A Natural Interaction Paradigm to Facilitate Cardiac and Nerve Anatomy Education using Augmented Reality and a Surgical Metaphor

Dr. Shashikala S V, Professor & HOD, Department of Computer Science and Engineering, Adichunchanagiri university, BGS Institute of Technology, BG Nagara, Karnataka

Amith D, 4th Year, 7th Sem, Department of Computer Science and Engineering, Adichunchanagiri university, BGS Institute of Technology, BG Nagara, Karnataka

Disha T S, 4th Year, 7th Sem, Department of Computer Science and Engineering,Adichunchanagiri university, BGS Institute of Technology, BG Nagara, Karnataka

Lekhana H L, 4th Year, 7th Sem, Department of Computer Science and Engineering,Adichunchanagiri university, BGS Institute of Technology, BG Nagara, Karnataka

Likith R, 4th Year, 7th Sem, Department of Computer Science and Engineering,Adichunchanagiri university, BGS Institute of Technology,BG Nagara, Karnataka

Abstract: This study describes a design methodology for developing an interactive visualization environment using Augmented Reality (AR) based on Head Mounted Displays (HMDs) to provide a learning experience for cardiac and Nerve anatomy. After precise model geometry was obtained by computed tomography imaging techniques and optimized in a 3D modeling software package, photo-realistic texture mapping was achieved by using 3D painting software. Using this strategy makes modeling intricate, organic geometry easier. The Unity game engine was used to provide animation, rendering methods, and augmented reality functionality. The architecture and development of the system depicts complicated learning information, maximizes immersion, and facilitates natural gesture interaction inside a real- world learning environment. An accessible way to illustrate cross-section rendering in augmented reality was achieved by combining hand input with a surgical

dissection metaphor. This technique has led to well-directed lessons being learned.

Keywords: Augmented Reality (AR), Head Mounted Displays (HMDs), cardiac and Nerve anatomy, Unity game engine

1. INTRODUCTION

Medical students find it challenging to comprehend the anatomical anatomy of the heart and nerve because of the organ's complexity arrangement of several parts and multi- chambered structures. Conventional anatomy teaching approaches, which rely on 2D slides, plastic models, and photographs, might be less successful since they don't include student participation and make it harder to comprehend 3D structure from 2D materials. Through the resolution of these issues and the creation of a more engaging, dynamic, and adaptable learning environment, augmented reality (AR) and virtual reality (VR) can improve anatomy education. This work is a component of a larger educational initiative that uses cutting-edge technology to facilitate the efficient transmission of knowledge about cardiac and nervous system anatomy and physiology to medical students. A prototype for an interactive Augmented Reality Learning Environment (ARLE) that uses a head-mounted display (HMD) is now being created.

Its goal is to communicate the many inner and outside structures of the heart and nerves

In as well as the fundamentals of its circulatory system. The primary goal in designing this was to provide students with an authentic interactive enhanced reference tool that they could contrast with textbooks, tangible models, dissections, and surgical observation sessions. The prototype ARLE aims to achieve the following design objectives:

(1) enhancing the process of producing intricate, organic models using 3D scan data extracted from Computed Tomography (CT)

(2) augmenting learner immersion through HMD-assisted stereopsis

(3) enabling natural interaction with AR visualizations without requiring marker- based tracking, mobile devices, or physical peripherals

(4) presenting information in a realistic and captivating way with the help of graphic and animated content.

The design of the prototype system is the main emphasis of this study, which also highlights the significance of promoting natural interaction and employing a multi-layered strategy to provide visual learning information..

2. RELATED WORK

The key benefits of utilizing AR or VR in anatomy instruction are that these tools can support learners with limited visual- spatial skills [1] and promote more embodied, active, and exploratory learning, which enhances memory retention and learning efficiency [2]. Significant study has been done on the use of various delivery modes, such as highly immersive (3D VR) and less immersive (desktop) , for virtual learning for anatomy students[3]. For example, propose that a 3D immersive VR system can be a helpful substitute for traditional anatomy instruction techniques. Virtual reality and augmented reality representations of pelvic anatomy were compared against images and actual models in [4]. They discovered that "true stereopsis is critical in learning anatomy" and that physical models were a better learning tool than virtual and augmented reality. A Unity-developed virtual learning. resource on skull anatomy was made accessible in two distinct delivery modalities (more and less immersive) as part of a pilot research[5]. It was discovered that the stereoscopic delivery required more mental effort, and some individuals reported feeling more physically uncomfortable and disoriented. [6] examined the efficacy of presenting material on human physiology via non-AR on a tablet and AR using the HoloLens HMD. The study showed that both learning styles might be beneficial, even though some individuals experienced vertigo when wearing the HoloLens. However, no significant changes were found in test results.

Other research, however, points to the potential advantages of AR/VR for anatomical learning, including immersive interaction and visualization[7]. As an illustration of this,[8] developed an immersive anatomy atlas that allows users to engage with human anatomical structures through virtual dissection. With the help of an interactive manipulation tool, users may toggle visibility within a specified radius, adjust organ transparency, and utilize a head-mounted display (HMD) and bi-manual controls to study anatomy. Additionally, the program offers a cross-section feature that lets users disclose and conceal particular geometries. Students who used the interactive atlas had a higher memory rate than those who used standard anatomical textbooks. GAAR (Gross Anatomy Augmented Reality) is a mobile AR learning tool that [9] describe. Users of the tool might feel as though they are working on a "real" organ by engaging with 3D objects, video, and information. The Magic Book app for medical students to learn neuroanatomy; an app that combines AR and 3D modeling for learning molecular biology [10] and Human Anatomy in Mobile- Augmented Reality (HuMAR),which focuses on 3D visualization of specific bones, are the four interactive AR tools reviewed in a review of mobile AR applications for learning biology and anatomy[11]. According to [11], augmented reality (AR) has the ability to visualize complicated data and facilitate active learning. Additionally, they go over commercial augmented reality (AR) learning applications for learning biology and anatomy[11]. According to [11], augmented reality (AR) has the ability to visualize complicated data and facilitate active learning. Additionally, they go over commercial augmented reality (AR) learning applications for anatomy, emphasizing features that allow the user to interact with the 3D models, like the "Pinch In-Pinch Out" gesture, and controllers that allow the user to move 3D models in four directions, rotate, scale, or "peel off" the layers of an organ. Six applications are evaluated and compared by [12]: AR for the Study of Human Heart Anatomy Web-based AR for Human Body Anatomy Learning Human Anatomy Learning Systems Using AR on Mobile Application. An AR application for smartphones and tablets for cardiac physiology learning. A human heart teaching tool and a mobile AR application for teaching heart anatomy. Marker-based mobile augmented reality (AR) systems, according to [12], allow users to scan real-world physical pictures and display 3D visualizations that can be interacted with using a mobile smartphone. In summary, the ability to offer anatomy-related learning information through immersive HMD-based technologies like AR/VR is greatly enhanced by the unique interaction modes inherent in the hardware. Transparency methods and simulated dissection make natural interaction more easily accessible. For teaching anatomy, less immersive methods—that is, mobile augmented reality with touch-based graphical user interfaces—that allow for less natural engagement than head-mounted displays, however, are more frequently employed. The construction of the anatomy and the visualization of cardiac blood circulation are among the issues that must be resolved. One particular problem for developers is simulating dynamic fluids to simulate physiological processes including human circulation . For such dynamic visualization to occur without incurring costly processing of pre-cached particle animations, a game engine's physics processing power is needed. The ensuing limits of popular gaming engines in depicting liquids in real time at a sufficiently realistic level exacerbate the challenge.

3.PROPOSED SYSTEM

By utilizing augmented reality (AR) technology and a natural interaction paradigm, the proposed system aims to revolutionize the teaching of heart and nerve anatomy. Students and medical professionals will be able to interact with 3D representations of the heart and nervous system in real time thanks to this technology, which seeks to create an immersive, interactive learning experience that goes beyond typical textbook approaches. Users may see and operate realistic, anatomically correct 3D representations of the heart and nervous system in their actual environment by utilizing augmented reality technology. With the use of voice commands and intuitive gestures, this engagement becomes more natural and engaging. A complex augmented reality platform, accessible through AR glasses or mobile devices, lies at the heart of the system. This platform creates 3D representations of the heart and nervous system that are highly detailed and anatomically correct. The technology simulates the true motions and functioning of these organs by using sophisticated rendering techniques to provide realistic textures and dynamics. It also incorporates machine learning algorithms to offer adaptive learning experiences, tailoring the information according to the user's engagement style and level of learning.

Numerous interactive elements are available in the system, all aimed at improving comprehension and memory. With movements and voice instructions, users may manipulate the 3D models to examine heart and nerve cross-sections, dissect layers, and zoom in on certain parts. This system's capacity to offer a hands-on learning experience without requiring actual specimens is one of its main pedagogical advantages. This not only increases accessibility to anatomy instruction but also permits repeated practice without incurring expenses or raising ethical issues. Complex anatomical features might be difficult to learn from typical 2D textbooks or photographs; nevertheless, AR's immersive nature helps.

The flexibility of this system to various learning situations is one of its primary features. It may be utilized for independent study on one's own or in a classroom context, where a teacher can lead students through intricate anatomical structures and clarify ideas that are difficult to understand through text or 2D graphics alone The AR system may provide pertinent information, including the structure's name, function, and typical diseases connected to it, when a user points at a specific area of the model. This feature makes learning more enjoyable by giving users access to instantaneous, contextual information.

In order to guarantee accessibility, the system is made to work with a variety of gadgets, such as tablets, smartphones, and augmented reality headsets. This means that instructors and pupils with different means may utilize this cutting-edge teaching tool extensively. This suggested approach is a major advancement in medical education. Through the integration of augmented reality's immersive qualities with a natural interaction paradigm, learning becomes more efficient, interesting, and approachable while providing a strong and user-friendly instrument for comprehending the intricacies of heart and nerve architecture.

4. SYSTEM ARCHITECTURE

An immersive and dynamic learning environment is made possible by the intricate, multi-layered architecture of an Augmented Reality (AR) system for Cardiac and Nerve Anatomy Education. Generally speaking, this architecture consists of a number of essential parts, each of which is vital to the overall operation of the system. The front end of the system, or the User Interface (UI) Layer, is where users interact with the augmented reality application. Learners may easily move through different anatomical regions because to the UI's intuitive and user-friendly design. Usually, a 3D model and menus are included in this layer Additionally, it might provide users the ability to personalize their education by letting them choose certain cardiac or neuronal systems to examine in greater depth.

The AR engine, which superimposes digital data on the physical environment, is the brains behind the augmented reality system. Good, anatomically correct 3D models that users may rotate, examine,and interact with are rendered by the AR engine.The heart and nerve may be visualized in dynamic ways using AR. An three-dimensional model of the heart and nerve may be seen by students who use an AR-enabled smartphone to scan a picture from a textbook or a specified marker. With the use of virtual manipulations, one may examine various sections of the model, such as blood veins, valves, and chambers. Layer-by-Layer Exploration:

Using augmented reality, students may explore the several levels of the heart and nerve anatomy, including the complex network of coronary arteries and veins and the pericardium, myocardium, and other layers. Students may gain a thorough understanding of the intricate anatomy and operation of the heart and nerve by carefully examining each layer.

Dynamic Blood Flow Visualization: AR can replicate the heart's blood flow, showing how the ventricles, atria, and valves work in real time. Understanding heart sounds, cardiac cycles, and the fundamentals of blood circulation may all be greatly aided by this interactive portrayal.

AR can offer a thorough understanding of the neurological system, encompassing both the central and peripheral neural systems. With the use of 3D models of the brain, spinal cord, and nerve pathways, students may engage with them and develop a spatial comprehension that is not always possible with 2D representations.

Neuron Function: Students may see how nerve cells interact by examining a picture or a model of a neuron. AR may provide a visual representation of synaptic transmission, illustrating the exchange of chemical and electrical information between neurons

4.1 System Architecture

Different AR devices, such tablets, smartphones, and headsets (like the Microsoft HoloLens), must work with the system. To do this, the program must be optimized for various screen sizes, computing powers, and input modalities (such as hand gestures). High-resolution visuals and real-time interactions should be supported by the hardware with minimal delay. An advanced system of technology, content management, data analysis, and educational integration are all intricately woven together in the architecture of an Augmented Reality Cardiac and Nerve Anatomy Education system. Together, these elements provide students studying human anatomy an interesting, educational, and approachable learning environment.

5.SUGGESTED FRAMEWORK

The framework's introduction would start by stressing the value and advantages of augmented reality in medical education. This section will describe how AR can provide students an interactive, 3D representation of the anatomy of the heart and nerves, which will help them better comprehend the intricate structures and functions. Additionally, it will discuss how augmented reality (AR) improves learning beyond conventional approaches by bridging the knowledge gap between theory and practical comprehension. The design of the AR learning modules would be the main topic of this important part. Different facets of cardiac and neural anatomy, including the heart's structure, blood flow, nerve routes, and neuro-cardiac interactions, would be covered in each session. Students would be able to see, alter, and dissect virtual models through the interactive courses. In order to measure comprehension and retention, this section would also advise including tests and interactive evaluations in the augmented reality setting.

6. METHODOLOGY

In order to create an engaging and successful learning environment, there are many essential phases in the approach for utilizing augmented reality (AR) to teach cardiac and nerve anatomy. Compared to conventional approaches, this approach for offers a more participatory and engaging form of teaching by utilizing augmented reality technology to improve comprehension of complicated anatomical structures and their roles.

1. Development of Augmented Reality Content: Detailed 3D models of the heart and nervous system must be made in the first phase. Anatomically correct and very precise models are required for up close examinations of structures such as the heart chambers, valves, main veins, neurons, and nerve networks. To achieve maximum realism in the models, special focus should be placed on the textures, colors, and motions (such as heartbeats and nerve impulses). With 3D modeling tools, this material may be created and subsequently included into an augmented reality platform.

2. AR Platform Development and Selection: Selecting the appropriate AR platform is essential. The platform should be simple to use, available on several platforms (such as AR glasses, tablets, and smartphones), and able to process high-quality 3D models with little latency. In addition, the platform has to provide interactive functions like rotating, zooming, and dissecting the models. It may even have animations that mimic physiological processes like nerve signal transmission or the heartbeat.

The User Interface (UI) and User Experience (UX) design play a vital role in guaranteeing the intuitiveness and ease of usage of the AR application. The user interface should be straightforward yet functional, making it simple for students to move between the various parts of the heart and nervous system. In order to provide varied degrees of information or explanation as needed, the design should also take into account the diverse levels of users' experience with anatomy and augmented reality technology.

7. CONCLUSION

In conclusion, an AR environment that presents anatomical visualizations (Both Heart and Nerve) in three dimensions using head-mounted displays (HMDs) can enhance immersion and user friendliness by presenting models in three dimensions, anatomical visualizations, especially those involving complex organ structures with intricate shapes and configurations, may benefit from a dissection metaphor when viewed in an AR HMD.

8.FUTURE WORK

Future technological developments will concentrate on improving the accuracy of CT image extraction. This could alleviate the problem of low scanning resolution resulting in missing geometry in thin and complicated portions of biological systems. Following acquisition, the structures will undergo more remodeling and retexturing, producing an AR representation of the cardiovascular architecture that is increasingly thorough. The project will proceed with empirical user studies with cohorts of medical students that have been deliberately selected to examine interaction patterns and the efficacy of learning while using the ARLE when development and a study design are completed. It's also intended to build AI-based assessment methods. This includes ideas to use CT scan data to model the patient's unique heart and nerve structure, to use ECG data to identify potential diseases, and to animate the heartbeat rhythm and neuron transmitter on the 3D model to aid in decision-making and serve as an educational tool.

9. REFERENCES

[1] Bogomolova, K., Hierck, B. P., Looijen, A. E., Pilon, J. N., Putter, H., Wainman, B., and van der Hage, J. A. (2021). Stereoscopic three‐ dimensional visualisation technology in anatomy learning

[2] Cakmak, Y. O., Daniel, B. K., Hammer, N., Yilmaz, O., Irmak, E. C., & Khwaounjoo, P. (2020). The human muscular arm avatar as an interactive visualization tool in learning anatomy

[3] Kurul, R., Ögün, M. N., Neriman Narin, A., Avci, Ş., and Yazgan, B. (2020). An alternative method for anatomy training: Immersive virtual reality.

[4] Neriman Narin, A., Avci, Ş., and Yazgan, B. (2020). An alternative method for anatomy training: Immersive virtual reality. Anatomical Sciences Education

[5] Wainman, B., Pukas, G., Wolak, L., Mohanraj, S., Lamb, J., and Norman, G. R. (2020). The critical role of stereopsis in virtual and mixed reality learning environments

[6] Birbara, N. S., Sammut, C., and Pather, N. (2020). Virtual reality in anatomy study pilot evaluating Anatomical Education different delivery modalities.

[7] Moro, C., Phelps, C., Redmond, P., and Stromberga, Z. (2021). HoloLens and mobile augmented reality in medical and health science education,

[8] Venkatesan, M., Mohan, H., Ryan, J. R., Schürch, C. M.,Nolan, G. P., Frakes, D. H., and Coskun, A. F. (2021). Virtual and augmented reality for biomedical applications.

[9] Gloy, K., Weyhe, P., Nerenz, E., Kaluschke, M., Uslar, V.,Zachmann, G., and Weyhe, D. (2021). Immersive Anatomy Atlas

[10] Bakar, W. A. W. A., Solehan, M. A., Man, M., and Sabri, I.A. (2021). GAAR: Gross Anatomy using Augmented Reality Mobile Application

[11] Safadel, P. and White, D. (2019). Facilitating molecularbiology teaching by using Augmented Reality (AR) and Protein Data Bank (PDB)

[12] Kalana, M. H. A., Junaini, S. N., and Fauzi, A. H. (2020). Mobile augmented reality for biology learning

[13] Romli, R. and Wazir, F. N. H. B. M. (2021, July). AR Heart: A Development of Healthcare Informative Application using Augmented Reality