised for the development of 3D video games and interactive multimedia, including visual architecture and real-time 3D animation. The Unity Game Engine serves as both a game engine and an editor. By utilising the Vuforia SDK for Unity, one can employ Unity 3D as a powerful tool for generating Augmented Reality experiences.

Hardware requirements analysis is a process that determines the specific hardware components necessary for constructing and operating the system under development. The suggested hardware for constructing and operating this application includes: (1) The computer should have a minimum configuration consisting of an Intel dual-core 3 GHz

processor, 1 GB of RAM memory, a 120 GB hard disc, a 14" monitor, stereo speakers, and an internet connection in order to access the Cloud Server. (2) The minimum specs for an Android-based smartphone include a processor with a speed of 600 MHz, a display with 256K colours and a resolution of 480 x 320 pixels, internal memory of 512 MB ROM and 512 MB RAM, external memory support for microSD cards up to 32GB, audio playback compatibility with MP3/AAC+/WAV/WMA formats, video playback compatibility with MP4/H.264 formats, and connectivity options such as HSDPA, 3G, GPRS, and WiFi. An operating system is a software programme that manages computer hardware and software resources and provides common services for computer programmes. The Android operating system, specifically version 2.2 Froyo, has an HTML browser and a 5.0 megapixel CMOS camera. It can connect to the internet either through a data package from a certain telephone company or through a Wi-Fi connection. This allows users to execute applications and access the Cloud Server.

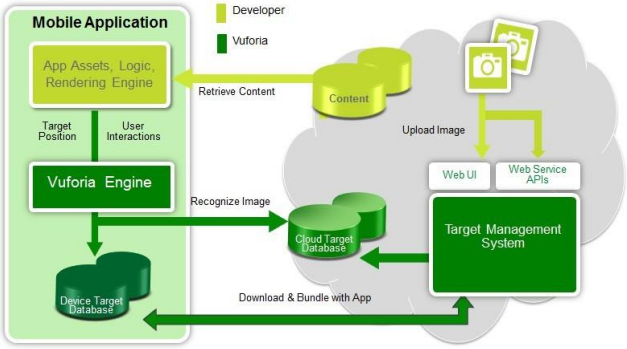

Fig 3. Vuforia Database Diagram

4.3. System Architecture

The system architecture is constructed with the Vuforia Software Development Kit (Figure 4). The Vuforia Software Development Kit (SDK) necessitates the presence of multiple crucial components in order to function effectively. The elements encompassed are: (1) A camera is necessary to ensure that every frame is collected and transmitted efficiently to the tracker. (2) The Image Converter transforms the camera format (such as YUV12) into a format that can be recognised by OpenGL (such as RGB565) and for tracking purposes (such as brightness). (3) The Tracker module incorporates computer vision algorithms capable of identifying and monitoring physical things inside the camera video. Various algorithms analyse the images captured by the camera to identify new trackables and assess virtual buttons. The outcomes will be saved in a state entity that will be utilised by the video backdrop renderer and can be retrieved from the application code. (4) The Video Background Renderer is responsible for generating images from the camera and storing them in the state object. The efficiency of the video backdrop renderer is significantly influenced by the device employed. (5) The Application Code initialises all of these components and carries out three critical stages in the application code, which include querying state objects on

newly identified targets or markers. Ensure that the application logic is updated whenever new input is entered, and display augmented graphics. (6) Target Resources, generated through the utilisation of the online Target Management System. The downloaded materials consist of a configuration xml file, named config.xml, which enables the developer to customise some elements in the trackable. Additionally, there is a binary file that contains the trackable database.

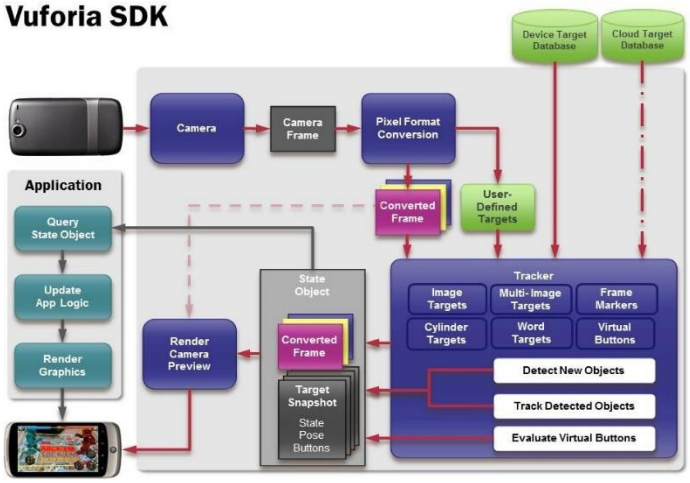

Fig 4. Vuforia SDK Architecture

4.4. Marker Reading Process

The Application's interface for network topology recognition is utilised to identify marker photos in the paper sheet and present information and augmented reality content in the form of three-dimensional network topology objects. Figure 5 illustrates the procedure of reading the marking.

The user aligns the Android smartphone camera with an image, which serves as a marker for the programme to search the database and locate the suitable object to be shown on the smartphone screen. When the marker image and the image in the database are identical, the application displays the marked object on the marker image. The camera then proceeds to render the object, allowing the application to present augmented reality content and information based on the marker image. This presentation is adjusted to the device's database.

Fig 5. Marker Reading Process

4.5. System Design

The system is developed using the Android platform. It incorporates a marker-based media application, which consists of many markers with predefined patterns. Each marker is associated with specific coordinates and triggers the display of corresponding 3D objects. The displayed object will be the network topology system, with each marker revealing a specific part. The system's design is seen in Figure 6.

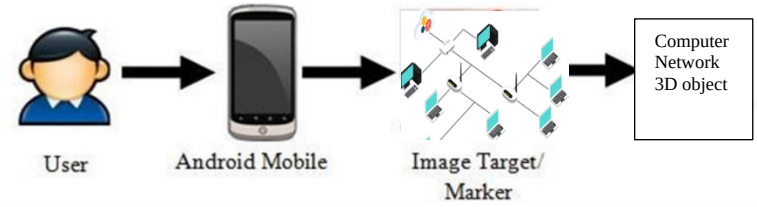

Fig 6. System Design

The target image is composed of images depicting computer netework topology. Before using an image as a marker in Vuforia, it needs to be converted into the *.unitypackages extension and added to the Vuforia database. The image should also have a config.xml file, which allows developers to customise various features of the trackable. The trackable database, along with the binary files, can be managed using the online Target Management System on the Vuforia website.

5 Conclusion

The findings highlight the need for innovative educational media that can be delivered through ICT, making teaching and learning more accessible and convenient. In response, a mobile-based Augmented Reality (AR) application, specifically designed for Android devices, has been developed to enhance the study of computer network topology. This application utilizes Vuforia and Unity 3D Engine to create an immersive learning experience, enabling students to visualize and interact with 3D models of network topology, which are otherwise difficult to observe directly.

The system's architecture is built around the Vuforia SDK, which employs various components such as a camera, image converter, tracker, and video background renderer to facilitate AR experiences. The

application works by recognizing marker images through the camera, which then triggers the display of 3D network topology models on the device screen. This interactive approach not only makes the learning process more engaging but also offers a detailed and realistic representation of network topology.

Overall, this AR-based learning medium provides a novel and effective solution for teaching complex subjects like network topology. By leveraging the capabilities of mobile technology and AR, the system enhances the educational experience, making it more interactive and accessible for both students and lecturers [23].

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