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Implementation and Evaluation of Augmented Reality Technology in Chemistry for Secondary Education in Bangladesh: A Case Study

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Abstract

There is a dearth of study on the effects and consequences of augmented reality in the field of education, and research on augmented reality (AR) technologies is still in its early stages. A user can check virtual objects superimposed on live video of this display reality via visual following or plan rendering in mobile augmented reality. While there have been a number of studies on AR, the ways in which these studies define AR and the circumstances in which they apply AR differ significantly. The textbooks in our country are not well organized and brings monotony while studying the chapters. Augmented Reality technology can solve this problem. We have seen in various articles that this technology is being used successfully. The study has been conducted to establish an effective system for making the education process easier. The purpose is to ensure that students can learn chemistry by not only memorizing but by understanding the concepts for which Augmented Reality has been used. Augmented Reality will help to get 3D vision of the concepts of chemistry. From the system established, students will be able to learn the difficult concepts easily and can enhance their knowledge which will help to build a better understanding of the concepts of chemistry.

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1. Introduction

1.1 Overview

The utilization of digitized graphical components, audio, or other sensory stimulation transmitted due to digitalization creates an augmented rendition of the real physical world. It is an increasing trend among businesses that deal with mobile computing and commercial applications in particular [1].

Chemical skills improve our quality of life in a diversity of ways by introducing advanced approaches to difficulties in health, materials, and energy use. Currently, educational textbooks have been established, as well as theories and reactions. Although the phenomena in the idea can be witnessed visually, further explanation need animations to illustrate the phenomena molecularly.

In this study we are going to propose and design an AR based framework for Chemistry books for interactive learning. Implementation and Evaluation of Augmented Reality in Chemistry serves the purpose of giving clear knowledge about the topic. Our purpose is to give proper idea and enrich the knowledge so that students have a clear concept while studying. Moreover, today's generation are more likely to use phone applications and Augmented Reality will serve this purpose by helping them to learn the concept by visualizing the models and reactions rather than only reading from the textbooks.

Previous studies show the poor performance of students in Chemistry which refers that chemistry is complex to learn. Chemistry is taught as a series of formulas to be memorized and applied just for the sake of learning. Students often fail to grab the actual concept due to lack of practical implementations. It can also be included that the structural compounds, reactions and many more difficult concepts are hard to understand by reading textbooks only. We are providing solutions where students can easily understand the topics. As a result, we will depict the models using Augmented Reality, which will aid in the simplification of the educational process and urge pupils to grasp abstract concepts. As a result, AR can be utilized to help students learn chemistry concepts that require good visualization.

1.2 Background

In 1957, a cameraman called Morton Heilig was the first to accomplish augmented reality to around extent. He created the Sensorama, a device that provided the viewer with images, noises, vibrations, and odors. Of course, the condition was non- automate, however, that was the initial challenge at enhancing an experience with new information. Myron Krueger, an American computer artist, formed "Video Place" in 1975, which permitted users to modify and communicate with holograms within actual time. Louis Rosenberg's AR system at USAF Armstrong's Research Lab in 1992, was greatest likely the first fully purposeful AR system. Virtual Stuffs was a complex robotic system created to recompense for the early 1990s lack of high-speed 3D graphics dispensation capacity. It allowed for the overlap of sensory data on a workstation in order to enhancing worker efficiency. Between then and now, augmented reality has seen a number of significant developments [2].

AR was first imagined as a science-fiction notion to contribute the original narrative in films, books, and plays.

The invention of augmented reality has revolutionized the way we live, work, and play. AR has dislocated every sector of the economy, fromeducation and healthcare to economics, manufacturing, and logistics [3].

1.3 Objective

General Objective

In this study we are going to develop Augmented System for studying chemistry. This system will aim in simplifying the educational process. Students will be motivated to understand abstract ideas and visualize the difficult concepts though this system.

Specific Object

- To design an Augmented Reality frameworkfor studying chemistry.
- To utilizing the Vuforia library and Unity, create an Augmented Reality system using the recommended framework.
- To study and implement virtual model, such as 3D into the proposed system.
- To find out the effectiveness of Augmented System as an educational tool for studying chemistry.

2. Literature Review

2.1 Overview

In this section we are going to concentrate on Augmented Reality and past researches, works, implementations conducted in Augmented Reality applications. Firstly, we have discussed the definition and previous works related to Augmented Reality. Secondly, we have focused on the Vuforia Tracking Library. Later we have given a short review of several methods on 2D, 3D implementation in chemistry field. Lastly, we have discussed rendering, Augmented Reality applications. We hope to eliminate the problems with spatial skills in chemical microstructure training as a result of these investigations.

2.2 Augmented Reality

Augmented Reality is a method of projecting computer-design digital data overlaying a live direct or indirect actual life environment. The history of augmented reality dates back to the 1960s, as per Johnson, Levine, Smith, and Stone (2010), and the initial platform was utilized for both Virtual Reality (VR) and Augmented Reality (AR). It incorporated a head-mounted optical see-through display that could be mechanically or ultrasonically monitored. AR in education and training is expected to have a more streamlined approach with wider user acceptance than ever before because of its potential to captivate and inspire learners by researching and managing content from a range of varied angles that have not previously been explored.Overall, we will see much more AR development and smaller, faster, less expensive, and better technology to support AR. We will also see improvements made to the way we interact in and with AR experiences as we learn more about how people use AR applications, as we develop new technology to support different kinds of interactions. Another

trend will be toward tools that make it easier to search and find AR experiences that might be useful [4].

2.3 Mobile Augmented Reality

Mobile Augmented Reality (MAR) is a novel display paradigm that allows virtual content to be projected in a way that gives the impression of physical and virtual co-presence [5].Augmented reality mobile devices are gradually becoming more powerful and less expensive. New hardware options, like as mobile projection devices, are increasingly becoming available, allowing for the development of new types of mobile AR applications. The terms "portable" and "mobile" augmented reality apps are used interchangeably. Some individuals are more willing to accept the necessity for additional technology for AR applications than others [4].

2.4 Augmented Reality Tracking Library

A software development kit for augmented reality may be used by programmers to create digital things that resemble the real environment. Because it includes features like 3D object tracking, photo recognition, visual SLAM (simultaneous localization and mapping), multi-tracking, and more, the AR SDK is vital for businesses creating AR experiences. SDKs can help with mobile apps, various CAD systems, marketing experiences, and more. Although these SDKs are primarily built for certain frameworks and hardware, several AR SDKs can be utilized on other platforms, increasing their versatility. To be eligible for the AR SDK category, a product must meet the following requirements: provide the ability to create custom AR experiences, allow for the modification of current augmented reality experiences, combine operating systems with hardware [6].

Vuforia

Vuforia stands a platform independent Augmented Reality (AR) and Mixed Reality (MR) progress stage that runs exact stalking and accomplishment happening a widespread collection of computer hardware (with portable strategies and varied certainty Head Mounted Displays (HMDs) like the Microsoft HoloLens). Visualization apps and games for Android and iOS by means of a punch-up authoring policy appreciation to Unity's firm with Vuforia. The Unity Asset Store has a Vuforia AR+VR samples package with several relevant examples exhibiting the platform's most significant features [7].

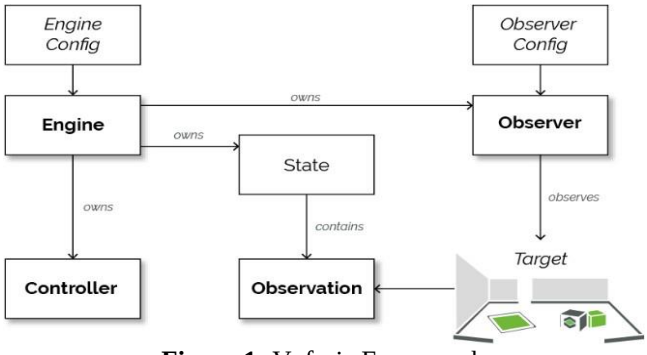

Figure 1: Vuforia Framework

2.5 2D, 3D generation

Augmented reality (AR) is a three-dimensional dynamic interaction that combines actual-world views with computer-generated features. AR differs from VR in that it layers computer features onto real- world items in real time, whereas VR is a self- contained computer environment [8].

An Augmented Reality experience is always 3D since the digital parts are placed in a 3D world. AR elements, on the other hand, can be two-dimensional or three-dimensional [9].

Real estate business cards are an example of 3d generation. Users initially feel they are receiving yet another business card from a real estate salesperson. Then, with just one click, the business card is transformed into a 3D augmented reality video introduction. Customers can be easily benefitted by seeing the video and can get idea about the company. Side by side the companies will be able to show their perspective to the customers easily [10].

2.6 Multimedia Generation

In participatory performance, interactive audio augmented reality (AAR) promotes collaborative storytelling and human connection. Spatial audio improves the auditory environment while also allowing for real-time management of media content and the overall experience. Nonetheless, the use of AAR to interactive performance techniques is understudied [11].

The user experience has received minimal attention in AAR research, which has emphasized on technological characteristics and interaction possibilities with gadgets and media.

3. Methodology

3.1 Overview

The designed model of the AR system and its stages of completion are discussed in this sector. It describes the objectives and explanation of the process of conduction of the research.Additionally, this chapter summarizes our methods, planning, design and analysis of the system.

3.2 Research Methodology

Our major purpose is to create an Augmented Reality system based on the projected framework using Vuforia library and Unity. We are going to show the 3D models of the reactions which will serve in simplifying the educational process. Students will be motivated to understand abstract ideas and visualize the difficult concepts. Based on the user's feedback we have evaluated the progress and its efficiency.

3.2.1 Development Methodology

We have done our research based on System Development Life Cycle (SDLC). The SDLC is a project

management model that outlines the steps necessary in taking a project from start to finish [12].

The SDLC approach clarifies the problem so that the plan can be implemented precisely. It is the most effective technique to maintain optimal control, reduce difficulties, and let the project manager to operate production without having to micromanage the project participants. The stages used in SDLC are perfect for the implementation of our proposed system. SDLC helps to transform the project into a functional and operational structure.

Planning is an important part while starting any work. We discussed the key components of the project as well as the vocational, financial, and manpower needed to finish the project. After planning, we defined the requirements and prototypes for our system and analyzed it.

The application, network, databases, user interfaces, and system interfaces were all designed. We used UML diagrams created during the design phase to meticulously implement the system's architecture in program code, designing procedures and algorithms for data processing and preparing project deliverables. User evaluation was used to test the system's functionality. Debugging was carried out to address the system's problems and issues. Following the completion of system testing, the program was declared ready for usage with the students of secondary education.

3.3 System Development

To develop the software, we follow the mentioned processes.

3.3.1 Data Collection

For gathering information, we have used the chemistry books of Higher Secondary students. We have analyzed the critical concepts from books and tried to make the complex ideas easier.

Moreover, some data and videos were collected from internet.

3.3.2 Integration and Testing

Here we have built our modules using unity and tested the modules in order to see its development. We faced some problems during the testing period. Sometimes when image was lost, the desired output was still visible. Also, the video start to be played automatically after starting the application.

3.4 Summary

We used the System Development Life Cycle for development methodology. The android platform was targeted for a mobile AR system. We also used libraries such as Android SDK (software development kit), Android NDK (Native Development Kit). During implementation we used default scripting code of unity and slightly modified where needed. Thus, using the above-mentioned method we designed and analyzed our model.

4. Implementation

4.1 Overview

This sector gives a quick overview of our system's implementation and evaluation. It mainly focuses our attempt on the development of the chemistry-based application on the mobile AR system for Android Smartphones. Here the working procedure of our system is discussed. Implementation of the audio, video visuals, multimedia generation has been discussed. The camera of Android is used for capturing real-time video. Lastly, the results and findings has been discussed from our survey which was carried out to determine the efficiency of our developed system.

4.2 Development of the AR System

Augmented reality (AR) development platforms provide tools to create AR products that superimpose computer-generated images into the real world.

The AR apps mainly operate by enabling the software to pinpoint particular patterns via the device camera, then overlaying digital information upon the real-world environment. A virtual user interface will appear on top of the object as the smartphone user points it at a certain setting or object. Next, the digital overlay is applied on top of the recognized pattern in animated or 3D images.In our system we have done audio, video capturing, 2d, 3d image recognition using unity and implemented the mobile AR system with an aim to make the study process easier in chemistry for Secondary Education in Bangladesh.

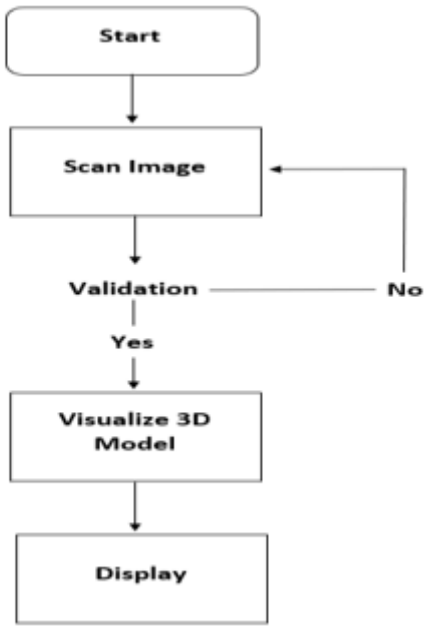

Figure 2: Flowchart of the system

4.2.1 Video Capturing

Augmented reality augments the real environment with the help of a gadget, most commonly a smartphone or tablet.For our system, we used an android smartphone's built-in Android camera. Video is captured at 1080*1920 resolution. For accessing the camera and video capture options, we utilized Unity's default script.

Firstly, we've designed a system-wide primary menu. After opening the system, the menu will be displayed with 3 options. The first option is model and on pressing the option click the default camera will be open. The camera then looks for recorded markers. When it locates the marker, it displays the required video or 3D model on the phone's screen, for which we have included the function “videoPlayer.Play()” in the “On Target Found()” procedure. When the image is lost the video or 3D model is lost as well, which is why we've included “videoPlayer.Stop()” to the “On Target Lost()” procedure. We have also used 2 buttons play and pause for manipulating video. In the play button in case of “On Target Found()” we have called the function “PlayPause.PlayVideo”. In case of pause button, “On Target Lost()” the function “PlayPause.PlayVideo” has been called.

Secondly, we have the periodic table which will open the default camera similar to the model option. After the periodic table gets scanned a 2D image will be displayed above each element name. Here inside the onclick option we used “PanelOpener()” function for showing the element details.Then we have our last option which is structure where the atomic structures of elements have been displayed.

4.2.2 2D/3D Graphics Generation

Vuforia stands as a platform independent Augmented Reality (AR) and Mixed Reality (MR) progress stage that runs exact stalking and accomplishment happening a widespread collection of computer hardware (with portable strategies and varied certainty Head Mounted Displays (HMDs) like the Microsoft HoloLens). Several third-party devices (such as AR/MR spectacles) and VR strategies with back-facing cameras are maintained by Vuforia.

Figure 3: 2D generation in our system

This image depicts 2D generation in our system. We have taken a 3D object and displayed 2D image on it.

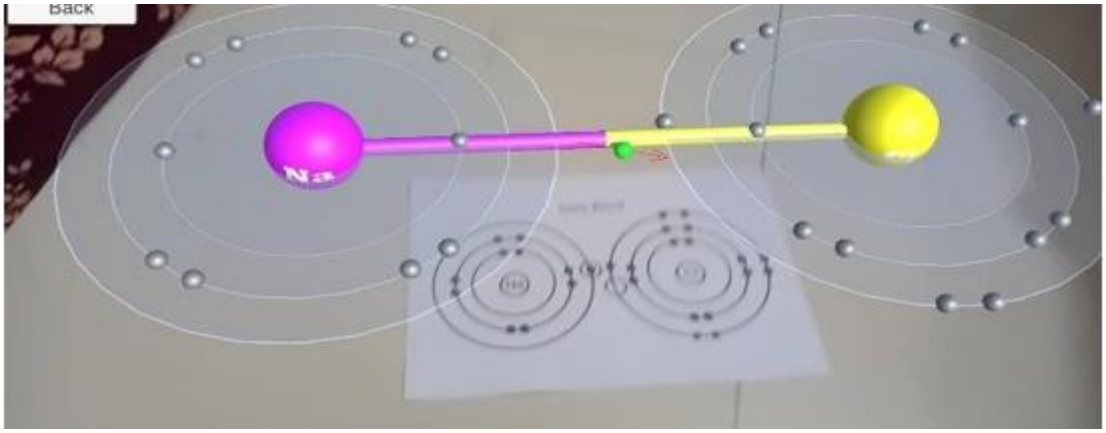

Figure 4: 3D generation in our system

Similarly, we have created the 3d images in our system. We have created the structure in blender and build the animation in unity. Some features of blender animation are not supported in unity due to library missing.Blender is suited for model creation, and it is utilized by a variety of graphics and VFX artists to bring their vision to life on screens in 2D and 3D computer graphics. The user interface is comparable to that of every other 3D working software that deals with data such as lines, nodes, and polygons. Blender was used for modeling, texturing, lighting, rigging, and rendering. Blender has been used for our system since the models were easily created according to our need without any interruption.

4.2.3 Multimedia Generation

The presentation of text, pictures, music, and video with connections and tools that allow the user to browse, participate, create, and communicate using a computer is known as multimedia.Multimedia is the use of text, music, video, graphics, and animation to deliver information in a visually appealing and interactive manner. Many digital platforms now function without multimedia, which improves user engagement and offers a dynamic educational or entertaining experience. Multimedia conveys information and encourages user interaction and creativity by combining various elements such as text, images, music, and video. It is an adaptable tool for education, entertainment, and communication throughout the digital landscape because of its immersive character, which allows users to explore content, share ideas, and interact successfully. Users' interactions with and consumption of digital material are transformed by the seamless integration of various components, which produce a rich and interactive environment.

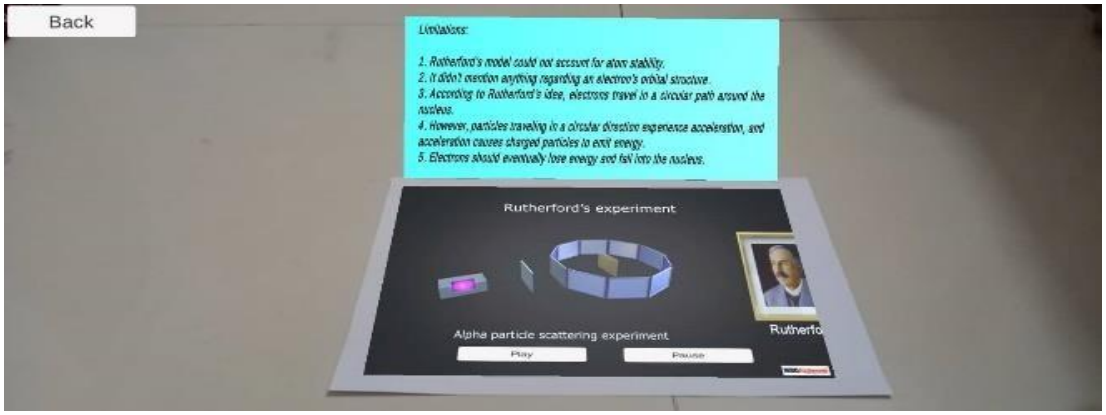

Figure 5: Video representation of our system

4.2.4 Result Analysis

For our system, we have surveyed on 110 participants. Among them,85.5% people have idea about the system implemented using augmented reality. On the contrary 14.5% people had no idea about it.People expressed differing opinions on the efficacy of augmented reality as a chemical study tool. 74.5% people strongly agreed,13.6% people agreed and 11.8% were neutral. Maximum responds were positive and people strongly agreed that augmented reality will be effective as a study tool in chemistry. Only few people gave a neutral answer.Therefore, it can be said that Augmented reality gives students the ability to visualize and understand more abstract chemical concepts which makes our system more effective and from the overview of the findings we can easily visualize that majority of the people gave positive review on the efficiency of Augmented Reality as a study tool in learning chemistry.The testing has been done after completing the system. The system is operational and displays the pictures that the Vuforia Engine can detect and track. By comparing extracted natural attributes from the camera picture against a predefined target resource database, the Engine recognizes and tracks the image. Similarly, we have created the 3d images in our system. We have created the structure in blender and build the animation in unity. The whole system works accordingly and helps to reflect Augmented Reality in our system.

Table 1: Respondents successes or failures in performing the functionality task

No	Statements	Responses				
		Yes			No	
1	Do you have any experience/knowledge related to Augmented Reality?	85.5%			14.5%	
2	Do you think Augmented Reality is effective as study tool for studying Chemistry?	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
		74.5%	13.6%	11.8%	0%	0%

5. Conclusion

5.1 Overview

This section comprises the outcomes of the research. The overall goal of this study was to simplify the educational process and assist students in grasping complex concepts by using this approach to visualize difficult subjects. We aimed to design an Augmented Reality framework for studying chemistry using Vuforia library and Unity and to implement virtual model, such as 3D into the proposed system. Also, evaluation and survey has been done to find out the effectiveness of Augmented System as an educational tool for studying chemistry. The percentages obtained from the data survey showed the system to be efficient and effective. The contribution, limitations and scopes for future work of the study are also discussed here.

5.2 Implementation of Video and Model

We have used unity and its functions for creating the 3D models and animation. We have called Unity's built-in tracking and AR registration systems. In the procedure "OnTrackingFound()", we used "videoPlayer.Play()". We called "videoPlayer.Stop()" into the function "OnTrackingLost()" for our desired video and 3D model. We called the function "PlayPause.PlayVideo" in the case of "On Target Found()". In case of pause button, "On Target Lost()" the function "PlayPause.PlayVideo" has been called. For onclick option we used "PanelOpener()" function in order to display the element details.

5.3 Implementation of Methodology and Objective

We chose the System Development Life Cycle technique for our system. Planning, system analysis, system design, development, implementation, integration and testing, operations and maintenance are all parts of the systems development life cycle. Here we have built our modules using unity and tested the modules in order to see its development. Our main aim and objective are to motivate students to understand abstract ideas and visualize the difficult concepts though this system.

5.4 Graphics Generation

The integration of Vuforia with Unity allows for the creation of vision apps with a drag-and-drop development methodology. We used Unity to create 3D and 2D graphics and Blender to make the models. Blender can be used to create models and to bring one's imagination to life and display in 2D and 3D computer graphics. We created the atomic model structures using blender's application interface. The atomic bonds and structures including atomic size, shape was created easily with blender. Thus, blender has been useful for our system for creation of the models.

5.5 Limitations and Recommendation for Future Work

Some recommendations for future research and studies in terms of this research are-

Although it may be incorporated in the future, handwritten word recognition is not currently included in the system. Users who don't have significant access to augmented reality (AR) devices may find it difficult to have a completely immersive learning experience from the program. The cost and availability of appropriate equipment may also limit the app's usefulness and prevent it from being accessible to a larger user base. Furthermore, because the software does not currently support handwritten word recognition, its utility for students who prefer handwritten notes may be restricted. In the future, handwritten word recognition could be added to improve the app's versatility and get over this problem, making it more appropriate for a larger variety of learning styles. These days, smart glasses and augmented reality are standard in the office. In the upcoming years, these tools may play a critical role in improving productivity, teamwork, and company results. Laboratory apparatus and instruments can be operated by a virtual hand.

5.6 Summary of the Research

We have developed a system to use Mobile Augmented Reality for Android Smartphones. The mobile AR system in this study incorporates 3D and multimedia modules. The literature review contains reviews on Augmented Reality, invention, future works and examples of Augmented Reality. The SDLC method was utilized to construct multimedia modules in mobile AR system for the study's development process. To prove the system's efficacy, we performed a survey. According to the results of the survey, 85.5 % of people are aware of the augmented reality system, and majority of the people believe it is beneficial for our education system. We have tried our best to successfully implement the system. Finally, the mobile AR system met the research objectives' expected outcomes. Moreover, the system can be developed further with the help of integrating some new features.

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