MARKER-BASED AUGMENTED REALITY APPLICATION FOR LEARNING ANATOMY

Kwame Agyemang Baffour

ABSTRACT

The study of anatomy is very important in health sciences as it provides basic knowledge about the human body and as well as the fundamental concepts on how the human body functions. There is a growing interest in teaching and learning in virtual environments particularly with Augmented Reality (AR) and Virtual Reality (VR). The goal of this project was to create an augmented reality application that will aid students in their study of anatomy by allowing them to visualize and examine various anatomical 3D models from different sides and angles, making the study of anatomy simpler, more participatory and interactive. Unity3D and the Vuforia SDK were used to develop the marker-based Augmented Reality application for this project. The marker used for this study comprised six (6) print outs of unique QR code images put together to form a cube which when scanned displayed different sides of the 3D model under study. The application also made the affordance for interacting with the different parts of the anatomical model on display using finger gestures. This interaction and input was made possible with the technique of Raycasting.

Index Terms:
Computing methodologies—Mixed/Augmented reality—;——Computing methodologies—3D model, marker—

1 INTRODUCTION

The study of anatomy is very important in health sciences as it provides basic knowledge about the human body and as well as the fundamental concepts on how the human body functions. According to Pabst & Rothkotter [3], the highest medical relevance was assigned to gross anatomy in a study of doctors seven years after their graduation. Any life sciences educational program must have anatomy as its cornerstone. However, there are considerable obstacles that students must overcome in order to study anatomy. In a college or university setting, when learning anatomy, students usually have difficulty trying to visualize different aspects of the human body, which inherently are too complex or abstract to fully understand without the aid of useful visual explanations or visualizations.

2 RATIONALE

In today's educational settings, virtual environments and digital games are widely used as instructional assistance tools [5]. There is a growing interest in teaching and learning in virtual environments particularly with Augmented Reality (AR) and Virtual Reality (VR). The goal of this project was to create an augmented reality application that will aid students in their study of anatomy by allowing them to visualize and examine various anatomical 3D models from different angles, making the study of anatomy simpler, more participatory and interactive.

3 RELATED WORK

Paper and blackboards are 2-D educational media that are very convenient, familiar, flexible, portable, and inexpensive [1] and are the most popular choice in educational institutions all over the world. However, those traditional teaching approaches restrict the provision of dynamic content and, more importantly, do not enable students to be immersed in and engage with real-world situations. Virtual reality can help with this issue, but it also risks causing students to become disconnected from the real environment [1]. Augmented Reality, however offers students the chance to become fully immersed in simulated real-world scenarios that are blended with their actual real world settings. In a study by Kurniwan et al. [2],The authors conducted a study to measure the impact of learning human anatomy using augmented reality application. An augmented reality application was developed for this study. This system uses augmented reality markers on a mobile computing platform as its technique. A photograph was taken to document the marking. The captured image is then cut up into fragments, and the pattern is compared to pictures kept in the database. The Floating Euphoria Framework and the SQLite database were both used in this study. The augmented reality program has features that allow for the interactive visualization of the entire body or specific organs. The augmented reality anatomy system was evaluated by conducting a test on high school students and medical students to see how well it worked for teaching the human body's structure. The findings indicated that the interactive augmented reality visualization in the human anatomy learning system makes it easier for students to understand human anatomy. In a survey by Radu [4], it was found that compared to other media like books, videos, or PC desktop experiences, augmented reality is more effective at teaching students about specific subjects. When used correctly, AR can be helpful for learning in a variety of ways. Long-term memory, group cooperation, motivation, and material comprehension can all improve as a result. It should be used as a supplement to traditional schooling, not as a replacement for it. The potential benefits of AR for education and learning have already been mentioned. Despite this, there are numerous hardware and program applications for this technology. In terms of hardware, there are three common choices: handheld devices, head-mounted displays, and spatial augmented reality.Handheld devices, such as smart-phones and tablets, are, for many reasons, the best option for modest AR experiences that have the purpose of enhancing the educational experience. Compared to other kinds of AR displays, they are less expensive, simpler to use, and use a lot of sensors, which are essential for an effective AR system. These sensors, which include cameras, GPS, accelerometers, gyroscopes, and digital compasses, can be used to accurately determine what the user is doing and where they are at any given moment. They also have sufficient computing power and the capacity to link to the internet with ease. The market penetration of smartphones and tablets, however, is their primary advantage. It is obvious that a platform like smartphones is much more effective than the others we listed for this use.

4 METHOD

4.1 Development Tools

Unity3D[1], a game development tool and the Vuforia SDK[2], a software development kit were used to build the Augmented Reality application for this project.

[1]https://unity.com
[2]https://developer.vuforia.com

4.2 Marker

This project was developed as a marker-based Augmented Reality application. A marker-based AR application requires a marker, which is a distinct image easily recognized by the camera which activates the augmentation. Markers, which can be made of paper or real-world objects, are distinct patterns that cameras can quickly identify and analyse. They are visually independent of their surroundings. The marker used for this study comprised six (6) print outs of unique QR code images put together to form a cube which when scanned brings up different sides of the 3D model under study.

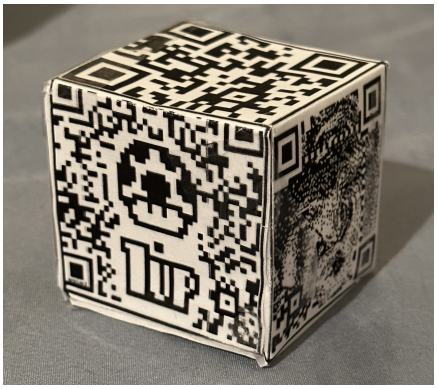

Figure 1: Marker for Augmented Reality Application

4.3 AR Display

The application was deployed on an IPhone 14 Pro Max with a screen size of 6.69 inches, refresh rate of up to 120 Hz and a resolution of 2796 x 1290 pixels.

4.4 3D Models

Several royalty-free 3D models of the human body were obtained from the internet, appropriately labeled with relevant information and imported into Unity3D to build the application. A 3D model of a human avatar was also downloaded from Adobe Mixamo [3] and used as the animated character for the application. The 3D models were of the FBX file format.

4.5 Animation

The talking animation, obtained from Adobe Mixamo was imported into Unity3D and applied to the avatar. The rest of the 3D models of the human body were not animated.

4.6 Input and Interaction

The application made the affordances for interacting with the different parts of the anatomical model on display with touch input using finger gestures. This interaction and input was made possible by the concept of Raycasting and the LeanTouch[4] Asset obtained from the Unity Asset Store. In 3D computer graphics, Raycasting is used to trace the path of light in a scene thereby making it possible to know which object or part of an object a ray of light intersects with. In this instance, Raycasting made it possible to know which part of the 3D model received touch input from the user's finger.

[3]https://www.mixamo.com

[4]https://assetstore.unity.com/packages/tools/input-management/lean-touch-30111

4.7 Audio and Text Annotation

Text annotations on each part of the 3D models in the application were obtained from several internet sources[5][6][7] and converted to audio using a free online text to speech tool, TextMagic [8]. The text annotations and audio were both imported into Unity3D and linked to the appropriate parts of the 3D models they represented. Whenever a part of the 3D model was touched, an audio and the text presenting some information on that part of the 3D model was played back and displayed to the user. Presenting the text and audio on touch of any part of the 3D model was made possible using Raycasting.

5 RESULTS AND DISCUSSION

On launch of the application, the user is presented with a menu containing images of the 3D models used in the application, and an exit button. Clicking on each of the menu items takes the user to the scene corresponding to that 3D model. Access to the smartphone's camera is requested the very first time the application is launched.

Figure 2: Menu of the Augmented Reality Application

By focusing the camera on each image of the marker (cube), the top, bottom, left, right, front, and rear of the anatomical model under investigation can be seen on the smartphone screen and interacted with using finger gestures. Although the application allows for interactions like scaling, translating and rotating of the 3D model in question, the rotation feature of the application is not very intuitive to use. It is generally more difficult to rotate a 3D object on a touch screen device using finger gestures. Having the marker in the form of a cube solves the problem with rotation by changing the view of the 3D model on display anytime the cube is rotated. When any part of the 3D model is touched, that part is highlighted green and its text annotation is displayed at the bottom right corner of the screen in addition to playing an audio of that text displayed. Touching any part of the screen other than the 3D model deselects the highlighted part of the model, sets its color to gray and stops the audio playback.

[5]https://www.cancer.gov/publications/dictionaries/cancer-terms/def/skull

[6]https://www.ncbi.nlm.nih.gov/books/NBK532292/

[7]

[8]https://freetools.textmagic.com/text-to-speech

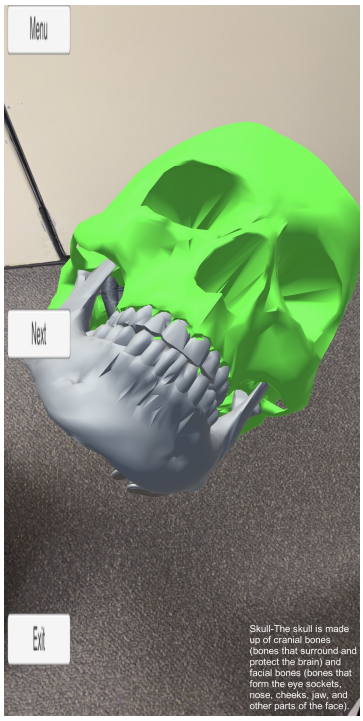

Figure 3: Scene showing a translated and scaled 3D model of the skull with both selected and deselected parts

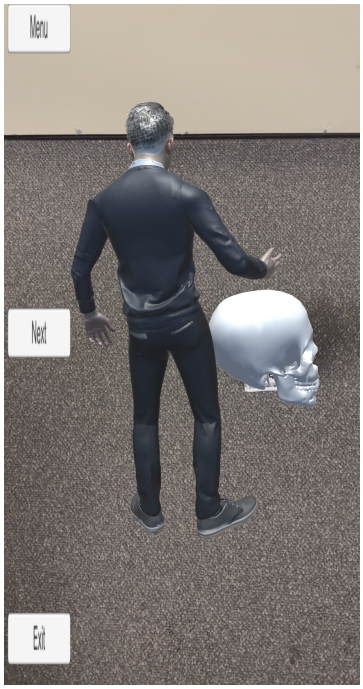

Figure 4: Side view of skull 3D model with Avatar

There is a Next button to go to the next 3D model, a Menu Button to go back to the Menu and an Exit button to quit the application on each scene. The application was exposed to several people to test out and the general feedback towards the application was positive.

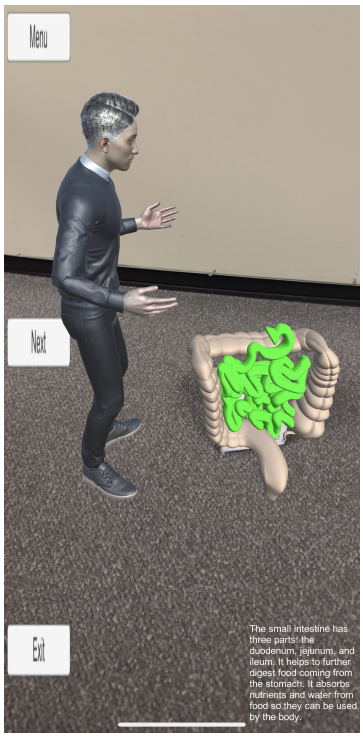

Figure 5: Scene showing selected part of 3D model of intestines with corresponding text annotation

6 LIMITATIONS AND FUTURE WORK

The application can be enhanced by increasing the number of anatomical 3D models used. These 3D models can also be animated to make the experience more interesting and interactive. A quiz asking users to answer questions or requesting that users assemble these 3D models will also be a good addition to the application to introduce a challenge to the users.

7 CONCLUSION

The study of anatomy is very important in health sciences as it provides basic knowledge about the human body and as well as the fundamental concepts on how the human body functions. This paper has described some problems in learning anatomy and also presented a solution to counter some of these problems. This study presents an marker-based augmented reality application to aid the learning of anatomy using a cube as a marker. Considering the benefits of the personalized and interactive AR applications for motivation and perception of anatomy learning, this tool could be modified and extended, in addition to other new technologies to help facilitate autonomous learning and also to reduce laboratory material and instructor costs.

8 LINK TO GITHUB REPOSITORY

https://github.com/kwameb4/NURSING_APP

REFERENCES

[1] M. Kesim and Y. Ozarslan. Augmented reality in education: current technologies and the potential for education. *Procedia-social and behavioral sciences*, 47:297–302, 2012.

[2] M. H. Kurniawan, G. Witjaksono, et al. Human anatomy learning systems using augmented reality on mobile application. *Procedia Computer Science*, 135:80–88, 2018.

[3] R. Pabst and H.-J. Rothkötter. Retrospective evaluation of undergraduate medical education by doctors at the end of their residency time in hospitals: consequences for the anatomical curriculum, 1997.

[4] I. Radu. Augmented reality in education: a meta-review and cross-media analysis. *Personal and ubiquitous computing*, 18:1533–1543, 2014.

[5] K. Segaran, A. Z. Mohamad Ali, and T. W. Hoe. Does avatar design in educational games promote a positive emotional experience among learners? *E-Learning and Digital Media*, 18(5):422–440, 2021.