Empowering Mizoram State Museum Applying Virtual Reality on Linked Data and Smart Objects

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Abstract—Augmented Reality (AR) and Virtual Reality (VR) can be combined to create Mixed Reality (MR) experiences that significantly benefit India's tourism department. These technologies enhance higher-order cognitive learning by immersing users in realistic environments, making them invaluable complements to traditional museum techniques. This Full Research explores the implementation of various algorithms, including Rendering Algorithm, pathfinding navigation meshes Algorithm, convolutional neural networks Algorithm (CNNs) and Simultaneous Localization and Mapping Algorithm (SLAM), to develop a 3D model of Advanced Mizoram State Museum Environment in Unity Hub. This model was then converted into a VR experience for the Meta Quest 2. First, I go to Mizoram State Museum to Collect the information and take the picture for Creating Dataset and Converting the 3D Image to the Unity Hub Application for advanced Museum Environment Creating Purpose. This Paper Only Explain the two Algorithms only Rendering Algorithm and Convolutional Neural Network Algorithm (CNN). The rendering algorithm was employed to optimize the Animals, Birds, Insects and Leaf's to get the information and Create the Dataset to upload the code. The Unity Hub application wants to them Object Assets. I go to Download to the Various Assets stores Example Unity Hub Assets Store, Sketch Fab and Blender Assets Store Websites. The Convolutional Neural Network Algorithm (CNN) have explained the Object Detection, Object Recognition and Object Identification to the information for the Visitors peoples. The 3D model of Mizoram State Museum effectively showcases biological animals, plants, insects, and human features, offering users the convenience of exploring the museum anytime and anywhere.

Keywords: Augmented Reality, Virtual Reality, Rendering Algorithm, Conventional Neural Network, Museum, Object Detection, Environment Creation, 3D View.

INTRODUCTION

This paper presents a comprehensive exploration of the infrastructure and specifications required to implement Augmented Reality (AR) and Virtual Reality (VR) experiences within the 3D model environment of Mizoram State Museum. The objective is to enable remote visitors and tourists to experience the museum's offerings through these immersive technologies. To create the 3D model, the museum was initially captured through photographs and videos. These images were then converted into 3D models using specialized software and integrated into a Unity Hub-based AR/VR environment. Four key algorithms were employed in the development of this AR/VR museum:

rendering, Visual Simultaneous Localization and Mapping (vSLAM), pathfinding and navigation meshes, and Convolutional Neural Networks (CNNs). In this Paper have Explained to the two algorithms only Rendering Algorithm and Convolutional Neural Networks Algorithm (CNN).

A Rendering Algorithm is a crucial component of computer graphics, transforming 3D scenes into 2D images or displays. It calculates how objects within a scene should appear from a specific camera perspective, considering factors like lighting, shading, texturing, and geometry. Rendering algorithms are widely used in video games, simulations, virtual reality (VR), and augmented reality (AR) to create realistic or stylized visual environments. The rendering process involves mesh generation, data loading, prefetching, and tile rendering. While rendering algorithms are fundamental to computer graphics, they can be complex and difficult to optimize. Techniques like global illumination, texture mapping, and normal mapping enhance the realism and detail of rendered images. The choice of rendering algorithm depends on the specific application's requirements. For instance, real-time games often prioritize speed and use rasterization, while photorealistic renderings for films or architectural visualizations may employ more computationally intensive methods like ray tracing or hybrid approaches.

In particular, experimentation consisted of two main stages: a preliminary and a parallel test. As concern the former, a group of domain experts was involved in this study in order to collect qualitative data and perform a preliminary selection of the most commonly used AR rendering techniques as evident from the existing literature. Second, the parallel test, carried out with the involvement of representative users, consisted in performing an inspection task on a physical prototype by adopting an AR application, implementing different visualization modalities according to the rendering techniques selected by the experts. Both quantitative and qualitative metrics were considered to evaluate the influence of the selected AR rendering techniques on user performance in detecting design discrepancies [1].

Convolutional Neural Networks (CNNs) are a powerful type of deep learning algorithm that have revolutionized various fields, including computer vision. In the context of AR/VR museums, CNNs can enhance the user experience by providing intelligent features such as object recognition, scene understanding, and interactive elements. For object recognition, CNNs can be trained on extensive datasets of museum artifacts to accurately identify and classify objects in real-time using camera input. Once an artifact is identified,

AR/VR experiences can offer additional information, including historical context, related exhibits, or interactive elements. CNNs can also aid devices in understanding the surrounding environment, including the museum's layout, object positions, and the presence of other visitors. This information enables relevant and immersive experiences, such as placing virtual objects in appropriate locations or suggesting exhibits based on the user's current position. Furthermore, CNNs can recognize hand gestures and other body movements, allowing users to interact with virtual objects or trigger specific actions within the AR/VR experience. By enabling natural language or gesture-based interactions, CNNs make AR/VR experiences more accessible to a wider audience. CNNs open up new possibilities for educational and entertainment experiences, including interactive exhibits, personalized tours, and gamified learning.

Evolutionary algorithms are often applied for optimal parameters setting. However, to this end, a considerable part of the search space should be explored. Finding the optimal ensemble of CNNs using an evolutionary approach is out of the scope of this study since this task has an extremely high computational cost because not only a large number of different architectures must be evaluated, but also a plethora of combinations of CNNs to form the ensembles. Instead, authors propose the use of an evolutionary algorithm for efficiently searching near-optimal ensembles of CNNs by evolving an initial population with no additional cost besides the evolutionary process itself. The term efficient search used in this study refers to a search strategy that can be implemented in con venational hardware and leads to reasonably good solutions from engineering viewpoint in a short period of time [3].

RELATED WORKS

Santina Fortuna *et al.*, 2024 (1) Augmented Reality (AR) is increasingly used in manufacturing to improve operators' performance in inspection and assembly tasks. This study evaluates the impact of different AR rendering techniques on user efficiency and accuracy during industrial inspections. Using a custom AR tool, qualitative and quantitative metrics were compared among selected rendering techniques. Results from 17 experts and 33 users showed that rendering methods significantly aid in identifying design discrepancies. A correlation was found between specific rendering techniques and the types of assembly errors detected, highlighting their potential in industrial applications.

Qing Gong *et al.*, 2024 (2) Virtual Reality (VR) Cultural Heritage Exhibitions (VRCHEs) present unique challenges

and opportunities in user experience (UX) design due to differences in interaction methods compared to traditional interfaces. Existing UX models are insufficient, lacking comprehensive insights and design strategies. This study uses grounded theory with qualitative and quantitative methods to build a detailed UX model for VRCHEs. It also proposes practical design strategies based on three-level coding and theoretical analysis.

Yarens J. Cruz *et al.*, 2021 (3) This paper introduces an ensemble-based image classification approach using five convolutional neural networks (CNNs) combined through a voting policy. An evolutionary algorithm was employed to optimize network parameters and voting strategies. The method was validated in a case study detecting metal sheet misalignments in submerged arc welding, outperforming seven other strategies across various metrics. It achieved superior performance while maintaining reasonable computational efficiency.

Wang Shu-Xi *et al.*, 2012 (4) The shortest path problem is common in many fields, with Dijkstra's algorithm being a well-known solution. However, it faces issues in directed graphs, adjacent vertices, and simultaneous "p-label" assignment. By addressing these, we significantly improved the algorithm, with experimental results showing effective resolution of these issues.

Mateus Mendes *et al.*, 2019 (5) This paper presents a model combining Augmented Reality (AR) and AI algorithms to enhance user experiences with a 3D map of Coimbra, using data from OpenStreetMap. The AR effect is achieved via video projection over a 3D printed map, allowing users to interact through smartphones and simulate optimized itineraries using genetic algorithms and A*. This model has applications for tourism, virtual reconstructions, and travel simulations.

Hassan Mohyuddin *et al.*, 2023 (6) This paper introduces a methodology combining gesture recognition data from a Leap Motion Controller (LMC) with the Spotted Hyena-based Chimp Optimization Algorithm (SSC) for feature selection in deep neural networks (DNNs). A comparative analysis shows SSC outperforms other optimization techniques like PSO, GWO, and SCA, achieving 98% accuracy in gesture recognition. The proposed approach enhances both accuracy and versatility in various feature extraction applications.

S. Suganya *et al.*, 2023 (7) The Virtual Museum Android App offers an immersive experience, allowing users to explore galleries, interact with exhibits, and learn about their history. It includes audio-visual guides and educational resources to enhance learning. The app uses graphical modeling and augmented reality to create a realistic and interactive environment.

Young Min Kim *et al.*, 2021 (8) 3D indoor environment scanning often faces issues like occlusions and misalignments, leading to geometry holes and texture ghosting. This article explores using planes to both represent the environment geometrically and solve inverse rendering problems, simplifying shape inference and intrinsic imaging. The resulting 3D content provides realistic, visually compelling environments suitable for AR/VR Applications.

Chioma Udeozor *et al.*, 2023 (9) Immersive learning technologies like VR, AR, and educational games offer significant benefits to teaching, but current assessment practices may not be sufficient for these environments. This paper develops a game-based assessment framework (GBAF) for evaluating learning in VR and AR, grounded in Constrictive Alignment and Evidence-Centered Design principles. It provides a stepwise design for assessments in immersive settings, including a case study on assessing engineering students' laboratory competencies.

Andreas Philipp Hassler *et al.*, 2019 (10) As life expectancy increases, more elderly individuals face age-related diseases, with frailty being a key factor linked to falls, hospitalization, and mortality. Predictive data mining can identify risk factors, aiding clinical decision-making to prevent adverse outcomes. This study developed predictive models using medical data from 474 participants, with the support vector machine (SVM) achieving the best accuracy (78.31%), and highlighted the potential of using incomplete medical data to predict frailty.

Valerie Czok *et al.*, 2023 (11) New technologies, such as augmented reality (AR), are transforming education by enhancing interactivity and understanding. This paper explores the positive learning effects of AR through a game-based environment, "Beat the Beast," focusing on microplastics within an interdisciplinary framework of biology, chemistry, and engineering. The approach aims to improve learning outcomes and motivation in science education.

Yuzhao Liu *et al.*, 2020 (12) Online apparel shopping poses risks as consumers cannot physically see or try on products. To improve this, an AR- and VR-based try-on system allows users to view garments on a personalized virtual body. User studies show that AR-based try-ons offer a more realistic shopping experience than VR, though personalized motions don't significantly impact the experience.

Shilong Su *et al*., 2023 (13) This study examines the effectiveness of extended reality (XR) in training for total hip arthroplasty (THA). A systematic review and meta-analysis of five studies with 106 participants showed XR training improved inclination accuracy and reduced surgical duration compared to conventional methods. However, the accuracy of anteversion was similar between both approaches.

Agariadne Dwinggo Samala *et al*., 2023 (14) This study analyzed international publications on augmented reality (AR) and virtual reality (VR) for learning from 2001 to 2021, using bibliometric analysis and data from Scopus. The findings show that both technologies have seen rising trends, with Denmark, India, and prominent researchers like Y. Zhou and Archana M. making significant contributions. The research predicts continued development of AR/VR and mixed reality (MR) technologies, emphasizing the importance of pedagogical competence in enhancing learning experiences.

PROPOSED METHOD

This Research is presented to the Mizoram State Museum to explain the use of Augmented Reality (AR) and Virtual Reality (VR) to the Mixed Reality in creating an advanced museum environment. The virtual museum allows visitors to explore exhibits in a 3D virtual reality space. I employed four different algorithms, but this paper focuses on two: the Convolutional Neural Network (CNN) and the Rendering Algorithm. First, I Collect the Dataset for the image and

Image to 3D convert Pictures to create the one Dataset in the All Type of Animals, Birds, Insects and leaf's after creation I upload the Dataset to the Convolutional Neural Network (CNN) Algorithm mainly YOLOv7 model code and execute the full code detect the object recognition, identification and all information in the output. The execute platform is Anaconda Jupyter Notebook in Python Kernal. The Rendering Algorithm is responsible for creating the museum's environment, handling data loading and per fetching, and developing the 3D view of the Mizoram State Museum. I open the Unity Hub Application and create the new terrain to put the one structural building in the application, next all Downloaded assets load and per fetching to the correct places into the terrain. The Advanced Mizoram State Museum Environment was Created after we Convert to the Augmented Reality to Virtual Reality (2D to 3D). The CNN, specifically the YOLOv7 model, is employed for object detection and recognition within the museum. It identifies animals, insects, and other items, providing detailed information about them, such as whether an animal or insect is poisonous or non-poisonous. The advanced museum environment was created using Unity Hub, offering an interactive space for tourists, visitors, and the general public. Wearing a VR headset, visitors can immerse themselves in the virtual museum. The CNN ensures accurate detection of objects, making it easy for visitors to explore and learn about the exhibits. This combination results in a seamless, immersive experience in the advanced museum environment.
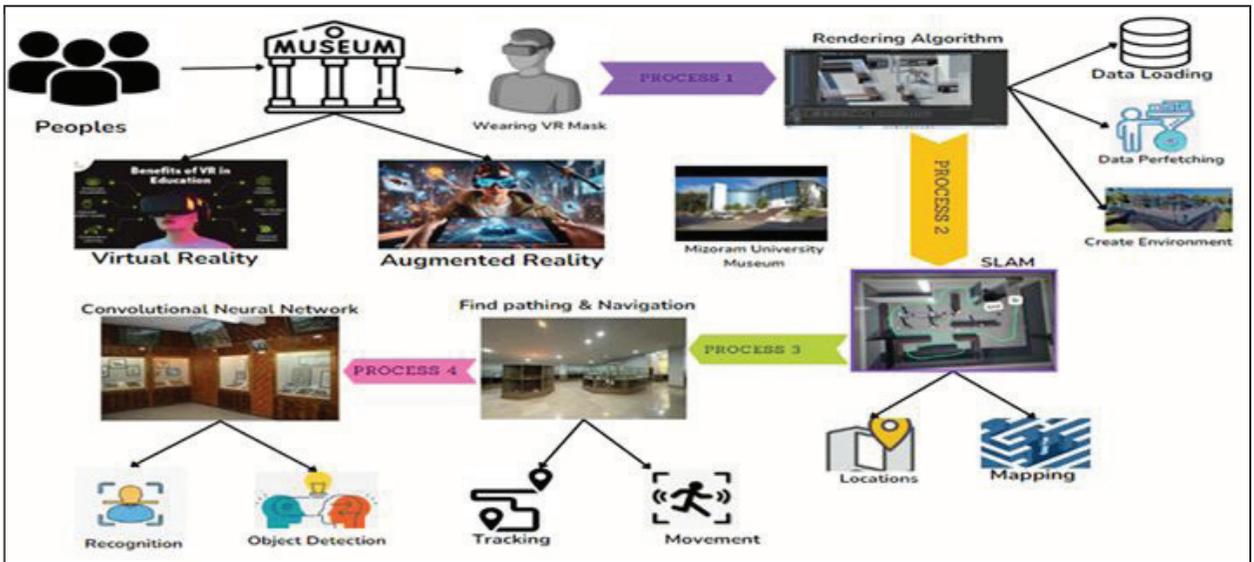

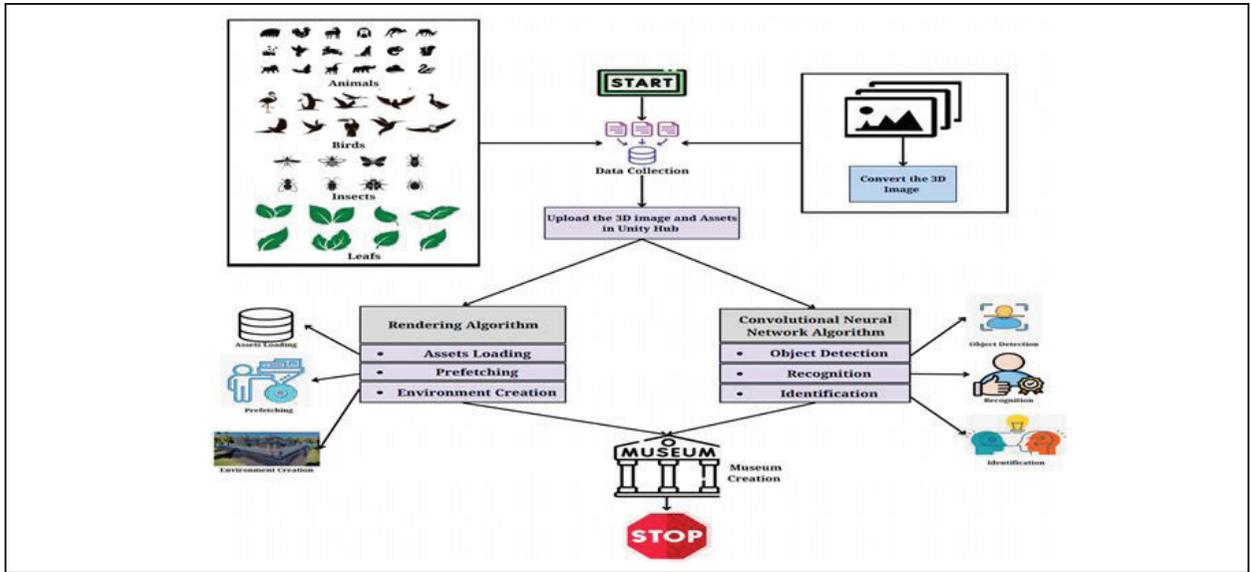**Fig. 1: Full Research Architecture in the Museum.**

Fig. 2: This Paper Architecture.

DATASETS

Empowering the Mizoram State Museum with Virtual Reality through Linked Data and Smart Objects. This project focuses on enhancing the Mizoram State Museum experience by applying virtual reality (VR) integrated with linked data and smart objects. The Mizoram State Museum, located at PPQ8+68R, MacDonald Hill, Zarkawt, Aizawl, Mizoram 796001 (Coordinates: 23.73795610514955, 92.71507056537367), is a three-story facility showcasing six distinct galleries. These galleries represent the cultural heritage, history, and biodiversity of Mizoram, including the History Gallery, Leaders Gallery, Zoological Gallery, Anthropological Gallery, Ethnological Gallery, Archaeological Gallery and Textile Gallery. As part of this initiative, our team conducted a full-day visit to the museum, gathering comprehensive data to recreate the environment in a 3D VR format. This immersive experience aims to provide a modern, interactive way for visitors to explore and learn about Mizoram's rich cultural and historical legacy.

Fig. 3: History Gallery.

Fig. 4: Anthropological Gallery.

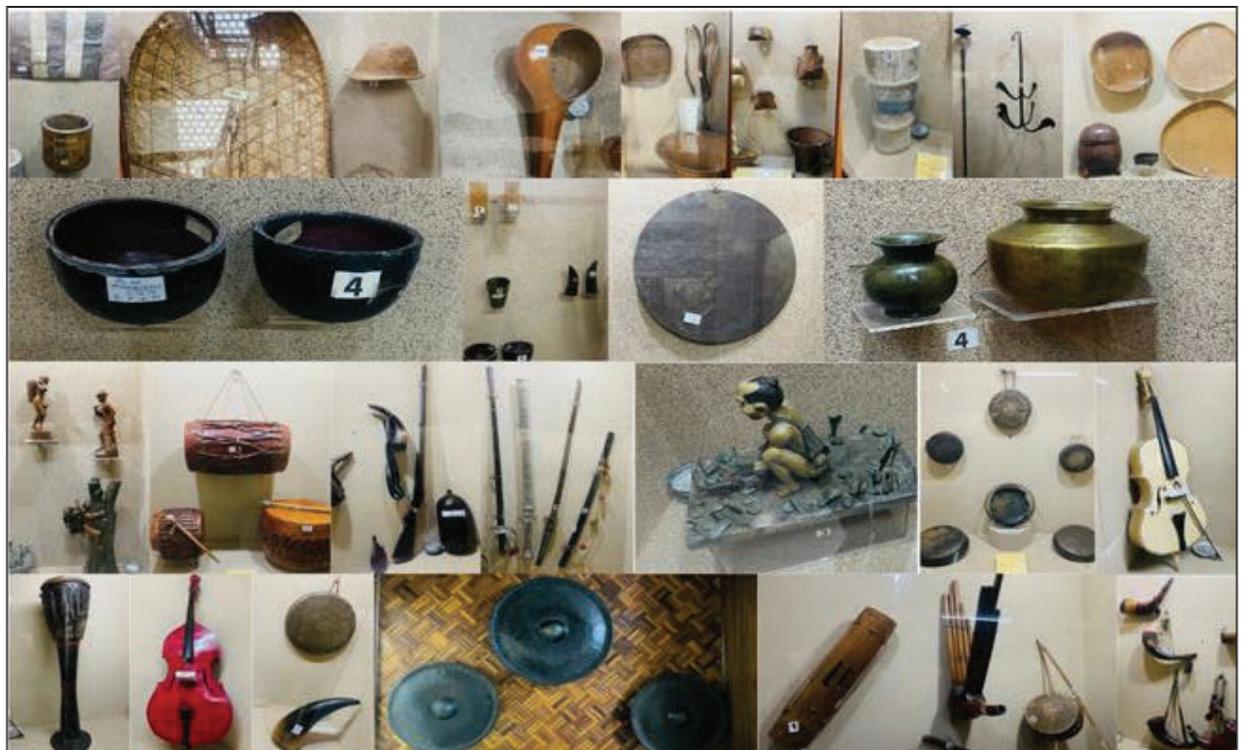Fig. 5: Archaeological Gallery.

Fig. 6: Leaders Gallery.
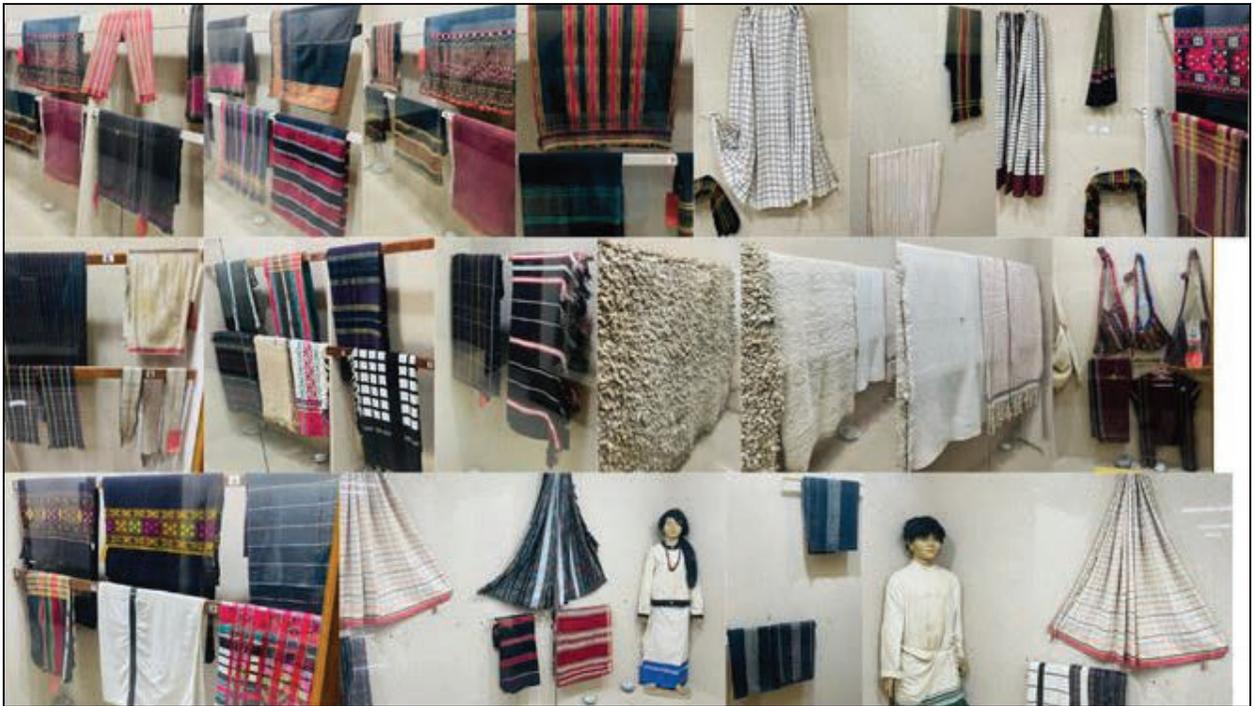

Fig. 7: Ethnological Gallery.

Fig. 8: Textile Gallery.

Fig. 9: Zoological Gallery.
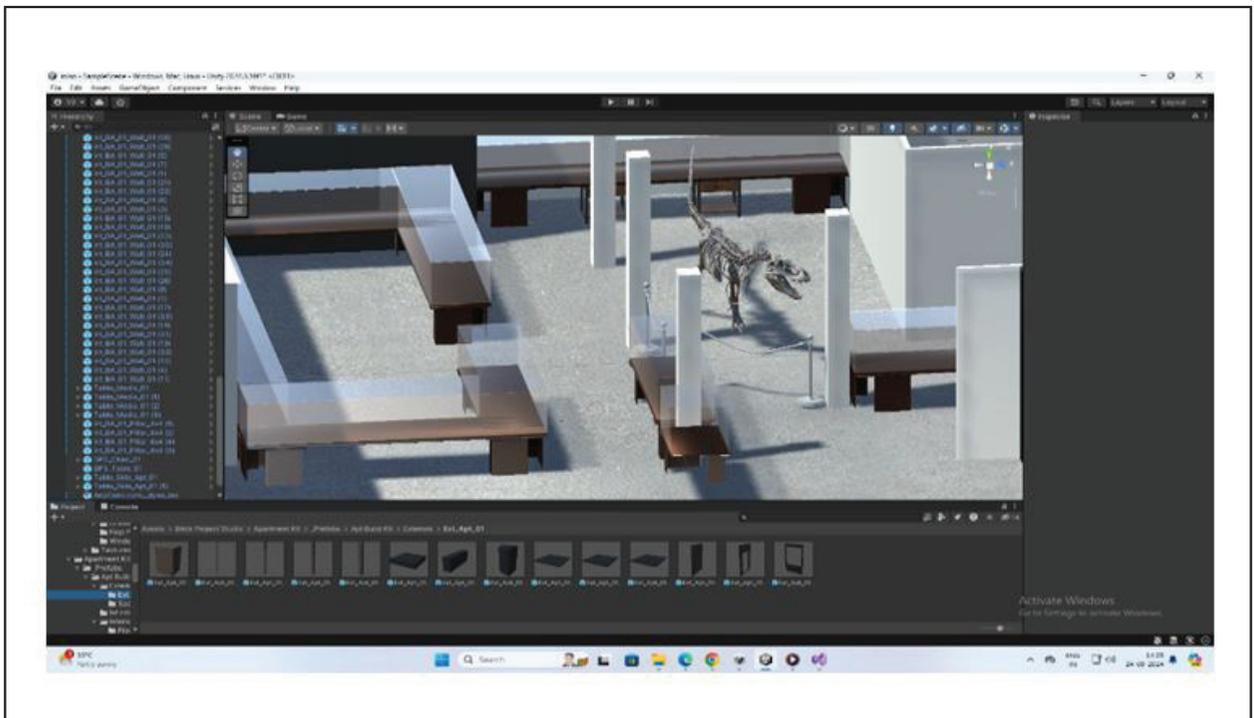
ALGORITHMS

Rendering Algorithms are responsible for converting 3D models of exhibits and surroundings into 2D images that users see in their VR headsets or AR displays. These algorithms handle lighting, shading, textures, and visibility to produce realistic scenes. While the process is complex, we can break it down into key equations used in different stages of the rendering process.

Rasterization Equation: Rasterization is the process of converting 3D vertices of a model into 2D screen coordinates. For AR/VR, this is done to display exhibits or virtual objects in a museum. The basic equation for transforming 3D coordinates (x, y, z) (x, y, z) (x, y, z) into 2D screen coordinates (x′, y′) (x', y') (x′, y′) using a Perspective Projection Matrix is:

$$\begin{bmatrix} x' \\ y' \\ w \end{bmatrix} = P \times M_{view} \times M_{model} \times \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

M_{model} The model transformation matrix (object's position in the world). M_{view} The view matrix (camera's position and orientation in the virtual museum). P The perspective projection matrix. (x, y, z). The object's 3D coordinates. (x', y') The object's 2D screen coordinates. Finally, you calculate the 2D coordinates.

$$x' = \frac{x}{w} , y' = \frac{y}{w}$$

Fig. 10: Creating to Advanced Museum Environment.

Here, w is the depth component used to handle perspective. The Rendering Algorithm is used to download datasets and load them into the Unity Hub application to create the terrain for the museum environment. I downloaded the datasets from sources such as Unity Hub Assets Store, Sketch fab, Polygon Gap, and Blender Store, using the same username across these platforms for consistency. After downloading the assets, I imported them into Unity Hub and added them to the terrain. First, I created a new terrain and placed the building asset on it. Then, I added various assets like animals, insects, birds, and leaves to the terrain. I carefully arranged all these assets in their correct positions and orientations to accurately represent the Mizoram State Museum environment. In conclusion, the Rendering Algorithm handles data loading, asset prefetching, and ultimately, the creation of the advanced museum environment.
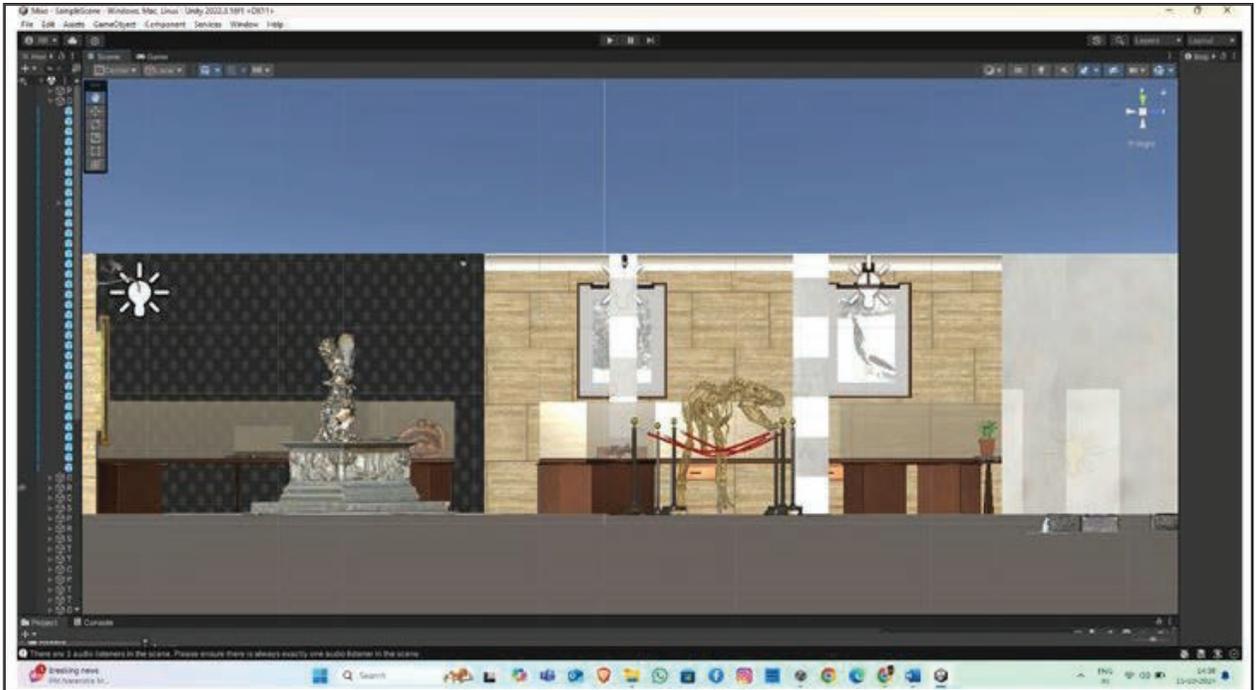
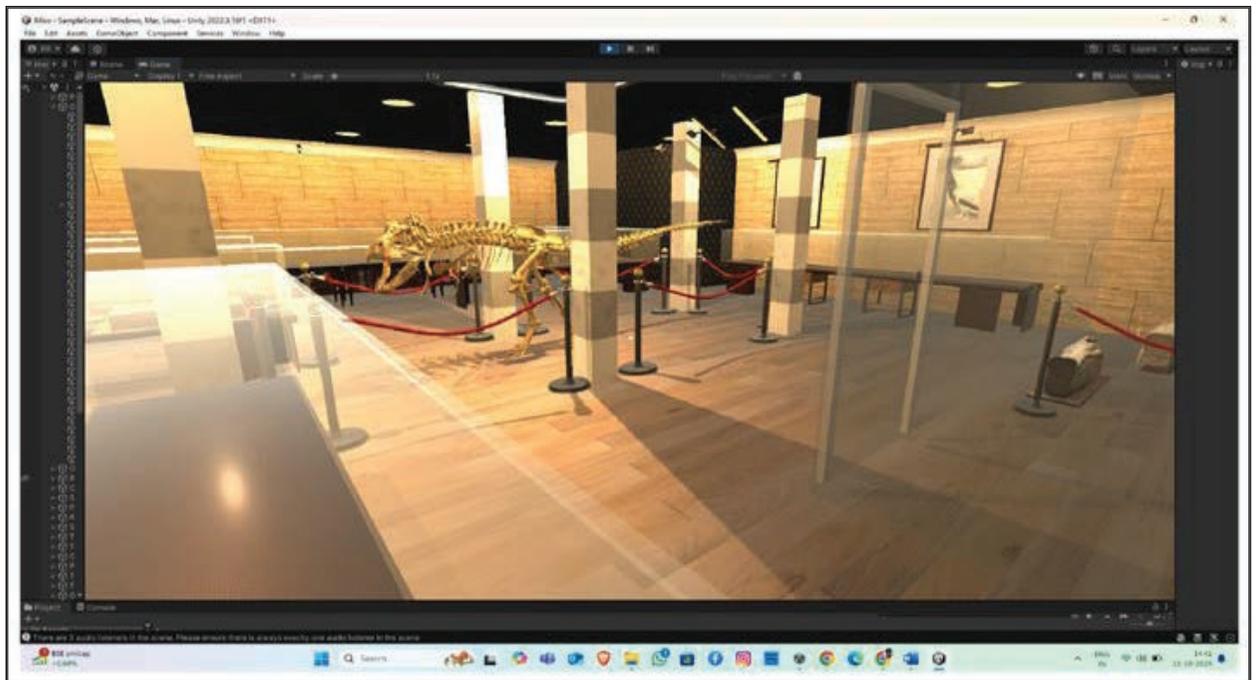**Fig. 11: Final Output for the Rendering Algorithm.**

Fig. 12: Fitting the Animal in the Environment.

Figure 3 illustrates the top view of the museum, showing the arrangement of all structures and the placement of objects within the environment. The image highlights asset information on the right side, package names on the left side, and the layout of asset structures and storage locations at the bottom. Figure 3 provides a side view and

the final output of the advanced Mizoram State Museum environment. The final output includes the proper lighting and color adjustments on the walls, as well as detailed information about the animals, insects, birds, leaves, and butterflies within the museum.

Convolutional Neural Networks (CNNs) YOLO (You Only Look Once) Algorithm YOLO is a state-of-the-art object detection algorithm that has gained significant popularity due to its speed and accuracy. It differs from traditional object detection methods by dividing the input image into a grid and predicting bounding boxes and class probabilities for each cell.

YOLO Works Grid Division: The input image is divided into a grid of SxS cells. Bounding Box Prediction: Each cell predicts a fixed number of bounding boxes (B) and their corresponding confidence scores. Class Prediction: For each bounding box, the algorithm predicts the probability of belonging to each class. Non-Maximal Suppression (NMS): To avoid redundant detections, NMS is applied to suppress overlapping bounding boxes with lower confidence scores

Convolutional Neural Networks (CNNs) are highly effective for image recognition tasks, as they are adept at identifying patterns and features within large datasets. This makes them well-suited for applications such as object detection, image segmentation, and even natural language processing. CNNs work by applying filters to input images, extracting key features, and then combining this information to make classification decisions. In a museum setting, CNNs can significantly enhance the visitor experience through

features like artifact recognition, personalized tours, and virtual reality interactions. For instance, visitors could use augmented reality (AR) devices to scan artifacts and receive real-time contextual information, or museums could leverage CNNs to analyze visitor behavior and optimize future exhibits accordingly.

While YOLO doesn't have a single, unified equation, its core concept can be expressed as:

$$y,i = \varphi(x,i)$$

y,i: Predicted output for cell i,(x, i): Input image (or feature map) for cell i, φ: Neural network function that predicts bounding boxes, confidence scores, and class probabilities. YOLO Architecture typically uses a deep convolutional neural network architecture. The network consists of several convolutional layers, followed by a fully connected layer. The final layer outputs the predicted bounding boxes, confidence scores, and class probabilities for each cell. Data Preparation: Gather and preprocess a diverse set of images, ensuring they are properly labeled and categorized. Model Building: Select an appropriate CNN architecture, construct the model using layers such as convolutional, pooling, and fully connected, then compile it with the chosen optimizer and loss function. Training: Train the model on the prepared dataset, adjusting hyperparameters and monitoring performance as necessary. Evaluation: Assess the model's accuracy and performance using a validation set. Deployment: Implement the trained model into the target application for recognition tasks.
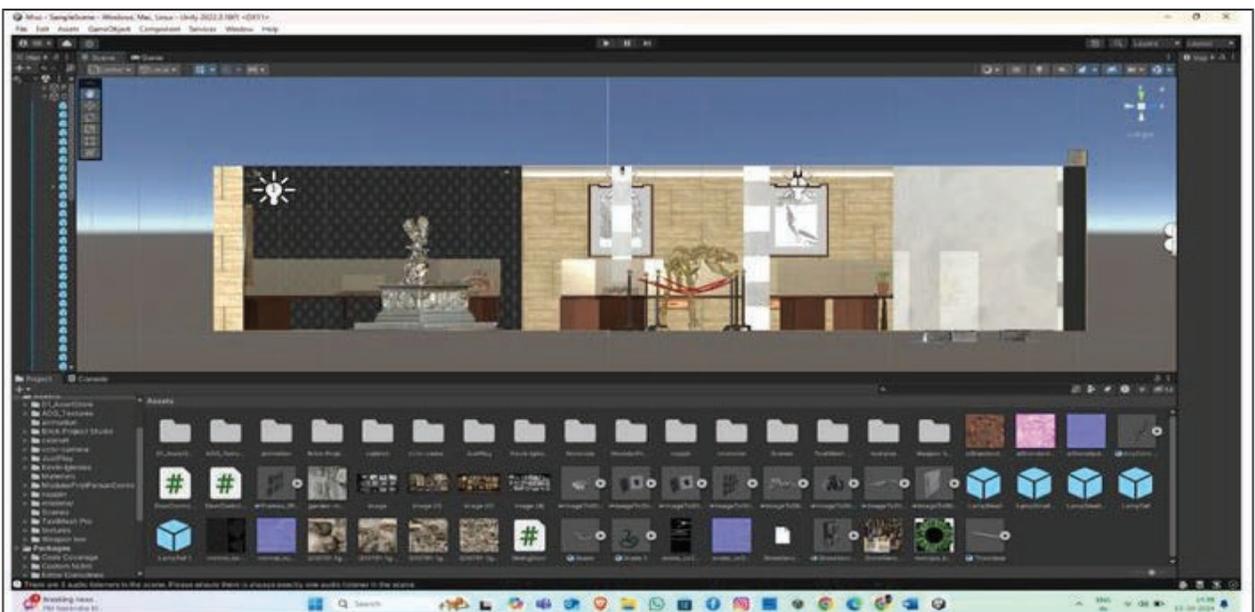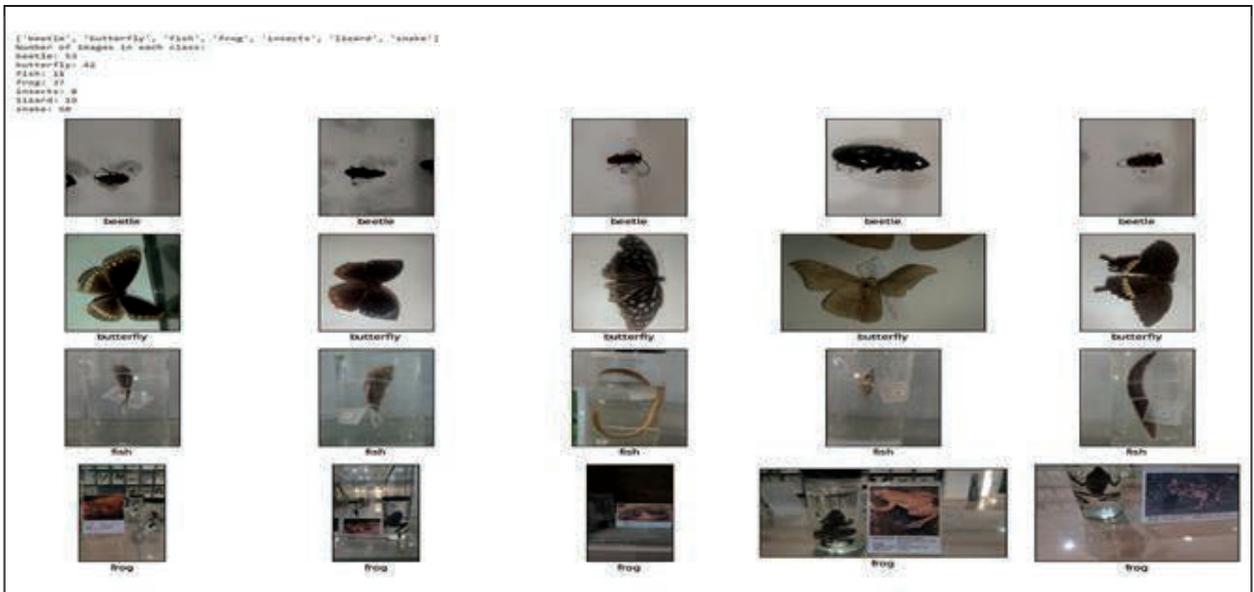

Fig. 13: Loading in the all Object in Environment.

Fig. 14: Classification of Museum Objects.

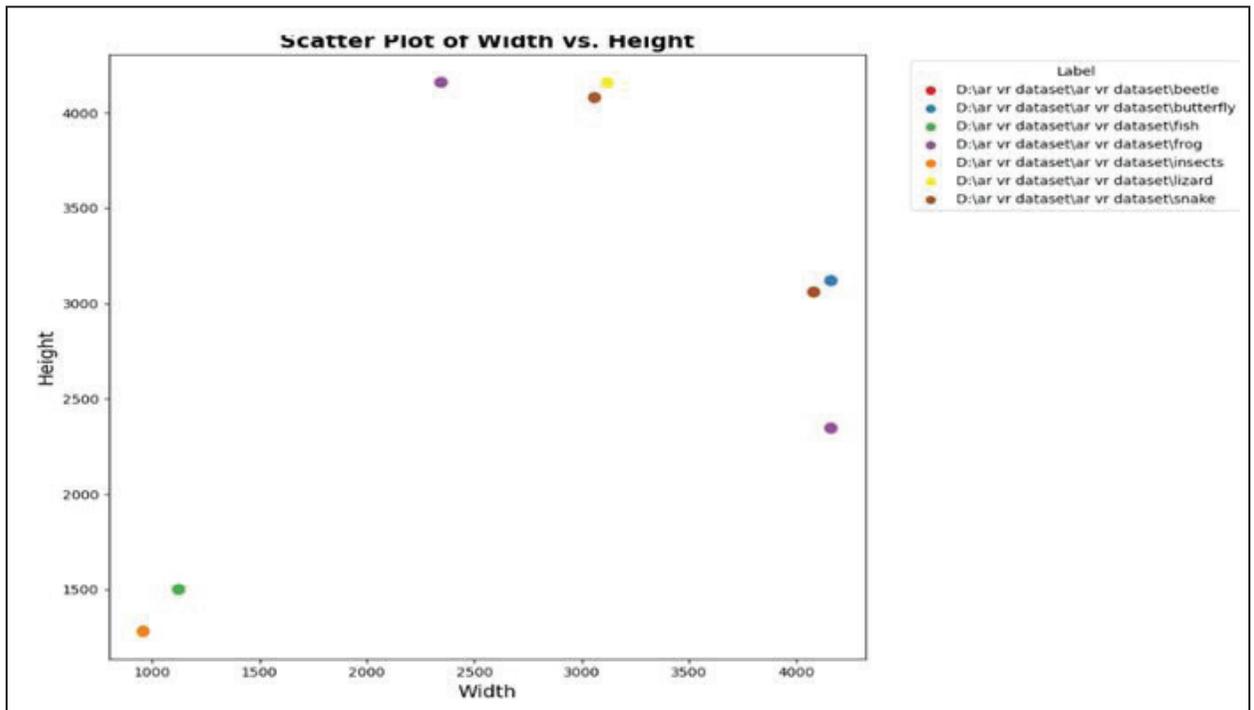**Fig. 15: Image Size Scatter Polt.**

RESULT AND CONCULSION

Virtual Reality (VR) holds immense potential to transform the museum visitor experience by offering engaging and immersive storytelling. Through VR, visitors can be transported to historical events and gain a deeper understanding of the context surrounding artifacts. This technology can also facilitate personalized interactions; for

example, smart objects can trigger tailored VR content that aligns with individual preferences and interests, enhancing the overall engagement. In terms of educational value, VR enriches the learning experience by providing rich historical and cultural contexts. Interactive exhibits allow visitors to manipulate virtual objects and participate in simulations, which fosters a more profound comprehension of the museum's collections. This hands-on approach not only makes learning more enjoyable but also encourages critical thinking and exploration. Moreover, VR can attract a diverse range of audiences, drawing in new visitors while encouraging repeat visits through unique and memorable experiences. Additionally, the ability to share VR encounters on social media can further promote the museum, extending its reach and impact. However, there are challenges to consider, including technical limitations related to hardware requirements and user experience. Developing high-quality VR content is often time-consuming and resource-intensive. Additionally, integrating VR with existing museum systems and collections may require careful planning and significant investment. In summary, while VR presents exciting opportunities for museums to enhance visitor experiences, improve educational value, and increase engagement, addressing the associated challenges is essential to fully realize its potential in the cultural sector.

LIMITATIONS

While integrating Virtual Reality (VR) with linked data and smart objects at the Mizoram State Museum offers exciting opportunities, several challenges need to be overcome for effective implementation. A key issue is the technical requirements; high-quality VR experiences demand advanced hardware and software, which may not be available in all museum settings, potentially creating inconsistencies in visitor experiences depending on the museum's budget and infrastructure. Additionally, creating immersive VR content is both time-consuming and resource-intensive, requiring specialized skills in technology and cultural heritage expertise that may be limited among museum staff. Ensuring cultural accuracy and sensitivity in VR content is also critical, as any misrepresentation could diminish the authenticity of Mizo heritage. Technical glitches during VR sessions could disrupt the visitor experience and reduce the likelihood of return visits. Accessibility presents another challenge; while VR can offer greater inclusivity for some individuals with disabilities, others, such as those prone to motion sickness or with visual impairments, may find it difficult to engage with VR. Moreover, incorporating linked data requires careful planning and the development of

strong data management systems, which may pose logistical hurdles. Staff training is essential to equip museum personnel with the skills to guide visitors and address technical issues effectively. While VR experiences can boost the museum's visibility through social sharing, there is a risk of oversimplifying or commodifying cultural stories. Lastly, maintaining long-term visitor interest in VR experiences can be challenging, as content will need regular updates and innovations to stay engaging. While VR holds significant potential to enhance visitor engagement at the Mizoram State Museum, addressing these challenges will be key to its successful and sustainable use.

Declaration of Competing Interest: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability: The data that support the findings of this study are openly available at the Online Assets Store.

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