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Augmented Reality (AR) And Virtual Reality (VR) Based on Educational Game for Mode of Quadratic Reflectance Distribution

Suleiman Ibrahim Mohammad[1,2,*], *Ramesh Prabhakaran R.*[3], *N. Raja*[4], *Hanan Jadallah*[1], *Badrea Al Oraini*[5], *and Asokan Vasudevan*[6,7,8]

[1]Electronic Marketing and Social Media, Economic and Administrative Sciences, Zarqa University, Jordan
[2]Faculty of Business and Communications, INTI International University, Negeri Sembilan, Malaysia
[3]Department of Computer Engineering, School of Engineering and Technology, Mizoram University, Mizoram, India
[4]Department of Visual Communication, Sathyabama Institute of Science and Technology, , Tamil Nadu, India
[5]Department of Business Administration, Collage of Business and Economics, Qassim University, Qassim, Saudi Arabia
[6]Faculty of Business and Communications, INTI International University, Negeri Sembilan, Malaysia
[7]Faculty of Management, Shinawatra University, Pathum Thani, Thailand
[8]Business School, Wekerle International University, Budapest, Hungary

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Abstract: Digital games, such as virtual reality (VR) and augmented reality (AR), provide substantial educational benefits by fostering higher-order cognitive learning and immersing learners in realistic scenarios. These tools effectively complement traditional teaching methods. The aim of this research is to provide educators with a customized framework for evaluating the educational impact of digital games, VR, and AR. It presents a case study that evaluates a VR game during its design phase using Evidence-Centered Design (ECD). The study outlines crucial stages and components necessary for a systematic assessment approach. Additionally, it addresses challenges related to scanning and rendering complex 3D indoor environments, particularly issues concerning occlusions and alignment. The study underscores the significance of transforming museum exhibits into a 3D format accessible to both students and the general public, enhancing understanding through live demonstrations. This method enriches comprehension for all participants involved.

Keywords: Augmented Reality (AR), Virtual Reality (VR), Immersive Learning Technologies, Game Based Assessment Framework, Evidence Centred Design, Unity Hub, Museum Environment, Rendering Algorithm

1 INTRODUCTION

Virtual reality (VR), augmented reality (AR), and digital games (DGs) constitute immersive technologies with diverse applications across multiple industries, including education, healthcare, travel, military services, and aviation [1,2,3]. These immersive learning technologies furnish interactive and contextual environments that enrich learning experiences, fostering deeper comprehension. Rooted in constructivism, immersive learning environments furnish interactive platforms for learners, aligning with Piaget's proposition (1973). Education places considerable emphasis on learning assessment, recognizing its pivotal role in students' development. Critical for a child's growth and integration into society, these skills are foundational. Furthermore, embracing a collaborative approach has demonstrated its ability to enhance academic performance. Unfortunately, the utilization of virtual reality can impede meaningful interactions among children, adversely affecting their social development and fostering a sense of isolation.

One potential application involves visualizing 3D content for indoor commercial purposes, such as real estate or interior design for homes, offices, or hotels. Realistic VR content, combined with physically precise rendering and simulation, shows promise in addressing conditions like Alzheimer's disease or providing data for machine learning tasks. Indoor environments are typically

* Corresponding author e-mail: dr_sliman@yahoo.com

depicted using either 3D reconstruction or image-based rendering methods [4,5,6,7].

The advent of augmented reality (AR) is reshaping our world, but what exactly does it entail? AR overlays digital imagery onto the physical environment using smartphones and tablets. Through your device's camera, you experience an enhanced version of reality, adorned with additional graphics, text, or animations. Augmented reality enriches your perception by integrating a technological layer into your surroundings [8,9,10,11]. You may have already encountered AR applications for entertainment and gaming. However, beyond gaming, augmented reality harbors intriguing possibilities that are just beginning to unfold. Notably, museums and other cultural institutions are embracing AR as an immersive method to exhibit artifacts and invigorate displays [12,13,14,15]. Unlike virtual reality (VR), which immerses users in a fully simulated three-dimensional realm, AR superimposes digital elements onto the real world, which serves as the backdrop. AR enhances the depiction of reality rather than replacing it, rendering it particularly suitable for enhancing museum exhibitions. It offers context and annotations to supplement what visitors are already observing. The potential for augmented reality in museum settings is vast, with cultural institutions worldwide leveraging this technology to revolutionize the tourist experience as it becomes more sophisticated and accessible. Are you prepared to perceive museum exhibitions in a new light? Continue reading to uncover how AR is introducing an exhilarating new era of interactivity for these venues. Utilizing this technology, museums can craft inclusive narratives that animate distant artworks, thereby expanding their revenue streams. International audiences can engage in captivating augmented reality experiences tailored to their preferences [16,17,18].

2 AR APPLICATIONS FOR MUSEUMS

Augmented reality opens up a world of new possibilities for museums to showcase their treasures and engage visitors. One of the most significant applications of augmented reality in museums

2.1 ADDING LIFE TO EXHIBITS

Augmented reality (AR) empowers museums to elevate static exhibitions by integrating dynamic digital overlays. Utilizing 3D animations and effects, artifacts once confined to silent display cases now burst into vibrant life. Witness historical relics being interacted with by virtual characters or fossils seamlessly assembling into complete dinosaur skeletons. Visitors are encouraged to immerse themselves in exhibits on entirely new levels, all thanks to augmented reality technology [19,20,21,22]. But AR goes beyond simple visual enhancement; it provides additional layers of information about displays. By simply pointing a smartphone towards a painting or sculpture, visitors can access a wealth of details such as the work's history, the creator, the medium, and more, all displayed on their screens without cluttering the exhibits. Envision curators or artists appearing as digital avatars beside their creations, offering insights and commentary. Museums can leverage AR to generate 3D replicas of historical figures, allowing them to engage visitors with discussions about the exhibits. Picture exploring a Picasso painting virtually while listening to a holographic Renaissance historian discussing their antiques, infusing the experience with a captivating human touch [23,24,25,26].

Visitors are actively engaged as participants through games designed to encourage exploration of the museum to unlock AR animations. Immersive exhibit environments are meticulously crafted through AR scavenger hunts, collection challenges, and a host of other interactive experiences [27,28]. Moreover, augmented reality enables museums to transcend the limitations of physical travel, reaching distant audiences worldwide. Through AR, cultural organizations can now share their treasures with global audiences, fostering inclusive narratives that breathe life into distant artworks and, in the process, create innovative revenue streams [29,30,31].

3 RESEARCH METHOD

This approach acknowledges that interior spaces primarily consist of flat, planar surfaces and identifies these planes within a 3D mesh. It then extracts the fundamental interior structure, distinguishing room elements from others. Assigning a single hue to each plane simplifies lighting calculations, while direct light sources are identified and frame consistency is maintained. The result is a concise, visually appealing 3D depiction of interior environments, complete with distinct room layouts and lighting details [32,33]. Various applications, such as mixed reality, indoor visualization, and navigation, can benefit from this output. Evaluating capabilities in dynamic conditions requires game-based evaluation grading techniques to adapt accordingly. To ensure a comprehensive evaluation, grading in these contexts must consider factors such as reaction speed, solution efficiency, errors, and students' requested recommendations, unlike traditional exams, which often focus on solely correct or incorrect responses. Incorporating feedback is a crucial aspect of creating assessments for immersive learning environments [34,35]. Feedback should seamlessly integrate into assessments, offering prompt responses such as advice or performance information immediately after an activity. Alternatively, feedback given after gameplay sessions may be suitable for existing games. This feedback can be provided to individual students or groups during debriefing sessions. Interestingly, studies suggest that immediate feedback enhances learning more effectively than delayed feedback [36].

4 RENDERING

At the heart of PBS lies the inquiry into discerning the quantity and trajectory of light emanating from an object's surface. Understanding the significance of this query necessitates an exploration into its role in scene rendering. In the realm of 3D computer graphics, rendering unfolds as the conversion of a three-dimensional scene's mathematical representation into a two-dimensional image. This image comprises a grid of pixels, each independently computed for its color—a process termed shading. These pixels essentially reside within the 3D scene, positioned on a plane just before the viewpoint, known as the near plane. Each pixel corresponds to a view direction vector originating from its center towards the viewpoint. The color of a pixel is contingent upon the light passing through its center along its view direction. This incoming light to a pixel originates from surfaces within the scene, either emitted directly or reflected from other light sources. Assuming light travels linearly, each pixel typically aligns with a singular surface point in the scene, directing light both through its center and along its view direction [37].

Two prevalent methods exist for establishing the surface point associated with a specific pixel. In offline renders, ray tracing is commonly employed, wherein a ray is cast from the center of a pixel along its negative view direction. If this ray intersects with a surface, the resultant hit point serves as the desired surface point. Conversely, real-time renders often adopt a different approach, projecting all surfaces onto the near plane through a series of linear transformations applied to the scene geometry. Subsequently, a process of rasterization and interpolation is undertaken to pinpoint the exact surface point for each pixel [38].

The Figure 1 Explain to the Object detection in the Terrain for the Environment to expain to the viewpoint and Image Explanations.

Within the realm of computer graphics, the rendering equation stands as an integral formulation, defining the equilibrium radiance departing from a specific point as the amalgamation of emitted and reflected radiance, operating within the confines of a geometric optics approximation. This concept was contemporaneously introduced into the field of computer graphics in 1986 by David Immel et al. and James Kajiya. Rendering times are significantly influenced by the complexity of your scene, encompassing various elements such as the quantity and dimensions of polygons, textures, lighting arrangements, shadows, reflections, refractions, and additional effects integrated into your scene.

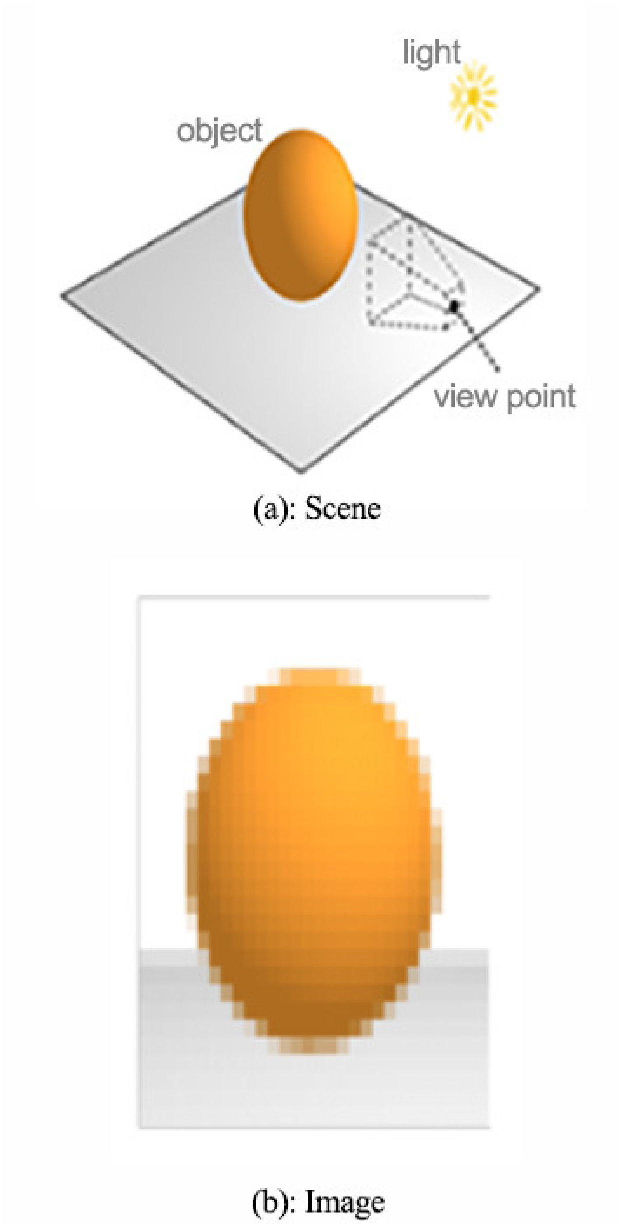

Fig. 1: Object Detection

The Figure 2 Explain to the All Directions and near plane View in the viewpoint of the environment in the Algorithm.

5 PROBLEM STATEMENT

Digital Games (DG), Augmented Reality (AR), and Virtual Reality (VR) represent adaptable technologies with diverse applications across industries like healthcare, education, tourism, the military, aviation, and museum environments. These immersive technologies facilitate the

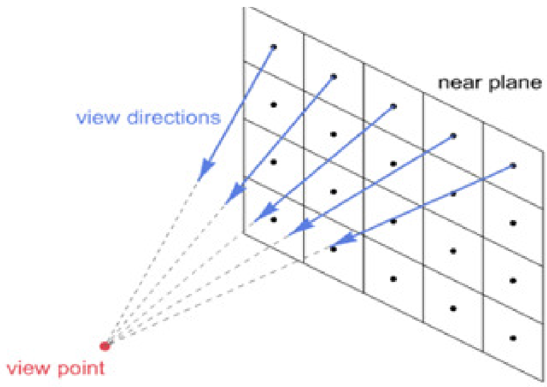

Fig. 2: Plane View

creation of contextualized and interactive learning environments, enriching educational experiences and fostering stronger engagement with the subject matter. This includes their utilization in museum equipment, where VR masks and related specifications enhance the visitor experience by offering immersive exploration and deeper connections with historical or artistic content.

6 MODULES

6.1 CONSERVATION OF ENERGY

The rendering equation finds its foundation in the fundamental principle of energy conservation. Illustrated by the variable L, representing radiance, this equation dictates that the outgoing light (Lo) at any given point and direction results from the combined contribution of emitted light (Le) and reflected light (Lr). This formulation encapsulates the intricate interplay between light emission and reflection, providing a robust framework for understanding and simulating light behavior in diverse visual contexts.

6.2 POSITIVITY

The rendering equation serves as a cornerstone in computer graphics, offering a powerful tool for achieving realistic and visually stunning imagery. By encapsulating the intricate interactions of light within a scene, it enables the creation of lifelike simulations and immersive virtual environments. Embracing the principle of energy conservation, the rendering equation ensures that rendered scenes maintain physical accuracy, enhancing the viewer's sense of immersion and believability. Moreover, its mathematical elegance and versatility empower artists and developers to explore creative possibilities and push the boundaries of visual storytelling. In essence, the rendering equation embodies the potential for endless innovation and artistic expression in the realm of computer-generated imagery.

6.3 LAW OF REFLECTION

The rendering equation framework implicitly incorporates the law of reflection, a fundamental principle in optics, which serves as a guiding principle for simulating light behavior in virtual settings. This law states that when a light beam strikes a surface, its angle of incidence and reflection are equal. This idea is applied to the rendering equation in the computation of reflected radiance (Lr), which takes into consideration the light that reflects off objects in a scene. The rendering equation makes sure that the directionality of light is precisely recreated by following the law of reflection, which adds to the authenticity and realism of rendered images.

6.4 FRESNEL EQUATIONS

The Fresnel equations play a crucial role within the rendering equation framework, particularly in modeling the complex behavior of light at the interface between different materials. These equations describe how the reflectance and transmittance of light vary with the angle of incidence and the properties of the materials involved. In the context of the rendering equation, the Fresnel equations inform the calculation of the amount of light that is reflected and transmitted at each point on a surface. By considering factors such as the refractive indices of the materials and the angle of incidence, these equations help determine the proportion of light that is reflected back into the scene and the proportion that continues through the surface.

Integrating the Fresnel equations into the rendering equation enables the simulation of realistic optical effects such as reflection, refraction, and specular highlights. This enhances the fidelity of rendered images by accurately capturing the behavior of light as it interacts with surfaces of varying materials and geometries, thereby contributing to the overall visual realism and immersion of virtual environments.

7 ALGORITHM

7.1 ANALYTIC LIGHTS SOURCES

In the context of illuminating analytic scenarios, the luminous landscape is delineated by several key factors as represented in the formula (1) where N, symbolizing the numerical quantity of analytic lights employed; $f_r(p, \omega_i, \omega_o)$, which signifies the proportion of incoming radiance deftly redirected towards the desired outgoing trajectory; $(\omega_i.n)$, representing the division of radiance subsequent to its projection over the surface; and $L_r(p,\omega_i)$, encapsulating the radiant intensity originating from the incoming direction.

$$L_r(p,\omega_i) = \sum_{i=1}^{N} f_r(p,\omega_i,\omega_o)\,L_i(p,\ \omega_i)\,(\omega_i.n) \qquad (1)$$

Together, these elements compose a comprehensive framework for understanding and manipulating the intricate interplay of light in analytical settings, guiding the optimization and visualization of various scenarios with precision and efficacy.

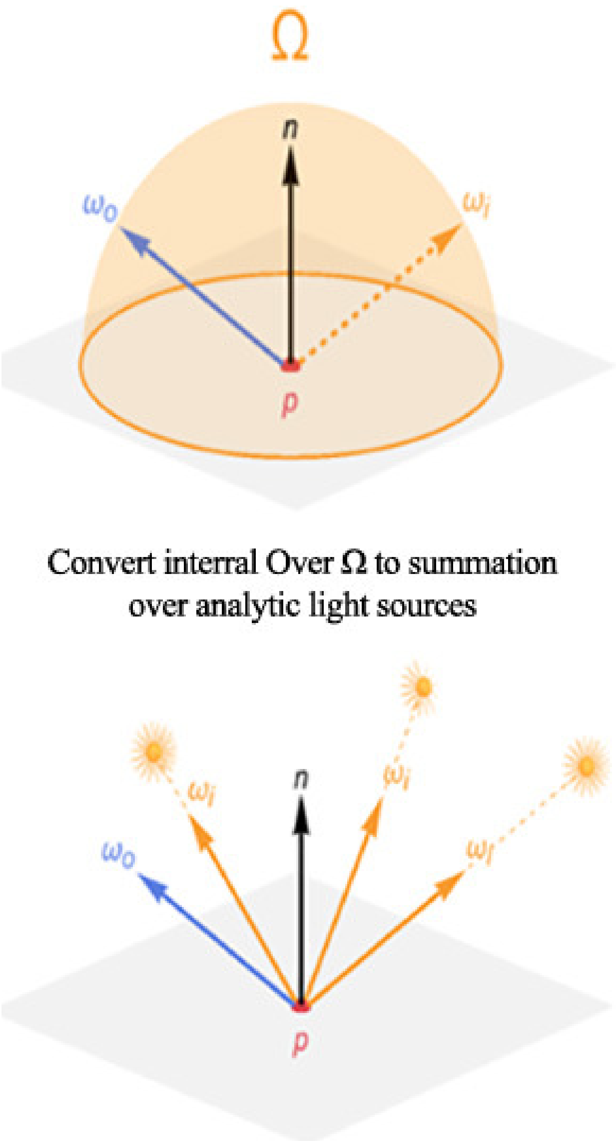

Fig. 3: Iilluminating Analytics

The Figure 3 Explain to the Convert integral over to Summation over light source illuminating analytics.

7.2 BIDIRECTIONAL REFLECTANCE DISTRIBUTION FUNCTION

In the realm of directional illumination, the orientation of light is defined by a set of parameters represented in the formula (2) where: θ_i, representing the zenith angle of the incident direction ω_i; ϕ_i, denoting the azimuth angle of the incident direction; θ_o, signifying the zenith angle of the outgoing direction ω_o; and ϕ_o, indicating the azimuth angle of the outgoing direction. These parameters serve as pivotal descriptors, intricately shaping the trajectory and intensity of light as it traverses through space, enabling precise analysis and manipulation of illumination patterns in various applications.

$$f_r(\omega_i,\omega_o,n) \equiv f_r(\theta_i,\phi_i,\theta_o,\phi_o) \qquad (2)$$

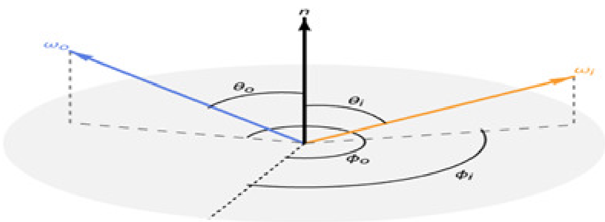

Fig. 4: Directional Illumination

Figure 4 and 5 Explain to the Directional Illumination and Measured Bidirectional Reflectance Distribution Function of data of the Real Materials.

The video stream rendering process unfolds in four key stages: refining, loading data, generating meshes, and rendering tiles. This operation is triggered by the frame manager, receiving each image frame as input and executing sequentially. In the “MESH RENDERED” phase, the geometry sourced from the Mesh Filter undergoes rendering via the Mesh Renderer, positioned according to the specifications within the Transform component of the corresponding Game Object. Notably, when “Receive Global Illumination” is enabled, the Mesh Renderer component becomes visible within the Inspector window, ensuring comprehensive illumination handling.

8 DATASET

Within the Unity game development community, developers can tap into the Unity Asset Store, a digital marketplace brimming with a vast array of pre-made components aimed at streamlining the game creation

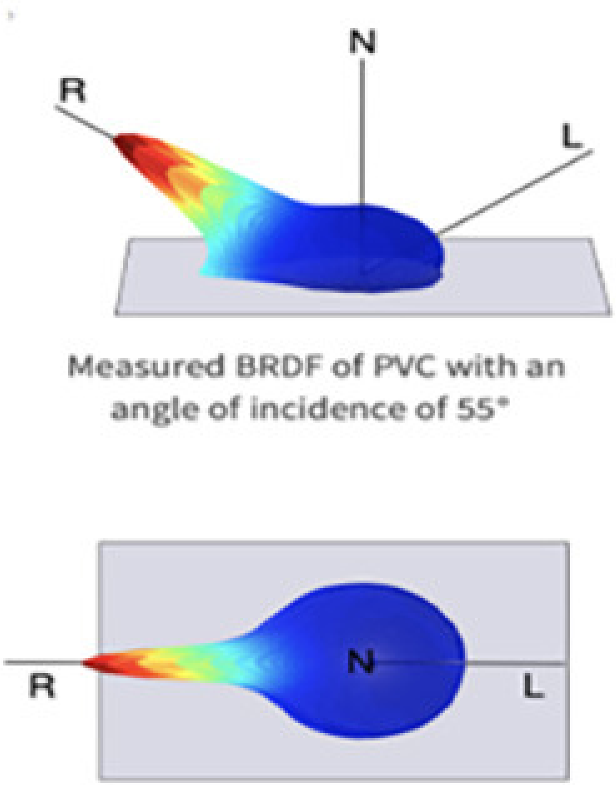

Fig. 5: Measured BRDF data of real materials

process. These resources encompass a diverse range of elements, including 3D figures, 2D animations, materials, visual effects (VFX), scripts, audio codes, and various instruments and add-ons. Whether seeking paid or free assets, developers can navigate the store's extensive catalog using categories, prices, and other filtering parameters to locate the precise components required for their projects.

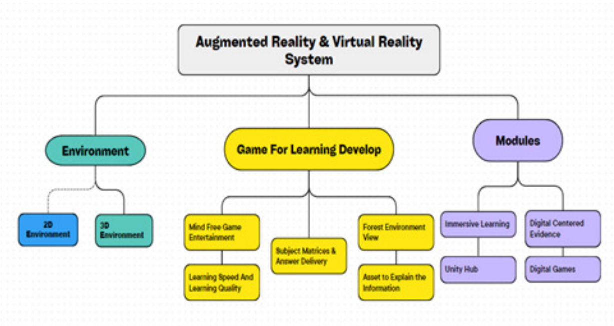

Fig. 6: AR & VR Game Architecture

The Figure 6 Shows to Augmented Reality and Virtual Reality Game Directional Algorithm Architecture.

9 WORKING MODEL

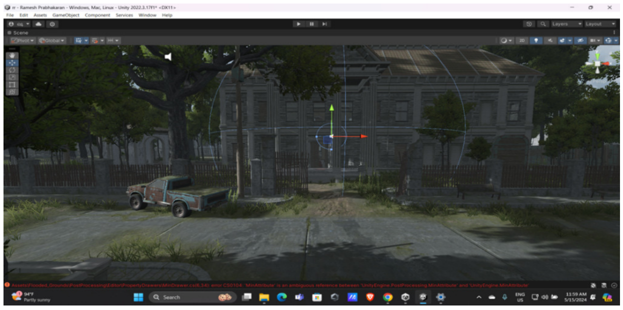

Fig. 7: Analytic Lights Sources

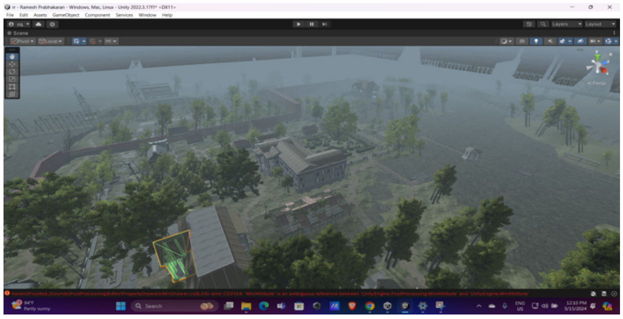

Fig. 8: Precision and Efficacy

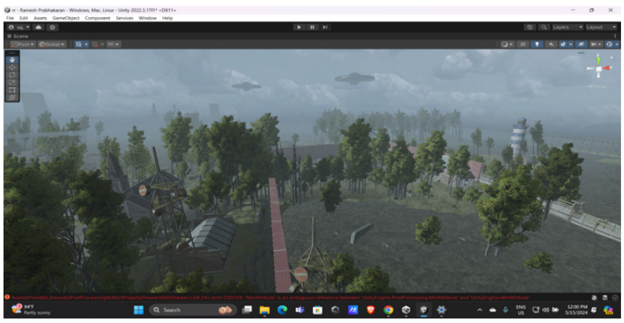

Fig. 9: Top view of the Environment

The Figure 7, 8 and 9 Explain to the Analytic Lights Sources. Precision and Efficacy. Top view of the

Environment in working model in the Terrain in the unity hub Application.

10 RESULT & CONCLUSION

To develop in the countryside environment, the Unity Hub application is utilized to apply the Mesh Rendering Algorithm for Unity Asset Store Dataset. The building perspective and the sources of analytical lights that serve as directional points are identified using the environment. Students and staff from the Biotechnological and Geotechnical Department were observing and gathering test samples for our museum and rural development zones. The Created Environment's overall view was enhanced using augmented and virtual reality. The augmented reality provided an easy-to-understand representation of the entire environment, including the different building structures and analytical lights. A virtual reality (VR) headset was being used by the players in Meta Quest 3 to play in the environment. The Common people was used in this game.

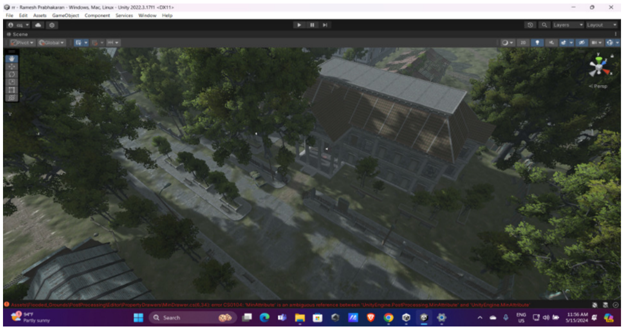

Fig. 10: Created Environment

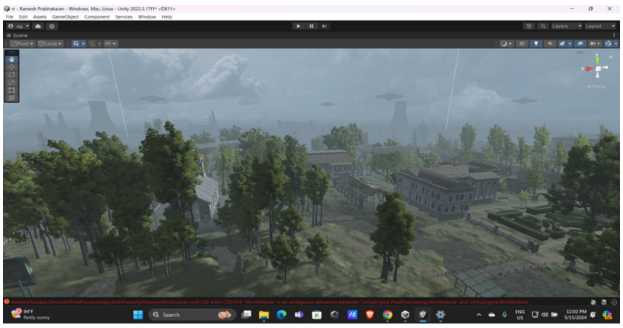

Fig. 11: Top view of Bidirectional Reflectance

The Figure 10 and 11 Explain to the Created Environment and Top view of Bidirectional Reflectance in the out put image in the Game mode view.

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Data Availability

No new data were generated or analysed 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.

Declarations & Conflct of interest

The authors declare no conflct of interest.

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Suleiman Ibrahim Shelash Mohammad is affiliated with Electronic Marketing and Social Media at Economic and Administrative Sciences Zarqa University, Jordan, and is a Research follower at INTI International University, Malaysia. His research interests include digital marketing, virtual reality, and educational technology. He has published numerous papers in reputable journals and conferences. His ORCID ID is 0000-0001-6156-9063.

Ramesh Prabhakaran.R is affiliated with the Department of Computer Engineering at Mizoram University, India. His research focuses on computer engineering with specific emphasis on virtual and augmented reality applications. He has made significant contributions to educational technology and immersive learning environments. His ORCID ID is 0009-0005-0983-9800.

N. Raja is an Assistant Professor at Sathyabama Institute of Science and Technology, Department of Visual Communication, Chennai, Tamil Nadu, India. His research interests include visual media, digital communication, and immersive technologies for education. His ORCID ID is 0000-0003-2135-3051.

Hanan Jadallah is affiliated with Electronic Marketing and Social Media, Economic and Administrative Sciences at Zarqa University, Jordan. Her research interests include digital marketing strategies, blockchain applications in business, and consumer behavior in digital environments. She has contributed to multiple research projects on technological integration in marketing.

Badrea Al Oraini is affiliated with the Department of Business Administration, College of Business and Economics at Qassim University, Saudi Arabia. Her research focuses on business applications of emerging technologies including AR and VR, with emphasis on educational and training contexts.

Asokan Vasudevan is a faculty member at the Faculty of Business and Communications, INTI International University, Malaysia. His research interests include communication technologies, immersive learning, and technology adoption in educational contexts.