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EXPLORING HUMAN ANATOMY IN THE DIGITAL AGE: AN AUGMENTED REALITY (AR) AND VIRTUAL REALITY (VR) INTEGRATION FOR GEN Z

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Abstract: **The integration of Augmented Reality (AR) has transformed traditional two-dimensional learning methods into a three-dimensional, interactive experience in the field of human anatomy education. AR technology immerses students and healthcare professionals in a lifelike environment, allowing them to visualize and interact with anatomical structures, whether through glasses or mobile devices. This dynamic approach improves comprehension by providing a realistic view of spatial relationships and functionality. AR applications allow for virtual dissections, exploration of structures from various angles, and even surgical procedure simulation, fostering hands-on learning. Furthermore, AR facilitates collaborative learning by allowing multiple users to interact with virtual anatomy models at the same time, breaking down geographical barriers and creating an engaging and accessible educational ecosystem for learners worldwide.**

Keywords: **Anatomy, Augmented Reality, Mobile app, Education, 3D Modeling, AR Core.**

I. INTRODUCTION,

Augmented Reality (AR) and Virtual Reality (VR) are two closely related but distinct technologies that have revolutionized our digital experiences. AR augments the real world by overlaying digital information, graphics, or virtual objects onto our physical surroundings, enhancing our perception and interaction with reality. In contrast, VR immerses users in entirely computer-generated environments, effectively transporting them to virtual realms where they can interact with a fully simulated world.AR has found its way into our daily lives through smartphone apps like Pokémon GO, which superimpose virtual creatures onto real-world locations, and smart glasses like Microsoft's HoloLens, which offer hands-free AR experiences. VR, on the other hand, is commonly associated with immersive gaming, where users wear headsets to enter captivating virtual worlds.

Beyond entertainment, AR and VR have made significant inroads into industries such as healthcare, education, architecture, and manufacturing. In healthcare, AR assists in surgeries by providing real-time data overlays, while VR is

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used for medical training and therapy. In education, AR enhances learning with interactive content, and VR offers immersive simulations for training and exploration. However, their potential to transform how we learn, work, shop, and connect with others is undeniable. As technology advances and becomes more accessible, AR and VR are poised to continue reshaping our world. Technologies that exist in security domains include digital signatures, which are used in digital documents to provide authentication, integrity, and non-repudiation. Also with blockchain in play, the storage of certificates is more secure. With these technologies, an application was created that facilitates the secure validation of digital certificates.

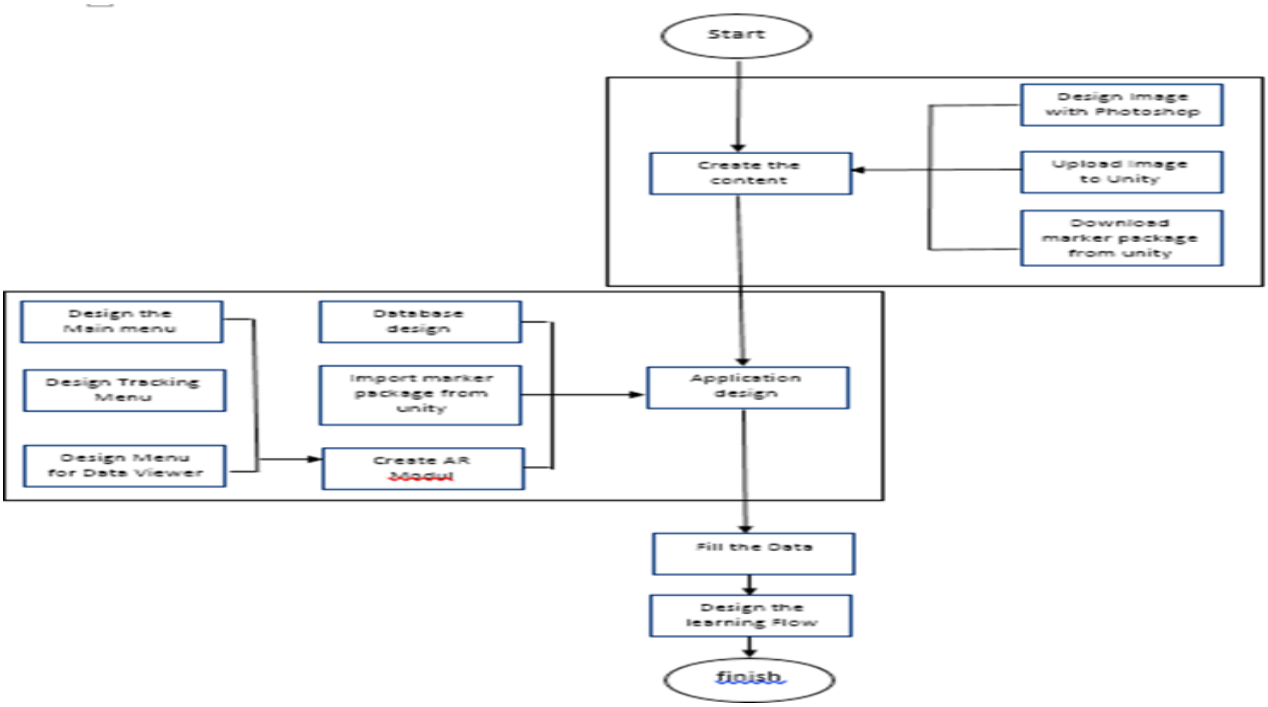
II. LITERATURE SURVEY,

2.1 Augmented Reality in Anatomy

This research project seeks to enhance learning experiences, particularly in the complex field of anatomy, through the application of Augmented Reality (AR).Students face a significant challenge in understanding the intricate relationships and functions of body organs in three dimensions. The proposed method entails utilizing AR technology to provide students with guided exploration of anatomical details, allowing for a structured learning approach. The goal is to determine the effectiveness of augmented reality as a tool for understanding anatomy concepts, recognizing the subject's importance in a variety of fields, including health science. Traditional learning methods, which rely on static images and textbooks, frequently fail to convey the complexities of systems such as the Digestive System or the Heart. AR technology is expected to bridge this gap by providing a more immersive experience.

2.2 Human Anatomy Learning Systems Using Augmented Reality on Mobile Application

Due to limitations in visualizing the body anatomy from a 2D to a 3D image, students typically struggle to learn human anatomy. The goal of this research is to use augmented reality technology to develop a learning system for human anatomy. It is anticipated that by utilizing this system, students will be able to visualize 3D images and comprehend the anatomy of the human body with ease. This system uses a mobile computing platform's augmented reality marker technology. By taking a picture, the marker is recorded. Subsequently, the acquired picture is segmented, and the pattern is compared with pictures kept in the database. In this study, the SQLite database is integrated with the Floating Euphoria Framework. Features in the human anatomy system augmented reality allow for the interactive display of the entire body or specific organs. We tested the augmented reality anatomy system with high school and medical students to see how effective it was for teaching them about the human body's anatomy in order to assess the application's usefulness. The findings demonstrate how much easier it is for students to learn human anatomy when they use an interactive augmented reality visualization system.



2.3 Augmented reality in medical education: students' experiences and learning outcomes

With the use of comparatively recent technology, digitally created three-dimensional representations can be combined with actual environmental stimuli to create augmented reality (AR). Utilizing smartphones, tablets, or other gadgets, augmented reality (AR) can create a highly engaging learning environment and immersive, hands-on experience. Applications for AR are being developed for use not only in entertainment and gaming but also in healthcare, retail and marketing, education, travel and tourism, the military, the automotive industry, manufacturing, architecture, and engineering. The use of AR in industry is expanding rapidly. The unique educational benefits that augmented reality (AR) provides, like interactive simulations and remote learning, are also driving the adoption of AR-based teaching programs in medical schools worldwide. Among them are the primary objectives of augmented reality (AR)-based learning, which are to improve the understanding of complicated material and streamline its delivery. We also discuss how AR can improve medical students' experiences by fostering their interpersonal, practical, and cognitive abilities. A number of AR medical training programs, including HoloHuman, OculAR SIM, and HoloPatient, are used to illustrate these concepts.

2.4 Integrating Data Directly into Publications with Augmented Reality and Web-Based Technologies – School-AR

In this innovative research, the authors tackle a key challenge in scientific communication by addressing the disparity between the dynamic nature of digital information in research and the static presentation in traditional publications. They demonstrate a novel approach using web-based and augmented reality (AR) technologies to seamlessly integrate digital data into the publication system. The authors present a framework accessible to the scientific community, illustrating its potential to revolutionize communication by augmenting articles with interactive digital content. An example showcases augmented data directly layered onto a publication, accessible through both AR mobile applications and web-based PDF viewers, exemplifying the transformative impact of this integration. Furthermore, the study introduces a dual-purpose QR code system, streamlining access to augmented content through the Schol-AR app. This innovative approach not only modernizes the scientific publication process but also enhances accessibility for users, making the exploration of augmented data from diverse datasets, including cellular and MRI data, more interactive and user-friendly.

2.5 AR Mobile Application for Human Anatomy

Human biology's primary subject is anatomy. Human anatomy is the study of the internal organ systems of the body, from cells to organ systems. It is challenging and time-consuming to study the internal structure in the 2D model. This research aims to create a 3D augmented reality human learning system anatomy. It could be challenging to comprehend the internal structure when studying anatomy with 2D models, puppets, or textbooks. An Android app that makes use of augmented reality is one such solution. The application has an interactive menu that lets you scan an image to view a 3D model in real space. In this study, a human body learning system is created using augmented reality technology. It is hoped that by employing this method, students will be able to easily visualize the various parts of the human body in three dimensions. Using AR technology, students can learn more quickly.

2.6 Virtual and augmented reality in biomedical engineering

This paper explores the concept of extended reality (XR), encompassing virtual reality (VR), augmented reality (AR), and mixed reality (MR) technologies, and their potential to transform various aspects of work, social interaction, and sensory experiences. The authors highlight the growing acceptance of these technologies in society, attributing their popularity to advancements in photonics, among other factors. The unique characteristics of VR, AR, and MR are discussed, emphasizing how each technology offers distinct immersive experiences.

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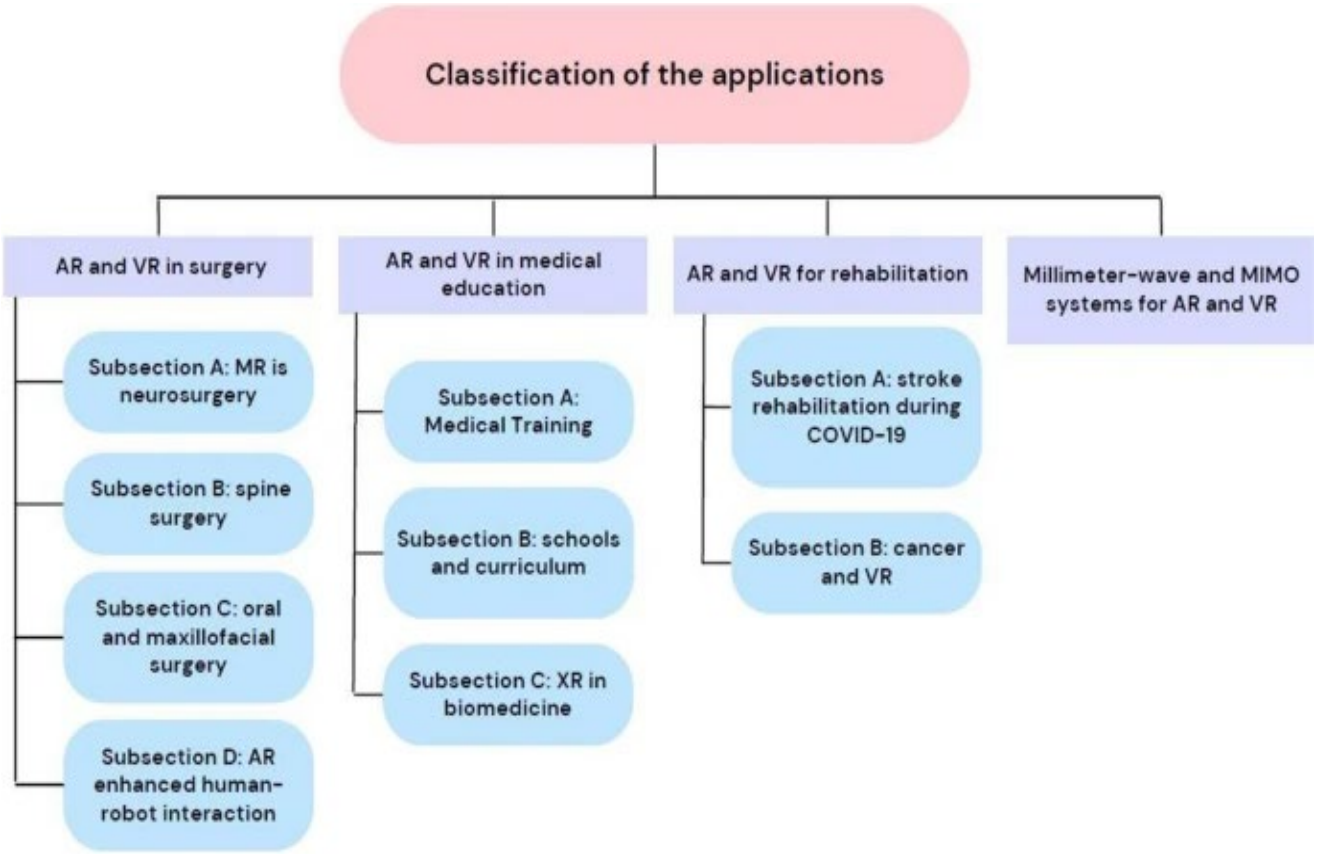

The primary focus of the paper is on the maturity of AR technologies for consumer applications and their potential in enhancing clinical practices in healthcare. The authors stress the need for innovations that can address existing technological and societal challenges in AR devices, urging engineers, computer scientists, and end-users to explore the vast potential of AR technologies. The technical aspects, such as marker-free tracking and the integration of real and virtual data, are discussed, with a particular emphasis on medical AR where the distinction between real and virtual information can be crucial. The paper aims to guide future scientific research toward overcoming challenges and promoting the development of practical applications for AR technologies in various domains.

2.7 ScoolAR: An Educational Platform to Improve Students' Learning Through Virtual Reality

Applications of virtual reality (VR) and augmented reality (AR) have been studied in a number of fields. Though their potential has been widely recognized, there is still a barrier preventing their widespread adoption in the educational sector: there aren't enough user-friendly platforms that allow educators and students to create their own AR/VR experiences. This paper closes this gap by presenting a brand-new platform called ScoolAR that was created with education in mind. As of present day, the state of the art shows no indication of a didactic tool that makes it possible to create AR/VR applications without knowing how to program. Based on these tenets, ScoolAR was created to get around these restrictions, allow for an autonomous content creation system, and increase awareness and participation in the use of AR and VR applications in regular educational settings. This paper describes not only the architectural framework of the proposed platform, but also the outcomes of experiments carried out in an authentic didactic scenario. Taking into account two student groups, the first one underwent the study phase through frontal lectures while the second group received assistance using the ScoolAR framework. The test conducted demonstrated that the first group performed better than the second on every evaluation metric.

2.8 Comparison Table:

S.NO	TITLE	AUTHOR & YEAR	TECHNOLOGIES	RESULT	PROS	CONS
1.	**Augmented Reality in Anatomy**	Sanket Patil , Anup Rao , Neeraj Pardeshi , Mahesh Gavhane, Dr. Dattatray Waghole - 2021	3D modeling, mobile app development, Project based AR technology	Improved visualization, interactivity, and engagement, leading to better anatomical understanding.	The interactive nature of AR applications, including labeling and detailed information integration, makes learning more engaging and motivates students to explore the subject further.	Although the paper emphasizes the affordability of AR compared to traditional methods, the development and maintenance of high-quality AR applications can still be expensive.
2.	**Human Anatomy Learning Systems Using Augmented Reality on Mobile Application**	Michael H Kurniawan, Suharjito, Diana, Gunawan Witjaksono - 2018	3D modeling, mobile app development, marker-based AR technology.	Significant improvement in student learning outcomes compared to traditional methods.	Improved visualization and understanding, Enhanced engagement and motivation, Accessibility and affordability, Reduced reliance on cadavers.	Technical limitations, Cost, Lack of research.
3.	**Augmented reality in medical education: students' experiences and learning outcomes**	Poshmaal Dhar, Tetyana Rocks, Rasika M Samarasinghe, Garth Stephenson, and Craig Smitha - 2021	Marker-based AR technology, pre-designed anatomical models.	Improved spatial understanding and knowledge retention compared to traditional methods.	Improved learning outcomes, Increased student satisfaction, Enhanced engagement and motivation..	Technical limitations, Cost, Lack of research, Potential for distraction.
4.	**Integrating Data Directly into Publications with Augmented Reality and Web-Based Technologies – Schol-AR**	Tyler Ard, Michael S.Bienkowski, Sook-Lei Liew, Farshid Sepehrband, Lirong Yan & Arthur W.Toga - 2022	Web-based AR platform, interactive 3D visualization.	Enhanced scientific communication and education through interactive 3D models and additional information.	Enhanced interactivity and engagement, Improved accessibility to data, New possibilities for data visualization.	Technical limitations, Cost, Lack of standardization.

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5.	**AR Mobile Application for Human Anatomy**	Chandana J, Priya Kumari, Prof. Rekha B S - 2023	Mobile app development, 3D modeling, markerless AR technology, gamification elements.	Improved student knowledge and motivation through interactive 3D models, quizzes, and gamification elements.	Improved visualization and understanding, Enhanced engagement and motivation, Accessibility and affordability, Reduced reliance on cadavers.	Technical limitations, Cost, Lack of research.
6.	**Virtual and augmented reality in biomedical engineering**	Aya Taghian, Mohammed Abo-Zahhad, Mohammed S. Sayed & Ahmed H. Abd El-Malek - 2023	Educational platform design, Mobile based AR platform.	Revolutionizing healthcare through various applications like surgical training, rehabilitation, and medical imaging.	Improved visualization and understanding, Enhanced engagement and motivation, New possibilities for training and simulation.	Technical limitations, Cost, Lack of research, Potential for ethical concerns.
7.	**ScoolAR: An Educational Platform to Improve Students' Learning Through Virtual Reality**	Mariapaola Puggioni, Emanuele Frontoni, Marina Paolanti, Roberto Pierdicca - 2021	VR development, educational platform design	Creating immersive and engaging learning experiences for various subjects.	Improved learning outcomes, Increased student satisfaction, Enhanced engagement and motivation.	Technical limitations, Cost, Lack of research, Potential for motion sickness.

Table. 1.Literature survey

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III. PROBLEM STATEMENT,

Learning to read and understand everything from books and diagrams is essential for a medical student who wishes to study systems that are hard to see and understand, such as the digestive system, the heart, and other systems. Currently, students who want to study the anatomy of the many human organs need to be able to read and understand schematics or illustrations. Students can realistically explore the body and learn about its functions with the use of the software AR in Anatomy. This software allows users to zoom in, rotate, and see the anatomy of different human body parts in action. For smaller parts, the application also offers labels. AR helps students retain the content they have recently learned. Human body anatomy is a crucial issue in the field of genetics that requires understanding beyond junior high school. Although mannequins, or puppets, are a common form of educational resource for literature and anatomy, they are also insufficient in helping students comprehend the human body's anatomy. Augmented Reality (AR) is a technology that interactively merges a real world into a simulated world. Human body anatomy is a crucial issue in the field of genetics that requires understanding beyond junior high school. Although mannequins, or puppets, are a common form of educational resource for literature and anatomy, they are also insufficient in helping students comprehend the human body's anatomy.

Traditional methods of learning anatomy, such as textbooks and diagrams, often fall short in conveying the intricate details of the human body. Our application bridges this gap by employing augmented reality (AR) to bring 3D anatomical models to life before your eyes. With the ability to rotate, zoom, and pan through these models, users can gain a comprehensive understanding of the human body's structures and their intricate relationships. Our application goes beyond mere visualization, offering a suite of interactive learning experiences that transform abstract concepts into tangible realities. Engaging quizzes, captivating puzzles, and interactive AR simulations foster deeper comprehension and retention of anatomical knowledge. These interactive elements cater to diverse learning styles, ensuring that every user can find an engaging and effective way to grasp the complexities of

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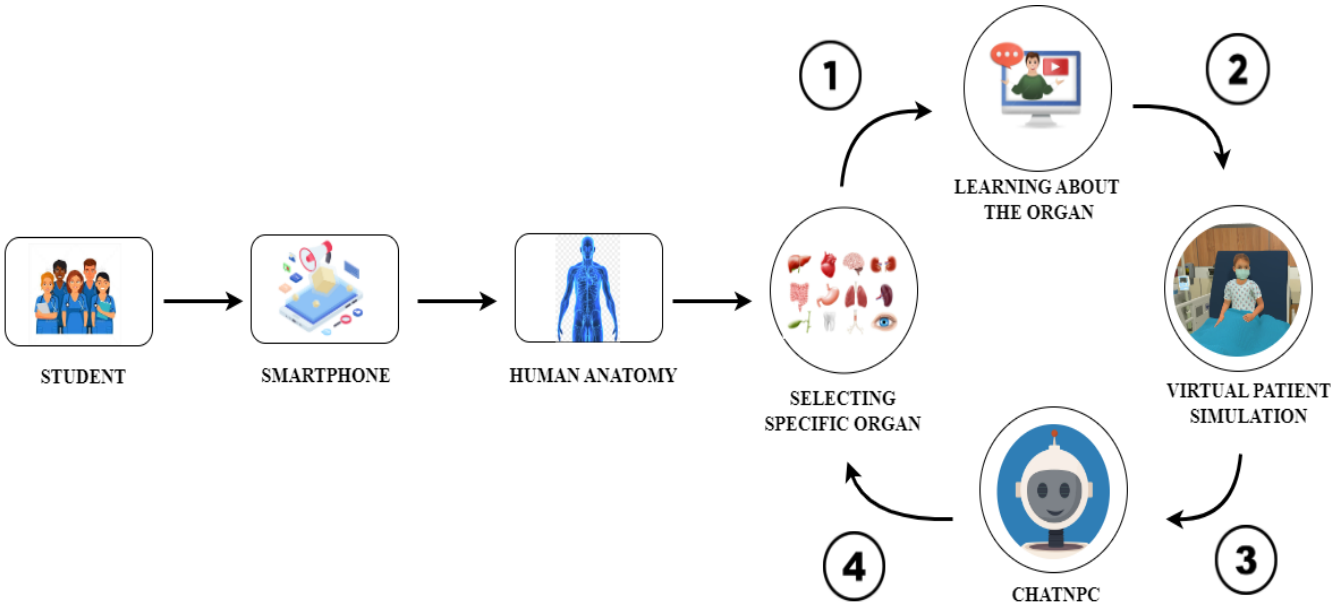
human anatomy. Whether delving into the intricacies of the cardiovascular system, deciphering the musculoskeletal framework, or unraveling the delicate workings of the nervous system, users can embark on personalized anatomical odysseys.

Our application goes beyond traditional learning, empowering users to unleash their creativity and share their knowledge. With the ability to construct their own AR experiences, users can craft personalized learning adventures to share with fellow anatomy enthusiasts. This fosters a vibrant community of learners where collaboration and knowledge sharing thrive. At the heart of our application lies in a collection of meticulously crafted 3D models, representing every intricate component of the human body. These models are not mere static representations; they are interactive tools that allow users to explore anatomy in unprecedented depth. With the ability to rotate, zoom, and dissect these models, learners can gain a comprehensive understanding of the spatial relationships between anatomical structures and their intricate functions

IV. ARCHITECTURE DIAGRAM



V. MODULES IDENTIFY,

5.1 ARCORE : ARCore is a platform developed by Google that enables the creation of augmented reality (AR) experiences for Android devices. Released in 2017, ARCore provides developers with tools and APIs (Application Programming Interfaces) to build AR applications that can interact with the real world. It uses a combination of the device's camera, sensors, and processing power to understand the environment and place virtual objects or information within it.Integrating ARCore into Unity involves several key steps to enable the development of augmented reality (AR) experiences. First, after installing Unity and Android Studio, a new Unity project is created. This SDK provides essential tools and components for AR development.

5.2 XR MANAGEMENT: XR management in Unity involves orchestrating the development of extended reality (XR) applications, such as virtual reality (VR) or augmented reality (AR), within the Unity game engine. Unity's XR platforms are navigated by XR managers, who also manage projects for particular devices, supervise interaction design, manage content creation, conduct rigorous testing, optimize performance, handle deployment, offer user support and training, and iterate on improvements. With this all-encompassing strategy, XR technologies are seamlessly incorporated into Unity projects, producing engaging and intuitive user experiences.

VI. STEPS INVOLVED IN MODULES IDENTIFIED,

In the development process using Unity for an educational XR app focused on human anatomy exploration, the initial steps involve setting up a Unity project configured for Android development and integrating XR platforms for compatibility. The scene composition within Unity includes designing a 3D model showcasing the human anatomy, comprising organs, bones, and muscles. A user-friendly interface is created to facilitate interactions, incorporating buttons or menus for navigation and body part selection. Scripting in C# enables interactivity, allowing students to click on specific anatomy components. The crucial aspect involves integrating animations for selected body parts,

offering informative content on functions or movements. Collaboration with content creators ensures the accuracy and visual appeal of 3D models, optimized for Android device performance. Rigorous testing on various Android phones is conducted to address compatibility and performance issues, followed by the implementation of user guidance and tutorials within the app. The final step involves building and deploying the app for Android devices, providing students with an immersive and educational experience in human anatomy exploration.

VII. CONCLUSION,

The proposed AR-powered mobile application revolutionizes human anatomy education by offering a transformative learning experience that transcends traditional methods. Its immersive visualization, interactive elements, and personalized learning journeys cater to diverse learning styles and foster deeper comprehension and retention of anatomical knowledge. By empowering users to construct their own AR experiences and fostering a collaborative community of learners, the application promotes creativity, knowledge sharing, and a deeper appreciation of the human form. Its potential to enhance classroom teaching, facilitate research collaboration, and prepare students for future careers in healthcare underscores its immense value in the realm of anatomical education. As AR technology continues to evolve, the possibilities for this application are limitless, paving the way for a future where anatomical learning is not just informative, but also captivating and transformative.

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Gratitude to my project supervisor, participants, and their families for the Human Anatomy for Gen Z platform. Special thanks to the broader community for encouragement. This project's success is a result of collective efforts and support.

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