Embodied Human Anatomy Visualization in VR

Ahsan Munir*
Friedrich-Alexander-Universität Erlangen-Nürnberg

M. Sc. Constantin Kleinbeck†
Friedrich-Alexander-Universität Erlangen-Nürnberg

Prof. Dr. Daniel Roth‡
Friedrich-Alexander-
Universität
Erlangen-Nürnberg

Abstract

Immersive technologies such as VR, AR, MR, and XR have revolutionized medical practice and education by providing immersive experiences that can help in training, education, and research. However, there is still a need for more research and reviews to fully understand the potential of these technologies in healthcare. The goal of this project is to develop a comprehensive human anatomy model with multiple subsystems that can be correctly animated and deformed in Unity and usable in VR. The model is specifically designed for medical students and health professionals to provide them with an immersive learning experience. The end user can wear the headset, controllers, and trackers of the HTC Vive system to interact with the model and switch between male and female anatomy models and their subsystems with ease. The implemented approach of supporting inverse kinematics with an external tracking system has the potential to improve virtual reality experiences and make them more interactive and realistic. This project aims to contribute to the development of immersive technologies for medical education and practice and pave the way for more advanced applications in the future.

Index Terms: H.5.1.a [Animations]: 3D modeling;
H.5.1.b [Artificial, augmented and virtual realities]: virtual reality—Inverse Kinematics

1 Introduction

The study of human anatomy is vital for medical professionals, biology students, physical therapists, and many other fields. Traditional methods of learning anatomy have largely relied on textbooks and 2D images, which can be limiting in their ability to convey the complexity of the human body. However, the integration of virtual reality (VR) technology in anatomy education has the potential to revolutionize the field by providing immersive and interactive experiences for learners. With the advancement of VR technology, incorporating inverse kinematics (IK) and external tracking can make the virtual model more realistic and interactive. The goal of this project, "Embodied human anatomy visualization in VR", is to bridge the gap between conventional methods and modern technology by creating a human anatomy model with different subsystems that is correctly animated and deformed in Unity, and can be used in VR with the support of IK and an external tracking system. This project has the potential to enhance the learning and research experience in anatomy education for medical professionals, biology students, and other interested learners.

*e-mail: ahsan.munir@fau.de
†e-mail: constantin.kleinbeck@fau.de
‡e-mail: d.roth@fau.de

2 Related Work

VR integration in anatomy education is a growing field with many existing solutions. 3D anatomy representation and motion tracking are widely used techniques to develop immersive educational content. VR anatomy education apps with interactive quizzes and labeling systems exist, however, limitations in accuracy and realism remain in existing solutions. For instance, some applications only provide pre-recorded animations and lack interactivity or real-time simulations. Some other apps may lack proper skeletal rigging or skinning, leading to unrealistic movement or deformation of the model. Despite these limitations, VR-based anatomy education has shown potential to be an effective tool for medical students, healthcare providers, and patients in physical therapy and rehabilitation. Moreover, the integration of immersive technology in anatomy education can bridge the gap between conventional methods and modern technology, which is highly beneficial for professional development. Many published papers have explored the use of VR in anatomy education, and some of them have suggested that VR can improve students' knowledge retention and engagement.

Some notable published papers in this field include "A systematic review of immersive technology applications for medical practice and education" by Tang et al. (2022) [4] which provides a comprehensive review of the current state of VR applications in healthcare. Another systematic review by Uruthiralingam et al. (2020) explores the use of VR for teaching anatomy to medical students and highlights the potential benefits of VR over traditional methods. Additionally [3], "Virtual Reality in Medical Education and Training" by Seymour et al. (2018) discusses the potential of VR in medical education and highlights some of the challenges and limitations of current VR solutions. And another survey "Virtual Reality and Its Applications in Education" by Kamińska et al. (2019) [2] shows the different aspects of VR in education. The article "An Augmented Reality magic mirror as additive teaching device for gross anatomy" by Kugelmann et al. (2017) [1] is the most relatable article, which also uses the mirror to showcase the human anatomy in AR. These studies provide valuable insights into the potential and challenges of using VR in anatomy education and highlight the need for further research and development in this field.

3 Method

The following section outlines the methodology and approach taken to develop the VR application for embodied human anatomy visualization. The process involved the use of industry-standard software and tools, as well as the implementation of best practices to ensure optimal performance and user experience.

- For each model bones were rigged and the mesh was skinned for each subsystem to ensure proper movement and deformation in Unity.
- The models were exported from Blender to Unity for further development.

- The models were converted to humanoid form to enable inverse kinematics implementation for each model.
- Inverse kinematics were implemented for every model to provide realistic movements based on user input.
- A scene was created in Unity to enable users to explore the models in a VR environment.
- A user interface was developed in Unity to allow for easy gender and subsystem switching.
- A mirror was incorporated into the VR environment, allowing the user to see their own anatomy.
- The VR headset was integrated through XR origin setup to provide a seamless experience for the user.
- A calibration implementation was added for user height adaptation to ensure a comfortable and accurate experience.

These steps were taken to bridge the gap between traditional anatomy education methods and modern technology, providing a revolutionary and immersive approach to anatomy education.

4 Results

Results from the Embodied Human Anatomy Visualization in VR project demonstrate the potential of VR technology in anatomy education. The model developed in this project provides a realistic representation of the human anatomy with accurate skeletal rigging and skinning, as well as interactive subsystems that allow users to explore different parts of the body. The IK implementation for every model and calibration for user height adaptation further enhance the realism of the model. The developed UI for gender and subsystem changing in Unity provides users with easy navigation through the various subsystems. The integration of VR headsets via XR origin setup allows for a more immersive experience. Overall, the project provides a valuable tool for students, healthcare providers, and patients in physical therapy and rehabilitation.

During the project exhibition, a questionnaire survey was conducted to gather feedback from users who experienced the Embodied Human Anatomy Visualization in VR project. The survey aimed to evaluate the effectiveness of the project in enhancing users' understanding of the human anatomy and to gather suggestions for future improvements. The results of the survey indicated that the project was well-received by users, with few reporting an improvement in their understanding of the human anatomy. Users also appreciated the interactive nature of the model and the ability to explore different subsystems. Some suggested improvements included improving the UI, and incorporating a more detailed muscular system. The survey results are presented in the 2D chart.

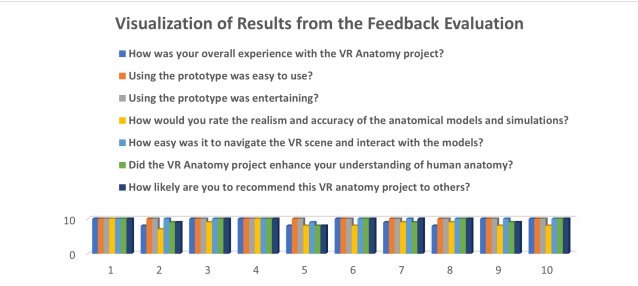

Figure 1: Visualization of the results from the feedback.

5 Discussion

The use of immersive technologies such as VR, AR, MR, and XR have the potential to revolutionize anatomy education for students in medical, biology, and related fields. The objective of this project is to narrow the gap between traditional approaches and contemporary technology, resulting in an immersive and interactive learning experience for the students. Moreover, this application has a wide range of applications beyond education. Healthcare providers can benefit from professional development and training, while physical therapists and rehabilitation specialists can use the technology for patient care. The application can also be useful for gym instructors and personal trainers for pressure point guidance and exercise demonstrations. Additionally, the use of VR technology can make large amounts of anatomical data more accessible to medical professionals, researchers, and students. It can also be used in various situations, such as pre-surgical planning, medical simulations, and scientific research.

In conclusion, this project showcases the potential of immersive technologies in the field of anatomy education and beyond. Its ability to provide an engaging and interactive learning experience, as well as its diverse range of applications, makes it a valuable tool for various fields.

6 Future Work

Future work for the embodied human anatomy visualization project in VR involves several aspects. One important aspect is to improve the accuracy and realism of the models and the interactive functionalities of the application. Additionally, it is important to evaluate the effectiveness of the VR-based anatomy education and its impact on knowledge retention and learning outcomes compared to traditional methods. Another crucial aspect is the user interface for switching between different models and their subsystems, which would be even better if it were integrated into the VR environment. Additionally, it would be beneficial to display the medical terminology for each body part in the VR environment's user interface.

Furthermore, the application can be integrated with other VR-based human anatomy projects to provide a more comprehensive and immersive educational experience. As a person interested in continuing this project, one can contribute by further improving the accuracy and realism of the model, and exploring other possibilities for interactivity. One can integrate this application with other educational tools, such as interactive quizzes or gamification techniques, to enhance engagement and knowledge retention for students and healthcare professionals.

7 Conclusion

The Embodied Human Anatomy Visualization in VR project successfully developed a realistic and interactive model of the human anatomy using VR technology. The project's focus on providing a valuable tool for medical students and healthcare professionals has been achieved by incorporating accurate skeletal rigging and skinning, interactive subsystems, and an easy-to-use UI for navigation. The project also aimed to bridge the gap between conventional methods and modern technology in anatomy education, and the integration of VR headsets made it possible to create a more immersive and realistic learning experience. The potential benefits of VR-based anatomy education were explored through a questionnaire survey conducted during the project exhibition, which showed a positive response from the users. Overall, this project provides a valuable tool for the medical community to enhance their knowledge and understanding of human anatomy, and it serves as a stepping stone towards the integration of immersive technology in healthcare education.

GROUP

The Embodied Human Anatomy Visualization in VR project was developed solely by me. As the only person in the team, I handled all aspects of the project, including research, development, testing, and documentation. Despite the challenges of working alone, I was able to create a valuable tool for medical students and healthcare professionals, which has the potential to enhance anatomy education and improve learning outcomes.

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