Implementation of Augmented Reality to Visualize Cell Organelles

Ai Myachha Chawloo[1], Monita Wahengbam[2], Subhrojit Saikia[3]

[1-3] NIELIT Jorhat EC of Guwahati, Assam, India

aimyachha@gmail.com[1]
monita@nielit.gov.in[2]
subhrojitsaikia7856@gmail.com[3]

Abstract. Cell biology is a foundational subject in the life sciences, yet traditional education methods often fail to convey the complexity and spatial relationships of cell organelles. This paper addresses this educational challenge by developing an augmented reality (AR) application that provides an immersive, interactive experience for exploring cell organelles. The primary objective of this application is to find an alternative method to enhance learning and engagement through AR technology, offering detailed 3D models that users can manipulate to understand cellular structures and functions better. The project is being developed primarily utilising Blender and Unity Editor for creating 3D models and integrating them into an android application. The application provides a user-friendly approach to interact with the digitally produced 3D models of the various organelles, to study their structures. This project is an attempt to pave the way for future expansions to include additional topics and more advanced interactive features, ultimately providing a novel approach to study cell biology.

Keywords: **cell biology, cell organelles, education, learning, augmented reality, blender, unity**

(Article history: Selected from 3rd NICEDT 2025, Ropar, 14-15 Feb 2025)

I. INTRODUCTION

Understanding cell organelles is fundamental to the study of biology and related sciences. Cell organelles, such as the nucleus, mitochondria, endoplasmic reticulum, and Golgi apparatus, each play critical roles in maintaining cellular functions. Traditional educational methods, often relying on static images and text, may not fully convey the complexity and spatial relationships inherent to these cellular structures.

Cell organelles are specialised structures within cells that perform specific functions necessary for life. For instance, the mitochondrion, often referred to as the "powerhouse of the cell," is responsible for producing energy through cellular respiration [11]. Understanding the intricate details and functions of these organelles is crucial for students in fields such as biology, biochemistry, and medicine. However, grasping these concepts can be difficult when limited to traditional learning resources.

Traditional educational tools, such as textbooks and 2D diagrams, provide essential information but cannot convey the three-dimensional nature of cell structures. Augmented Reality (AR) offers a promising solution to these challenges. By superimposing digital information onto the real world, AR creates an interactive learning experience that can enhance understanding and engagement. AR can allow students to visualise and manipulate 3D models of cell organelles, providing a deeper comprehension of their structures and functions.

Augmented Reality (AR) is a technology that superimposes computer-generated content, such as images, videos, or 3D models, onto the real-world environment. It enhances the user's perception and interaction with the physical world by blending digital elements with the user's view of their surroundings. An AR application follows the steps given below to augment an image into the real world:

Step 1. Environment Detection: AR begins by detecting the real-world environment using sensors and cameras on the device (such as a smartphone, tablet, or AR glasses). The device captures images or videos of the surroundings to gather visual data.

Step 2. Recognition and Analysis: The captured data is analysed to recognize and understand the environment. This involves identifying specific markers (QR codes, images), objects, or features (walls, floors) that serve as reference points. The system uses computer vision algorithms for image and object recognition or spatial mapping to build a 3D model of the environment.

Step 3. Tracking: Once the environment is recognized, AR systems continuously track the position and orientation of the device and the recognized objects. This tracking ensures that digital content can be accurately aligned and anchored to specific points in the real world, maintaining the correct perspective as the user moves.

Step 4. Content Overlay: Digital content (such as 3D models, animations, or informational text) is generated and aligned with the real-world environment. This content is overlaid onto the user's view of the physical world, appearing to interact with or enhance real objects.

Step 5. Rendering: The final stage involves rendering the combined view of the real and virtual elements on the device's display. The AR system uses the processed data to ensure that digital content seamlessly integrates with the live camera feed, creating an immersive and interactive experience for the user.

II. Literature survey

In recent times, augmented reality and virtual reality (AR & VR) have been integrated in almost every sector from marketing to scientific research and medical training. They are two of the most innovative advancements in the current age. Their potential for bringing improvements in the education system is massive. Using AR and VR learners are introduced to an immersive experience which can help in more engagement with the topic at study.

According to Chandrasekera et al.[1] (2018) AR interfaces rated higher in usefulness, ease of use, and intention. Learner preference did not significantly moderate the creative design process. Research conducted by Sherina, R.P. [2] (2023) revealed that AR enhances education and medical fields through interactive learning experiences, AR also aids in surgical procedures, medical training, and patient education. AR glasses assist low vision individuals in daily activities confidently.

In another research conducted by Al-Ansi et al.[3] (2023), it was discovered that challenges still exist while implementing AR and VR technologies in education. For instance the cost of implementing the technologies can be prohibitively high, creating a barrier for some schools and institutions. Additionally, many schools and teachers may lack the technical knowledge to effectively implement these technologies in the classroom.

However, recent research conducted by Tan et al.[4] (2024) on the influence of learner experience on AR/VR adoption in Vietnamese universities found that the AR / VR technology enhances students' learning behaviours in educational settings and it is recommended by the experts to implement the aforementioned technologies in the educational curricula. A systematic literature review on integration of AR in biology education conducted by Azzahra et al.[5] (2024) revealed that the challenges of AR implementation in biology learning include accessibility, hardware availability, cost, training,and adaptation to pandemic conditions. According to a research conducted by Hallaby&Syahputra[6] (2024), the integration of AR in biology education has been shown to boost student interest and motivation, leading to improved knowledge retention. AR can make learning more enjoyable, countering the perception of biology as a dull subject. AR effectively addresses common challenges in biology education, such as the difficulty of understanding abstract concepts, by providing concrete representations of organelles(Permana et al.[7] 2024). The integration of AR with problem-based learning strategies has been shown to enhance problem-solving skills, making learning more effective(Hui et al.[8] 2024).

III. Methodology

The process of developing the AR application can be categorised into a few steps.

- *Data collection:* In the first step, online and offline resources have been studied to collect the data to create an AR application and 3D models, along with the structural data of the cell organelles and other relevant data like importance of the cell organelles.
- *Pre-processing:* The required systems and software, i.e., Blender, Unity Editor, etc. are collected and configured.

- *Model design:* The 3D models are created using Blender and then implemented into the application using Unity Editor.
- *Implementation:* The AR application is developed using the 3D models that have been created in Unity Editor. The functionalities of the application were established using C# scripts.
- *Testing and results:* The AR application is built for Android OS and then tested in an Android smartphone to analyse the results. The application was tested in a well-lit classroom to observe the outputs.

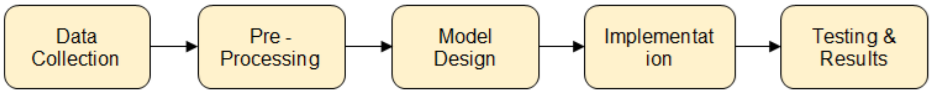


Fig 1 Steps to create an AR application

a. Data Collection

To create the augmented reality application, various online researches have been conducted to learn about the process of building an AR application. An AR application can be created using platforms like Unity Editor and Unreal Engine. Interactions can be integrated using C# scripts which can be created and edited conveniently using an IDE like VSCode.
For this project, Unity was selected as the platform of development. And the 3D models were created using Blender ver 4.

b. Preprocessing

*Installing Unity***.**Unity Hub’s installation file was downloaded from the official Unity website, and the downloaded file was run to install Unity Hub[13].
*Installing Blender***.** Similar to Unity, Blender was also downloaded from their official website, and then the installation file was run to install the software.
*Installing VSCode***.**VSCode or Visual Studio Code can be downloaded from the official website. Running the installation file provides a setup window with steps to install the application.

c. Model Design

To create the 3D models of the various cell organelles i.e., mitochondrion, endoplasmic reticulum, nucleolus, and other organelles, various text books and online resources were studied for 2D images and texts about their structures to prepare a proper representation of the organelles. The models were then created using Blender 4.1. The process for creating these 3D models varies according to the model. But the common steps include: Adding a mesh, followed by sculpting and slicing using box cutter tool. And then adding different materials to differentiate the various components of the model. After creation, the models were exported into “.fbx” format to make the models compatible for AR application development.

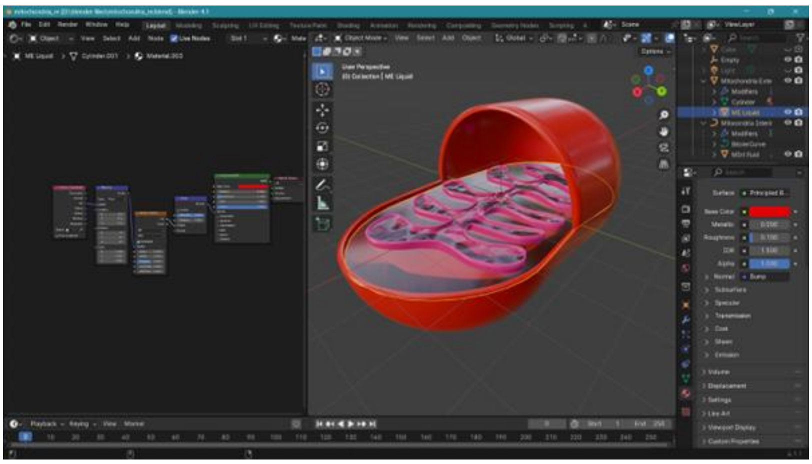


Fig 2 Creating a 3D model of mitochondrion in Blender.

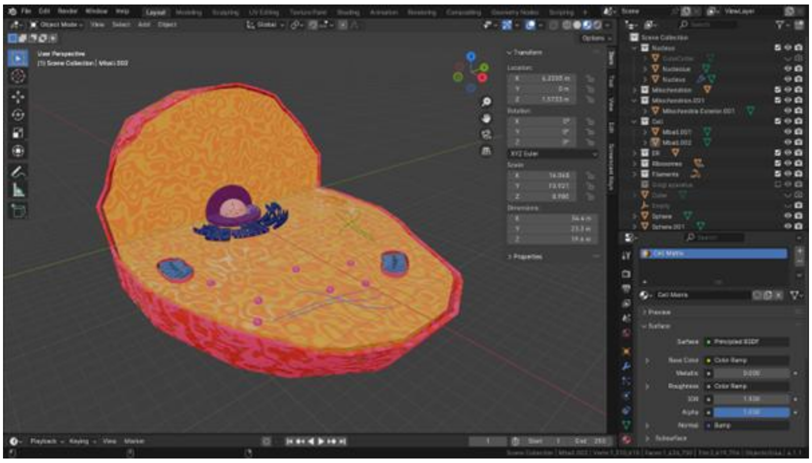


Fig 3 Creating 3D models of various Cell Organelles in an animal cell using Blender

d. Implementation: Development of the augmented reality application

A Unity project file was created using the AR Mobile Core template found in the Unity Hub ver 3.8.0. The AR Mobile template configures the project file to support Augmented Reality when deployed for mobile devices, both android and ios. Unity hosts a library of packages tailored for the development of various types of applications. The packages that are essential for augmented reality development include AR Foundation, Google AR Core XR plugin (for android builds) and Apple ARkit (for ios builds).[9] The AR Mobile template pre-installs all the required packages for the AR development including XR interaction toolkit, which aids in the interaction with the augmented 3D images.

The template contains C# scripts[12], menus, buttons, etc. which have been linked with the prepared 3D models (according to the needs of the research), which can be spawned by user input inside the AR mobile application. The semi-coded C# scripts can be modified to further optimise the user requirements. The current project was created for an android platform, therefore, in this case, Google AR Core XR plugin was implemented along with AR Foundation.

The prepared 3D models of the cell organelles were imported into the unity project and then different scenes (like home page, augmenting page) were created inside the project file. Various interactions (which are controlled by touch input) were linked with the buttons provided in the UI as well as the 3D models by using different C# scripts. These actions include spawning, scaling, rotating and relocating the 3D models in the rendering space.

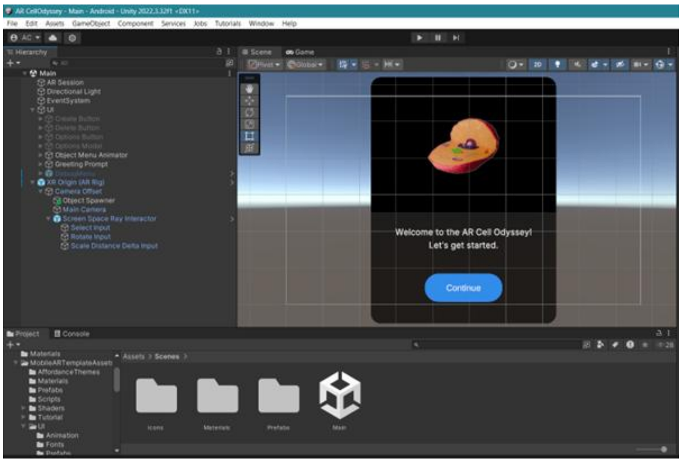
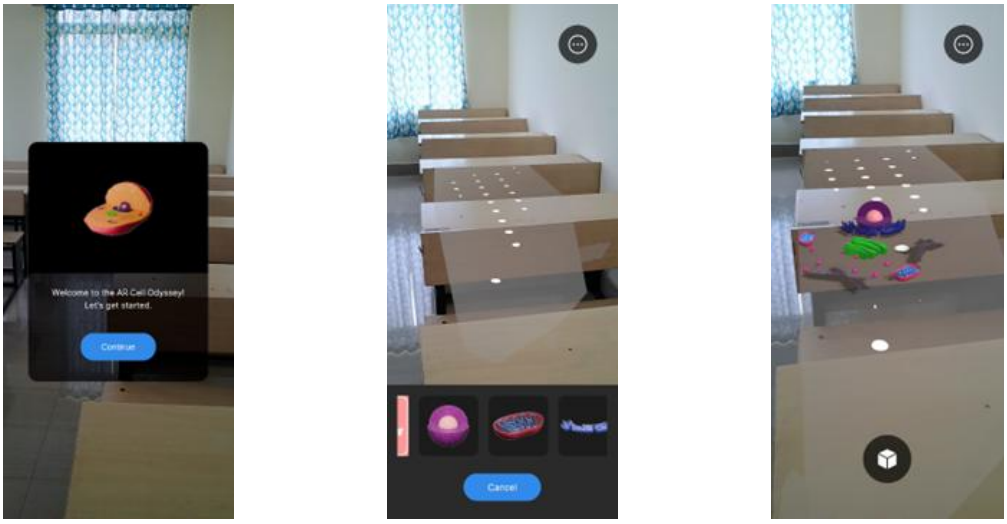


Fig 4 Development of the application using Unity

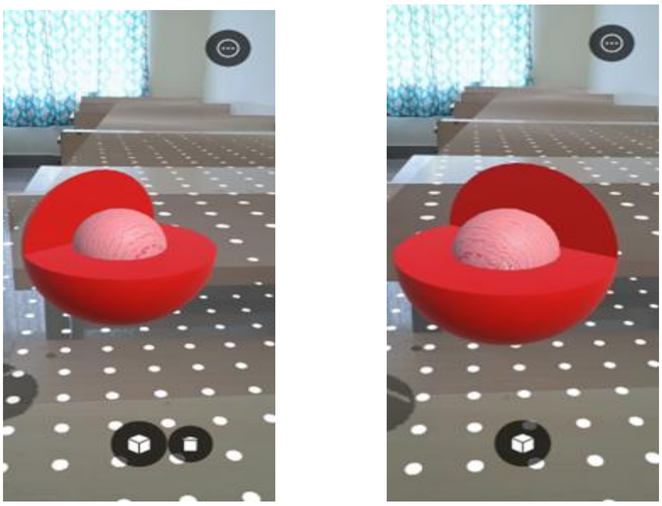
e. Results

An alpha version of the application was built for the android os, the android application was installed in a smartphone that supports ARcore, and tested to analyze the results of the development. Following are some screenshots of the application output run on an android device, which were taken in real-time.



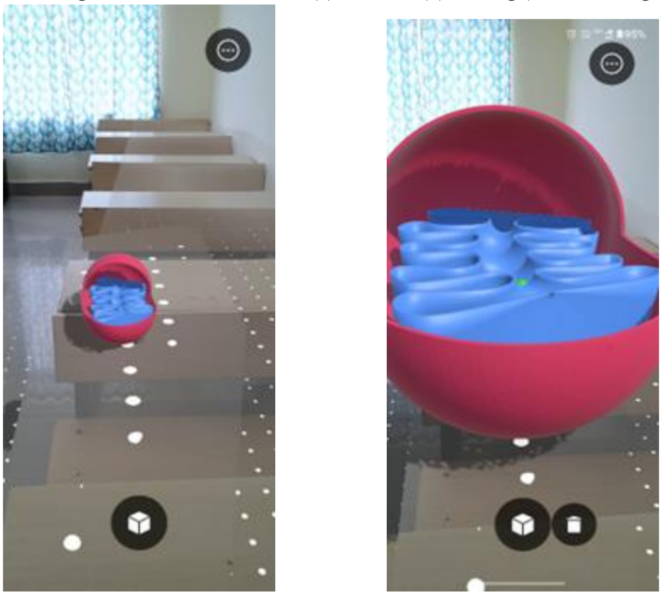
(a) Greetings Prompt (b)Plane Detection by the app (c) Overlayingdigital 3D models

Fig 5 Real-time Screenshots of the AR application – “AR Cell Odyssey”



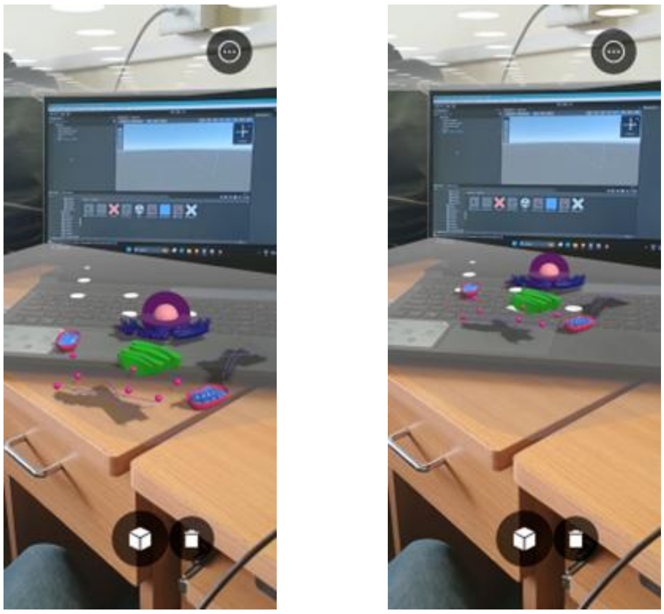
(a) (b)

Fig 6 Rotation of the augmented 3D model: before (a) and after (b) rotating (Real-time augmented models)



(a) (b)

Fig 7 Scaling the 3D model: (a) before, and (b) after scaling (Real-time augmented models)



(a) (b)

Fig 8 Relocating the 3D model: (a) before, and (b) after relocation (Real-time augmented models)

The AR application was created and tested in real-life conditions. The application successfully displayed the 3D models that were created using Blender. These models are effectively rendered within the AR environment, showcasing accurate plane tracking, content overlay, and seamless user interaction. The application supports additional functionalities, including user-defined resizing, rotation, and relocation of the augmented models. Users can also select and remove models as needed, providing a flexible and intuitive interface for exploring cell organelles in augmented reality.
However, the relatively large size of the application, viz., 139 MB, has led to some performance issues, most notably the occasional freezing due to the large size of the 3D models. While the application generally runs smoothly, these instances of freezing can interrupt the user experience and limit the app's accessibility, particularly on devices with lower processing power or limited storage. Despite this, the core functionality of the app has been well-received in the initial tests, and it effectively allows users to interact with and manipulate 3D models in a way that enhances their understanding of complex biological concepts.

IV. FUTURE WORK

Several enhancements can be implemented to improve the functionality and educational value of the AR app. First, optimising the 3D models and textures could significantly reduce the overall app size, ensuring smoother performance across a wider range of devices. Additionally, incorporating interactive labels and annotations for each cell organelle would allow users to access detailed information and context directly within the app, thereby enhancing the educational experience by providing immediate, relevant knowledge as users explore the models.

Introducing guided tutorials and quizzes could reinforce learning and assess user understanding, encouraging active engagement and helping users retain information more effectively. To increase accessibility, implementing multi-language support could make the app usable by a more diverse audience.

Lastly, features such as colour-coding, highlighting of key organelles, and note-taking capabilities could be considered to improve visual engagement and personalization. These enhancements would make the app a more powerful tool for learning and teaching about cell biology.

V. CONCLUSION

Augmented Reality and its sibling technologies, i.e., Virtual Reality and Mixed or Merged Reality are very promising in delivering entertainment and education. The current day and age urges for the implementation of these new technologies to revolutionise a new way of education, an immersive learning experience. Studies in the past have shown increased indulgence of learners while implementing VR, and same goes for AR and MR.

The development and implementation of this AR application has demonstrated the effectiveness of using augmented reality to enhance the understanding of cell organelles. The integration of 3D models with AR technology provides a more interactive and engaging learning experience, allowing users to manipulate and explore biological structures in a real space with virtual models. The additional features, such as resizing, repositioning, and model removal, further enrich the user experience, making the application a valuable educational tool for both students and educators.

However, the app's large size indicates a need for optimization to improve performance and accessibility. Reducing the app's size, particularly by optimising 3D models and textures, will be crucial for making it more widely accessible and enhancing overall user satisfaction.

References

1. Chandrasekera, T., & Yoon, S. (2018). Augmented Reality, Virtual Reality and Their Effect on Learning Style in the Creative Design Process. Design and technology education : an international journal, 23, 55-75.
2. Sherina, R.P. (2023). A comprehensive review of augmented reality in education and medical fields. i-manager's Journal on Augmented & Virtual Reality. 1, 25-31.
3. Al-Ansi, A.M., Jaboob, M., Garad, A., & Al-Ansi, A. (2023). Analysing augmented reality (AR) and virtual reality (VR) recent development in education. Social Sciences & Humanities Open.
4. Tan, T.L., Nguyen, H.T., Khanh, N.C., Le, T.H., &Vo, U.T. (2024). Researching Influences of Learner Experience on AR/VR Adoption - The Case of Vietnamese Universities. J. Inf. Technol. Educ. Res., 23, 7.
5. Waliyyatu, Azzahra.,Sariwulan, Diana., Eni, Nuraeni., Diana, Yusni., Indri, Andriyatno. (2024). Integration of Augmented Reality (AR) in Biology Education: A Systematic Literature Review. The eurasia proceedings of educational & social sciences, doi: 10.55549/epess.792
6. Syarifah, Fadiya, Hallaby., Ade, Syahputra. (2024). 2. Improving Biology Learning Through Augmented Reality Technology in Indonesia: A Review. JISA (JurnalInformatikadanSains), doi: 10.31326/jisa.v7i1.2029
7. Tutut, Indria, Permana.,Husamah, Husamah., Moh, Irfan, Nurhamdani., Alia, Zaskia., Aulia, Savitri., Diva, Aulia, Salsabila. (2024). Augmented reality in biology education: A systematic literature review. Research and Development in Education, doi: 10.22219/raden.v4i1.32636
8. Yu, Kok, Hui.,Mohd., Fadzil, Abdul, Hanid., Megat, Aman, Zahiri, Megat, Zakaria., Mohd, Nihra, Haruzuan, Mohamad, Said., Mohamad, Ikram, Zakaria. (2024). 3. A Systematic Literature Review on Types of Augmented Reality (AR) Technologies and Learning Strategies for Problem-Solving. International Journal of Learning, Teaching and Educational Research, doi: 10.26803/ijlter.23.5.4
9. Conway, A. (2023, November 3). Google ARCore: Everything you need to know about the augmented reality platform. XDA Developers. https://www.xda-developers.com/arcore/
10. Carnes, B. (2022, March 31). Augmented Reality Full Course. freeCodeCamp.org. https://www.freecodecamp.org/news/augmented-reality-full-course
11. Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretscher, A., Ploegh, H., ...& Darnell, J. (2008). Molecular Cell Biology. 6th edition. New York: W.H. Freeman.
12. C# reference: W3Schools.com. (n.d.). https://www.w3schools.com/cs/index.php
13. Unity Reference: https://docs.unity3d.com/Manual/index.html