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An Advanced Forest Environment Using Augmented Reality and Virtual Reality Technology

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Abstract

Virtual reality (VR) and augmented reality (AR), two types of digital games, help improve education in a variety of ways. They support higher-order cognitive learning and immerse students in realistic environments, making them an invaluable addition to traditional classroom teaching techniques. This study aims to give educators a specialized framework for assessing learning of plants, stones and sand etc. using digital games, virtual reality, or augmented reality. This study presents an evaluation of a VR game in forest environment, namely during the game design phase, as an illustration of how evidence-centered design, or ECD, may be used to create and carry out assessments. To provide a structured approach to assessment considerations, it outlines stages and specifies essential components that must be aligned. The study also identifies challenges related to scanning and capturing 3D interior environments, emphasizing issues with misalignment and intricate occlusions. The forest environment is created for a 3D scene to the Unity Hub Application. The live explanation of the module's feature was easily understood by the general people.

Keywords: Augmented Reality (AR), Virtual Reality (VR), Game Based Assessment Framework, Unity Hub, Forest Environment, Mesh Rendering, Process Innovation

Introduction

Augmented reality (AR) is an experience where designers integrate computer-generated input to enhance a user's real world. Designers supply materials for electronic media. Media such as graphics, music, video, and Global Positioning System (GPS) overlays can be used as inputs. Science fiction has been describing augmented reality since 1901 (Parekh et al., 2020; Mohammad et al., 2024a). Thomas Caudill first used the term "technology" in 1990 to aid Boeing employees in visualising complex aircraft systems. One notable accomplishment was

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the complex Virtual Fixtures AR system that Louis Rosenberg developed in 1992 for the US Air Force. Subsequent versions of AR targeted at consumers included the AR Quake game from 2000 and the AR Toolkit design tool from 2009. Beyond standard augmented reality, a technological boom occurred in the 2010s (see, for example, Microsoft's Holo Lens in 2015), and augmented reality software developed, grew more widely accessible, and gained appeal. Simultaneous Localization and Mapping, or SLAM, is a technology that blends real-world sensory input with computer-generated content to create augmented reality. To track its position and orientation in respect to its surroundings, the AR device makes use of cameras, accelerometers, gyroscopes, GPS, and even lasers (Duan et al., 2019; Ayyalsalman et al., 2024; Galdolage et al., 2024; Mohammad et al., 2024b). The system analyzes sensor data to identify elements or characteristics of the surroundings that could be improved. It employs image processing and recognition algorithms to detect and track objects in real-time. Augmented Reality (AR) offers benefits across various industries, from gaming and entertainment to e-commerce and manufacturing. Smartphone applications utilizing AR are popular among users in these sectors.

Creativity and technology of virtual reality are like gasoline and fire of Technology is driven by imagination and objectives. These factors play a part in the exponential growth of technology in contemporary society. Virtual reality, which, on the one hand, immerses the viewer in a certain time or location, is made possible by visual and auditory technologies that trick the brain into thinking it is somewhere else. This is the way that one comes upon a nonexistent universe. Do you find it attractive? Through the use of computers to deceive the mind, one can experience and, more excitingly, interact with a 3D scene in virtual reality. Wearing a head-mounted display that transmits input tracking makes this feasible. In order to give you a graphic experience and create a stereoscopic 3D effect with stereo sound, the display is split between the eyes. To create the illusion of authenticity and depth, the method uses photos of the objects taken at slightly various angles. Lenses are used to magnify the LCD or OLED screens inside, filling the entire field of vision with the information intended for visual and tactile perception. Thanks to technology and input tracking, the computer generates a captivating and lifelike world. Decades have passed since the invention of what is now known as virtual reality (VR), which takes you back to a time when 360-degree artwork shocked everyone by incorporating a virtual element (Kashive et al., 2019; Mohammad et al., 2024c; Shlash Mohammad et al., 2024a).

AR and VR make learning more exciting and hands-on. As a consequence, students' memory recall improves. It is really advantageous for students who struggle with learning. Using AR and VR to prevent pupils from growing uninterested in their academics is one method. Complicated issues and concepts are examined and simplified in both AR and VR for easy comprehension. AR and VR encourage students' freedom and self-directed learning. It's an excellent educational tool that fosters trust in children. AR and VR make distance learning more engaging and exciting. Because of its immersive features, immersive technology can improve student learning in unprecedented ways, making the use of AR and VR in education a viable option. AR and VR are two complementary technologies that promote technological growth. This has the ability to diversify educational experiences, offer new viewpoints, and give intelligent technology assistance in the future. AR and VR expand the ways that digital gadgets and the physical environment interact. Because, it can present students with text, images, videos, music, and 3D objects in real time, media learning that leverages this technology may readily increase student knowledge. AR and VR technology also stimulates student participation. Integrating virtual reality (VR) into educational content delivery can significantly enhance student engagement and

learning outcomes. VR enables active participation, allowing students to immerse themselves in interactive learning environments. For instance, they can virtually explore the moon or other distant locations, fostering interest and enthusiasm in subjects like Science and Geography. This immersive approach can improve knowledge retention and understanding. However, it's important to consider the high costs associated with implementing VR technology in educational settings (Kerr et al., 2012; Mohammad et al., 2024d; Shlash Mohammad et al., 2024b).

The Unity Hub application was employed to download landscape modules, including trees, rocks, and ground sand, and to create additional assets available in the Unity Asset Store. Various research students utilize the forest environment to collect samples; for example, those in Geotechnical and Biotechnology departments gather samples within the forest. The Forest Environment Game was introduced to all resources to identify individuals and students.

In Unity Game Services, environments serve as logical partitions that organize project-specific data. When initializing Unity Services within the Unity Engine, developers can specify different initialization options to direct analytics events to various environments. In the workplace, fostering team unity enhances employees' sense of purpose and connection. A cohesive team blends diverse perspectives and skill sets, leading to innovative solutions and improved decision-making. Moreover, such unity boosts morale and reduces stress levels among employees (Kim et al., 2016; Mohammad et al., 2024e).

Related Work

Hammad et al. (2023) designed the "V-Light: Leveraging Edge Computing for the Design of Mobile Augmented Reality Games" explores the integration of edge computing to enhance the performance and user experience of mobile AR games. It addressed challenges like latency, computational constraints, and energy efficiency in mobile devices. By offloading intensive tasks to edge servers, the system ensures smoother interactions and real-time processing, critical for AR environments. The proposed architecture demonstrates significant improvements in responsiveness and scalability for mobile AR applications. This study highlighted the potential of edge computing in transforming AR gaming experiences with reduced device dependency.

Hulusic et al. (2023) work pioneers the integration of Tangible User Interfaces (TUIs) within Virtual Reality (VR) for cultural heritage education. By merging physical interaction with digital environments, it significantly enhanced user engagement and learning. This approach bridged the gap between the tangible and virtual, leading to more intuitive and effective VR educational tools, ultimately serving educational and cultural preservation goals.

Walker et al. (2023) provided a comprehensive overview of immersive technologies in human-robot interaction (HRI), reviewed the application of VR, AR, and MR. The paper introduced a virtual design element taxonomy to classify research, highlighting its importance in improving HRI. It further discussed advancements in interaction and visualization, and suggested future research areas within immersive HRI.

Greenslade et al. (2023) investigated using everyday objects as interactive props for virtual objects in first-person AR games. An elicitation study revealed how users naturally interact with these objects to improve AR gameplay. The research offered insights for designing immersive AR games based on intuitive human-object interaction.

Balcomb et al. (2023) investigated the impact of virtual hand representations on user experience and performance in 3D VR interactions. Their research examined various virtual hand model

designs and their effects on immersion, task efficiency, and user satisfaction. The study emphasized the critical role of realistic hand representation in enhancing VR gaming experiences.

Zhao et al. (2023) explored "Gaze Speedup," a system that integrates eye gaze with gesture typing to improve text input in VR. By using gaze direction to predict user intent, the system reduced typing latency and enhanced accuracy. This research addressed usability challenges in immersive VR applications.

Kapetanaki et al. (2022) reviewed the application of Augmented Reality (AR) to enhance learning experiences for students with special educational needs. Their study assessed AR's effectiveness in improving engagement, comprehension, and accessibility. The findings highlighted AR's potential for creating inclusive and interactive learning environments through tailored content.

Kim et al. (2020) investigated the use of a Mixed Reality (MR) game to improve eye contact in children with ADHD. This study demonstrated the potential of MR-based interventions to create engaging therapeutic environments that enhanced focus and social interaction in a non-invasive manner.

Mendes et al. (2019) explored the integration of Augmented Reality (AR) for urban planning and navigation in "Projected Augmented Reality Intelligent Model of a City Area with Path Optimization." This research focused on AR-based city modeling and path optimization, utilizing advanced algorithms to enhance navigation and user experience within urban environments.

Liu et al. (2020) compared Virtual Reality (VR) and Augmented Reality (AR) try-on systems using personalized avatars. This study assessed the effectiveness of both technologies in virtual fitting environments, evaluating accuracy, user engagement, and satisfaction in tailored clothing simulations.

Chaurasia et al. (2020) addressed real-time stereoscopic view synthesis for mobile Mixed Reality (MR). This study focused on optimizing algorithms to generate immersive 3D views on mobile devices, emphasizing the importance of efficient rendering techniques for improved performance and visual quality.

Ahmadyan et al. (2021) introduced a large-scale, object-centric video dataset with detailed pose annotations, captured in real-world environments. This dataset was designed to advance research in object recognition and tracking by providing rich, labeled data for diverse machine learning tasks. It addressed the complexities of real-world video analysis, serving as a valuable resource for pose estimation and computer vision applications.

Rauschnabel et al. (2019) explored the potential of augmented reality (AR) mobile applications to enhance brand marketing. They emphasized AR's ability to create immersive and engaging user experiences, inspiring consumers with interactive and personalized content, thus improving brand perception. The study presented case examples demonstrating the successful integration of AR into marketing strategies to increase consumer engagement and brand loyalty.

Beck and Crié (2018) reviewed literature on the Oculus Rift virtual reality (VR) head-mounted display, focusing on its potential to induce motion sickness. The review highlighted that users sensitive to motion-related discomfort were particularly affected, and that gender-specific differences exist, with female users reporting stronger motion sickness symptoms than male

users. This paper examined the impact of the Oculus Rift on user comfort and potential design biases.

Shin and Chang (2018) investigated virtual fitting room technologies, exploring their impact on online and offline consumer behavior, including exploration, patronage, and purchase intentions. The study analyzed how virtual try-on tools influence customer decision-making and shopping engagement. It emphasized the growing importance of these technologies in modern retail, bridging the gap between physical and digital shopping experiences.

Methodology

This approach assumes that outdoor forest environments predominantly consist of flat, planar surfaces. It identifies these planes within a 3D mesh to extract the fundamental outdoor structural view, highlighting features unique to forest settings. Lighting calculations are simplified by assigning a uniform color to each plane, ensuring frame consistency and facilitating the identification of direct light sources. The outcome is a visually appealing and concise 3D representation of external surroundings. Evaluating competencies in dynamic scenarios requires game-based assessment methods to adapt accordingly. Unlike traditional tests that often focus on right or wrong answers, grading in these contexts must consider various factors such as errors, response time, solution efficiency, and student recommendations to provide a comprehensive evaluation. Incorporating feedback into assessment design is crucial for immersive learning environments. Feedback can be integrated seamlessly into assessments, serving as an essential component of education. In immersive settings, feedback may involve immediate actions, such as providing guidance or performance data immediately after an activity. Alternatively, when using pre-existing games, feedback delivered after gameplay sessions may be appropriate. This feedback can be offered to individual students or groups during debriefing sessions. Interestingly, research indicates that immediate feedback enhances learning more effectively than delayed input. The forest environment was explained to students in the game, detailing specific plants, trees, stones, and rocks. Our paper discusses the functionality of the Unity Application and Unity Hub. Initially, this paper launches the Unity Hub application and select the environment, which offers two options: 2D and 3D. This work then proceeds to Scene mode for environment creation and execution in game mode. In this work, we employed a Mesh Rendering Algorithm comprising four key steps: Mesh Generation, Data Prefetching, Tile Rendering, and Data Import. The subsequent phase in developing an advanced forest environment involved importing various assets from online stores such as SketchFab, Unity Asset Store, and Polygon Asset Store. Using the unity hub application, it created a fully immersive advanced forest environment. In the final stage, the work transformed the 2D environment into a 3D setting. Users can then wear a Virtual Reality (VR) headset to explore and experience the comprehensive advanced forest environment immersively (Kumar et al., 2021; Mohammad et al., 2024f).

Figure 1 illustrates the creation of augmented reality and virtual reality environments, along with modules and data stores, for the complete research presented in the paper. The forest environment in this project was populated with detailed representations of specific flora and geological features, including plants, trees, stones, and rocks. Development utilized the Unity engine, starting with the Unity Hub application. The process involved selecting the desired environment type (2D or 3D) and transitioning to Scene mode for environment creation. Game mode was used for execution and testing. A Mesh Rendering Algorithm was implemented, comprising four stages: mesh generation, data prefetching, tile rendering, and data import.

Diverse assets, sourced from online repositories like SketchFab, the Unity Asset Store, and the Polygon Asset Store, were integrated to create an advanced forest environment. The Unity Hub application facilitated the assembly of this immersive environment. Finally, a 2D environment was converted into a 3D experience, allowing users to explore the fully immersive advanced forest environment using a virtual reality headset. Figure 1 illustrates the architecture of the augmented reality and virtual reality environment, outlining the modules and data storage utilized in this research.

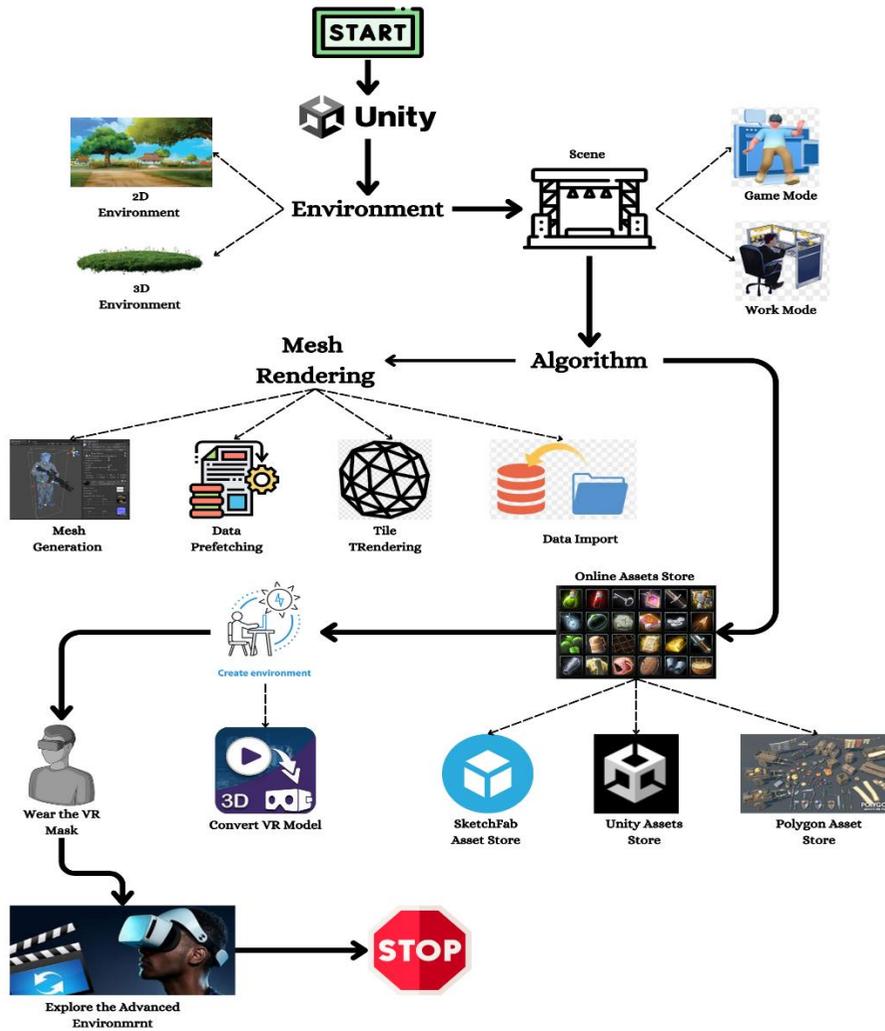


Figure 1: AR & VR Architecture

Algorithm

Two salient characteristics are its spatial homogeneity, which is the same in all orientations and places, and its linearity, which is limited to ads and multiplications. This means that the equation can be factored and rearranged in a variety of ways. This equation is of the second-class Freehold integral, akin to those found in quantum field theory. Four steps make up the rendering process for a video stream: Mesh creation, Data Import, Prefetching and Tile rendering.

Every image frame has a single call to this routine, which receives the image frame to render from the frame manager as input. The four main steps of the video stream rendering method are perfecting, data loading, mesh generation, and tile rendering. This function receives the image frame to be rendered as input from the frame manager and is executed once for each image frame. "MESH RENDERED" The geometry from the Mesh Filter is rendered by the Mesh Renderer at the location specified by the Transform component of the Game Object. With Receive Global Illumination set to Light Probes, the Mesh Renderer component appears in the Inspector window.

One way to express the rendering equation is as follows:

$$L_o(x, \omega_o, \lambda, t) = L_e(x, \omega_o, \lambda, t) + L_r(x, \omega_o, \lambda, t) \quad [1]$$

$$L_r(x, \omega_o, \lambda, t) = \int_{\Omega} f_r(x, \omega_i, \omega_o, \lambda, t) L_i(x, \omega_i, \lambda, t) (\omega_i \cdot n) d\omega_i \quad [2]$$

Here, in equation (1) the wavelength's total spectral radiance λ pointing outward in the direction of ω_o at time t_i from a specific location x $L_o(x, \omega_o, \lambda, t_i)$. The place in space x . The path of the light as it leaves ω_o . Specific colour of light λ . Time to t . Spectrum radiation emitted $L_e(x, \omega_o, \lambda, t)$ (Parekh et al., 2020). Spectrum brightness reflected $L_r(x, \omega_o, \lambda, t)$. Integral over Ω ($\int_{\Omega} \dots d\omega_i$). All feasible values for are included in the unit hemisphere around n $\omega_i \cdot n > 0$. The amount of light reflected from the bidirectional reflectance distribution function $w_{ito} \omega_o$ at position x time t and at wavelength λ . The incoming light's negative direction ω_i . Wavelength's spectral radiance λ coming inward toward x from Direction ω_i at time t . The normal at the surface x . The incident angle-related weakening of outward irradiance as light flux is spread across a surface whose area is greater than the projected area perpendicular to the ray. This is written quite a bit as $\cos \Theta_i$. (Duan et al., 2019; Mohammad et al., 2024g).

Figures 2, 3, and 4 illustrate the process of creating an advanced forest environment using the Unity Hub application.

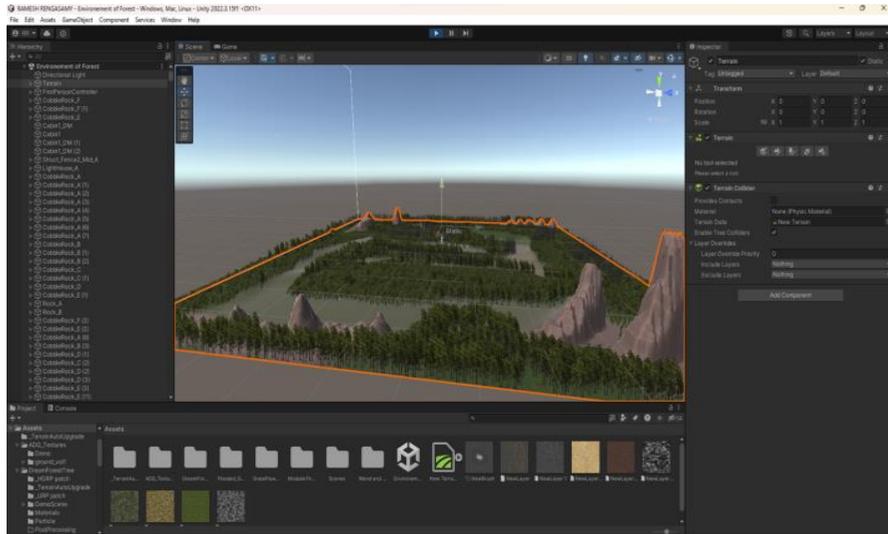


Figure 2: Creating in Forest Terrain view

Figure 2 illustrates the comprehensive design of the advanced forest environment within the Unity Hub application, showcasing the forest terrain view and the various modes available in the application.

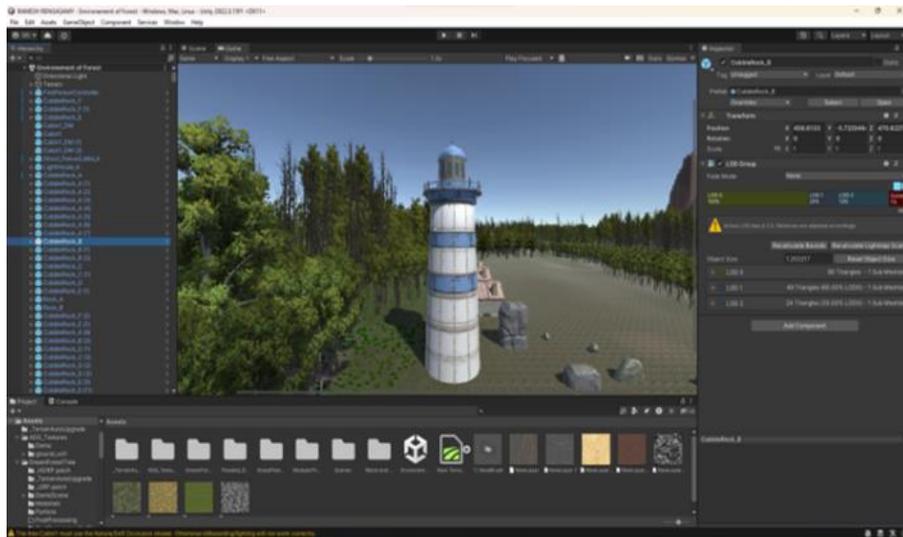


Figure 3: Creating in Forest Terrain view

Figure 3 illustrates the advanced forest environment during gameplay, showcasing features such as a lighthouse, crystal stones, and modules situated on sandy plains, along with their specifications.

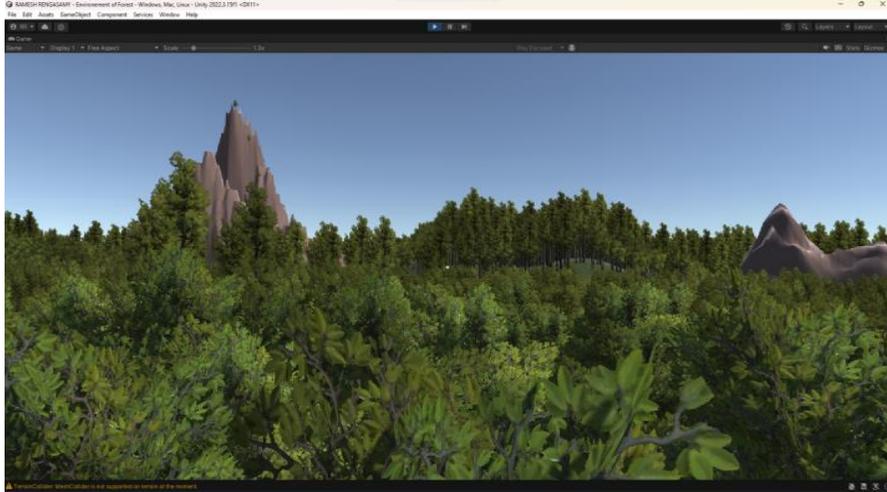


Figure 4: Top View of Forest

Figure 4 illustrates the top view and functionality of the game mode within the Unity Hub application, showcasing an advanced forest environment complete with trees, plants, and hills.

Result and Discussion

In this paper, dataset was collected from unity asset store. It is a digital marketplace and offers an enormous library of pre-made components that may be utilized to expedite the creation of video games. These resources may consist of: 3D figures and models, 2D animations and sprites, Materials and textures, Visual effects (VFX), Scripts and audio codes and Instruments and add-ons. The Unity Asset Store offers assets that are both paid for and free. To locate the assets, you need for our project, you can search the store using categories, prices, and other parameters.

The Unity Hub Application is used to Mesh Rendering Algorithm for Unity Asset Store Dataset Using to Develop in the Forest Environment. The Environment is used to the research Scholar and Common People to understand in all the specification of the Forest Nature. The test samples of Forest area and Hill station areas were collecting from the research scholar and students of the Biotechnological and Geotechnical Department. The Augmented Reality and Virtual Reality was using to the overall view of the Forest. The Augmented Reality was easy to view to the all environment to understand in the various trees and rocks. The People was using in the Meta Quest 3 is a virtual reality (VR) headset to play and explore in the environment. This game assured safety of the common people and also was saving the time. The findings show that realistic forest landscapes may be effectively simulated by AR and VR technologies. Users can virtually experience nature in a manner that closely mirrors real-world exploration, according to the high immersion scores. This had important ramifications for rural tourism, education, and environmental consciousness. Achieving complete realism was still difficult, though, especially when it came to mimicking delicate natural features like wind dynamics and intricate wildlife behavior. Notwithstanding the favorable outcomes, a number of difficulties were noted. The implementation of AR encountered challenges pertaining to outdoor use, including the inability to precisely overlay virtual components in different lighting situations. Twenty percent of VR users experienced motion sickness after extended use, suggesting the need for better locomotion strategies. Additionally, hardware dependency remained a barrier, as users required high-performance devices for an optimal experience. When it came to depicting natural aspects like

trees, water features, animals, and atmospheric effects, the produced forest setting showed excellent realism. Because the topography and plant distribution were diverse due to the use of procedural generation techniques, every session was different. Real-time lighting, dynamic weather systems, and high-resolution textures were all contributed to the overall realism. An average immersion score of 8.7 out of 10 indicated that participants felt very present, suggesting that the visual and aural components successfully replicated a real forest environment. Through haptic feedback, gesture-based navigation, and vocal instructions, users may engage with the virtual world. AI-powered animals produced a realistic and captivating experience by reacting dynamically to human inputs. The system's capacity for learning was enhanced by the inclusion of instructional components including species identification and ecological simulations.

Figure 5 and Figure 6 based on the output working of the Advanced Forest Environment in Unity Hub.

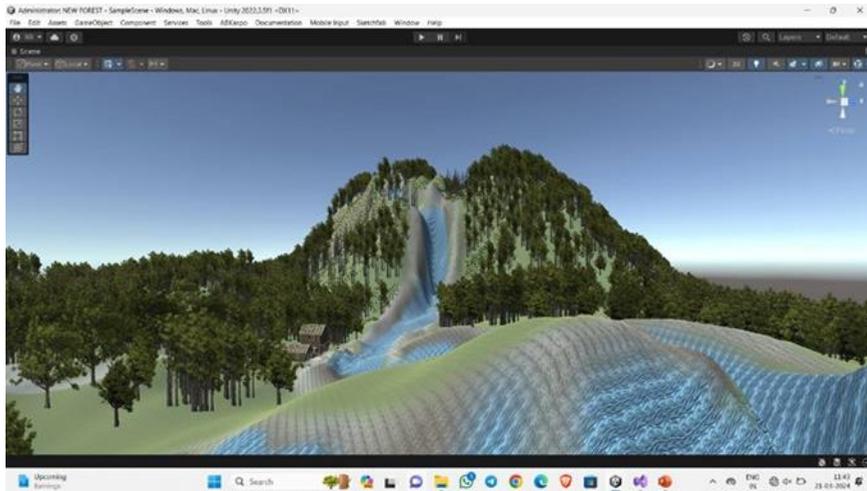


Figure 5: Game Play Mode for Terrain Falls

Figure 5 illustrated the game mode within Unity Hub, showcasing a terrain where a waterfall feeds into a river that flows into a lake, all set within an advanced forest environment.

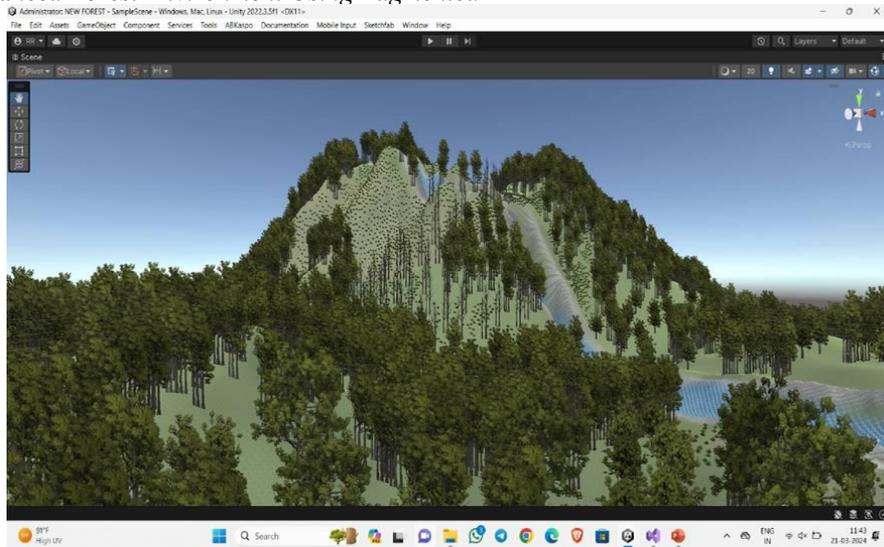


Figure 6: Play to Travel in the Forest Environment

Figure 6 illustrated the final output of the advanced forest environment within the Unity Hub application, showcasing the comprehensive view in gameplay mode.

Conclusion and Future Work

This work involved creating a sophisticated forest environment utilizing the unity hub application. Unity offers both 2D and 3D environments; for this project, the 3D environment was selected to design the terrain, resulting in a realistic forest setting. This environment was designed to be accessible to a wide audience, including students and the general public. Initially, the project focused on developing an augmented reality module. Upon completion, the environment was converted into a virtual reality module. Users could immerse themselves in the forest environment by wearing a VR headset, allowing them to explore the setting fully. This immersive experience enabled individuals, regardless of their location, to engage with and explore a forest environment.

Augmented reality leveraged technology to seamlessly blend digital data and images with the real world, creating immersive and interactive experiences. AR holds immense potential across various fields, including tourism, entertainment, healthcare, and education. While AR offers significant advantages, it also faces certain challenges that may hinder its widespread adoption and usage. One of the primary limitations is the high cost associated with AR technology. The specialized hardware, software, and ongoing maintenance can be a financial burden for individuals and institutions. To overcome these cost barriers and maximize the benefits of AR, it is essential to consider strategies such as Cost-effective hardware Explore more affordable AR devices and platforms that meet your project requirements. Open-source solutions utilize open-source AR frameworks and libraries to reduce costs. Cloud-based AR leverage cloud-based platforms to distribute AR experiences and reduce hardware costs (Al-Oraini et al., 2024). Strategic partnerships collaborate with technology providers or educational institutions to share resources and costs. Enhancing graphical fidelity while preserving performance efficiency should be the key goal of future research. Procedural generation methods for trees, foliage, and

terrain can be used to accomplish this, enabling dynamic and varied landscapes without the need for manual landscape design. Sophisticated ray tracing methods can improve lighting realism by mimicking the way light interacts with translucency, shadows, and reflections found in forests. Additionally, by lessening the rendering load on distant or peripheral objects, foveated rendering and Level of Detail (LOD) can maximize performance, especially for VR applications. The forest environment's interaction may be improved by using machine learning and artificial intelligence (AI). Based on user presence, AI-driven animal behaviors might replicate genuine wildlife movements, responses, and interactions (Chen et al., 2024; Ekanayake et al., 2024; Mohammad et al., 2024h). Weather patterns produced by procedural AI might be used to build dynamic settings where the ecology is impacted by factors like wind, rain, and fog. Furthermore, users may be able to experience long-term forest changes, including seasonal shifts, plant growth, and the consequences of deforestation, using AI-powered ecological simulations. The usefulness and realism of AR/VR forest landscapes will be significantly improved by next developments in networking, AI, IoT, graphics, and sensory technologies. By tackling these issues, the project has the potential to develop into a very advanced ecological teaching, conservation, and immersive exploration tool.

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Data Availability

No new data were generated or analyzed in support of this research.

Ethics Statement

One of the most promising areas for AR/VR technology is in the education sector, where the shortage of teacher or a trainer can be overcome. Immersive technologies like AR / VR and Mixed Reality will become the new engines of value creation in the experience economy.

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