International Journal of Internet, Broadcasting and Communication Vol.16 No.3 242-252 (2024)
http://dx.doi.org/10.7236/IJIBC.2024.16.3.242

IJIBC 24-3-26

Unveiling Zoological Realms: Exploring the Virtual Frontier, Analyzing Data Export Techniques, and Crafting Immersive Experiences

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Abstract

This study introduces a prototype for a virtual zoo initiative, aimed at optimizing resource utilization and minimizing animal displacement from their natural habitats. The prototype features a thoughtfully developed three-dimensional representation of an emperor penguin, with animations designed to emulate real-life behaviors. An investigation into file format distinctions for scientific research, encompassing Wavefront(OBJ), Collada(DAE), and Filmbox(FBX) formats, was conducted. The research utilized the Hololens 2 device for visualization, Unity for environment development, Blender for modeling, and C# for programming, with deployment facilitated through Visual Studio 2019 and the Mixed Reality Toolkit. Empirical examination revealed the OBJ format's suitability for simple geometric shapes, while DAE and FBX formats were preferred for intricate models and animations. DAE files offer detailed preservation of object structure and animations albeit with larger file sizes, whereas FBX files provide compactness but may face scalability constraints due to extensive data integration. This investigation underscores the potential of virtual zoos for conservation and education, advocating for further exploration and context-specific implementation.

Keywords: Mixed Reality, Hololens 2, Unity, Collada, Wavefront, Filmbox, Virtual Zoo

1. INTRODUCTION

In the ever-evolving realm of technological progression, the confluence of virtual and tangible realities has precipitated the emergence of Mixed Reality as pivotal frontier for scientific inquiry and innovation [1]. Among the forefront devices catalyzing this paradigm shift, the Microsoft Hololens 2 distinguishes itself for its unparalleled capacity to seamlessly amalgamate digital content within physical environments, heralding a new era of immersive experiences [2]. The crafting of bespoke content tailored expressly for the Hololens 2 necessitates a methodical and scientifically grounded approach, characterized by an intricate interplay of

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Manuscript Received: June. 21, 2024 / Revised: June. 26, 2024 / Accepted: July. 2, 2024
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diverse disciplines spanning from fundamental content creation processes to the intricacies of deployment strategies. Each stage of development, ranging from the intricacies of modeling and animation endeavors to the implementation of optimization methodologies, demands an acute adherence to scientific rigor and a nuanced understanding of underlying principles. Within this scientific odyssey, we embark on an expedition into the core of Mixed Reality development for the Hololens 2 [3]. Our voyage delves deeply into the scientific scaffolding underpinning content creation methodologies, meticulously dissecting the scientific rationales behind file format considerations and optimization techniques. Through a scientific lens, we navigate the multifaceted landscape of application development within Unity, dissecting the scientific rationale behind the integration of supplementary components from the Mixed Reality Toolkit to enrich user experiences and propel the boundaries of immersive technology forward. Join us as we traverse the scientific terrain of Mixed Reality development, unraveling the complexities of the Hololens 2 and spearheading the frontier of immersive technology with scientific precision and unwavering purpose.

2. THEORY

2.1. Mixed Reality and its Applications

At present, multiple scientific research entities globally are engaged in the development of mixed reality methodologies aimed at overlaying synthesized imagery onto tangible real-world entities. Mixed Reality encapsulates an array of technological paradigms that blend the physical and virtual domains, facilitating the creation of immersive and interactive encounters. Its applications span various domains, including Education, Training and Simulation, Architecture and Design [4], Remote Collaboration, Urban Planning, and so forth. In the realm of education, mixed reality presents immersive learning environments wherein students engage with three-dimensional models, simulations, and educational materials in a tactile manner [5]. This approach augments comprehension and retention by furnishing contextualized learning encounters. Trainees have the opportunity to rehearse intricate procedures within a safe virtual setting, thereby enhancing their proficiency and readiness [6]. Conducting a physical perambulation around the virtual environment ought to enable the student to undergo training with maximal realism [7]. Within the gaming and entertainment domain, mixed reality gaming converges virtual components with tangible environments, culminating in captivating encounters that obfuscate the distinctions between imagination and reality. Players possess the capability to engage with virtual characters and objects seamlessly embedded within their actual surroundings.

2.2. Mixed Reality for Optimizing Urban Planning

Urban planning entails the strategic coordination of land use and built environments, including considerations such as air and water quality. It also involves the management of infrastructure supporting transportation, communication, and distribution within urban areas, ensuring their accessibility and functionality. Mixed Reality presents promising opportunities for urban planning endeavors [8]. Through the fusion of virtual components with actual surroundings, Mixed Reality technology empowers urban planners to envision and engage with proposed developments within their environmental settings. This fosters informed decision-making, as involved parties can experience and evaluate the ramifications of urban designs instantaneously. Moreover, MR streamlines collaboration among diverse stakeholders by furnishing a common platform for deliberation and input, thereby enhancing the efficiency and sustainability of urban development initiatives.

2.3. Mixed Reality Hardware and Software

Mixed Reality comprises a range of hardware and software elements facilitating the fusion of virtual and tangible environments. Mixed Reality headsets serve as the principal hardware component, commonly equipped with transparent or semi-transparent displays that superimpose digital content onto the user's actual surroundings. Notable examples encompasses devices like Microsoft Hololens 2, Magic Leap One, and various offerings compatible with augmented reality and virtual reality technologies. These integrate a suite of sensors, including depth cameras, accelerometers, gyroscopes, and spatial mapping sensors, to monitor the user's movements and surroundings. This data is leveraged to precisely position virtual objects within the physical environments. Software Development Kits and platforms offer tools and resources essential for developing Mixed Reality applications. Prominent examples encompass Unity, Unreal Engine, and the Microsoft Mixed Reality Toolkit. Mixed Reality applications refer to end-user software that utilizes Mixed Reality technology for a range of purposes such as gaming, education, training, visualization, remote collaboration, and beyond. In essence, the symbiotic relationship between hardware and software elements within mixed reality environments enables the generation of immersive and interactive encounters that harmoniously blend virtual and tangible domains. This fusion unleashes innovative potentials spanning various industries and utilization contexts.

3. EXPERIMENT

3.1. Proposal Method

The central focus of this scientific inquiry revolves around enhancing the efficacy of urban planning methodologies, with a specific emphasis on the development and execution of a virtual zoo project. The overarching goal of this endeavor is to alleviate the considerable financial investments typically required for the establishment and upkeep of conventional zoological facilities.

This project involves creating a three-dimensional model [9], as shown in Figure 1, developing a virtual environment using Unity, integrating the 3D model into this environment, and deploying the final setup on a Hololens 2 device [10].

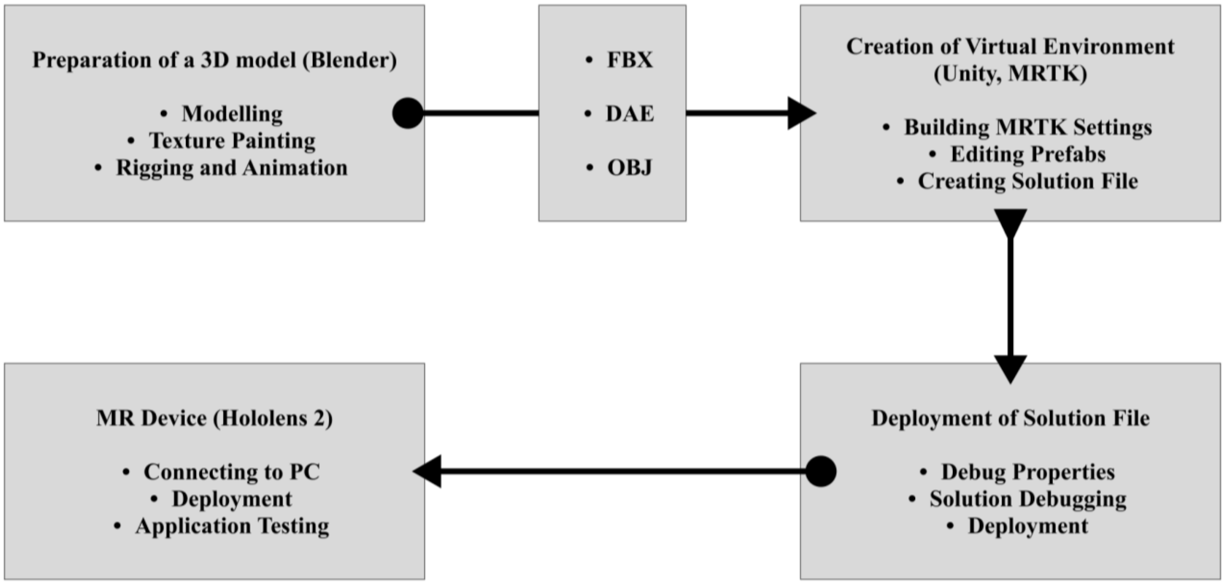

Figure 1. Application development stages.

Moreover, within the realm of scientific investigation, it is crucial to delineate the unique characteristics of file formats tailored for applications intended for employment on mixed reality devices, discerning those that offer optimal suitability for development within the designated domain.

3.2.Creating a 3D Model and Editing it for Export to Unity Environment

To illustrate the core premise of our scientific endeavor, we embarked on crafting a representation of an Emperor Penguin utilizing the Blender 3D modeling software. Initially, our approach involved commencing the model creation process within Blender by referencing pertinent source material. Employing a simplistic cube primitive, we initiated the model's development, utilizing a singular shape to delineate the entire structure. Central to the objectives of our scientific pursuit was the faithful emulation of real-world animal conditions, prompting the incorporation of a skeletal framework into the model. Striving to maintain a balance between complexity and fidelity, we deliberately avoided excessive polygonal intricacies or superfluous rigging to prevent undue complications within the model's construction. Following the completion of the rigging and materialization processes, we proceeded to imbue the model with a basic animation. The duration of this animation spanned 240 frames, adhering to a frame rate of 24 frames per second. Upon finalizing the animation task, we transitioned to the next phase of the workflow, which involved initiating the exportation process of the 3D model to the Unity software platform. We aim to export the 3D model in three widely favored file formats commonly utilized by users engaged in application development within the Unity environment. During the exportation process, several critical factors were carefully considered to ensure optimal outcomes. These factors included preserving the original integrity of the model, retaining materials and textures in their intended form, maintaining the proportionality of rigging and animations, and managing file size effectively. The chosen export file types encompass Collada (.dae), Filmbox (.fbx), and Wavefront (.obj). In the development pipeline for Hololens 2, several key considerations come into play, including the quality of the 3D model, texture fidelity, animation intricacy, and file size optimization. Each of these factors plays a crucial role in ensuring an immersive and efficient user experience within the Hololens 2 environment. The 3D model's structural integrity assumes primacy, necessitating meticulous attention to geometric detail, ensuring seamless integration and perceptual congruence within the user's augmented reality environment. Textural nuances demand meticulous scrutiny, with emphasis placed on high-resolution textures to enhance visual fidelity, facilitating discernment of intricate surface attributes for an enriched user experience. The orchestration of animations mandates a delicate equilibrium between verisimilitude and computational efficiency. Streamlined animation sequences mitigate computational strain, averting potential performance degradation on the Hololens 2 device. Minimizing the footprint of 3D models and associated assets assumes paramount significance, optimizing resource utilization and circumventing latency concerns. Employing strategies such as polygonal optimization and texture compression engenders streamlined file sizes without compromising visual acuity.

3.3. The Preparation Process of the Application in Unity and Deployment to Hololens 2

Upon completing the preparation of all three targeted file formats, our next step will involve commencing work on the Unity. We will initiate a new project in Unity and proceed to customize it according to our specific requirements. This necessitates modifying certain parameters within the Building Settings to match our desired configurations, as illustrated in Figure 2.

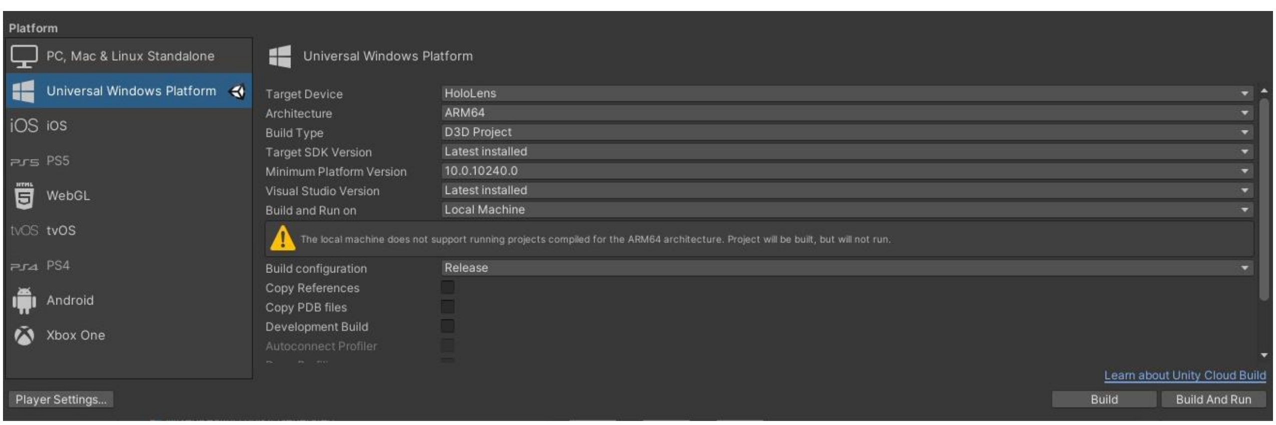

Figure 2. Configuring Universal Windows Platform

When creating an application for the Hololens 2 device, we emphasize configuring the Universal Windows Platform menu. Upon completion of the aforementioned tasks, we will proceed to download additional supporting components required for our project from the Mixed Reality Toolkit. Indeed, we have successfully configured the environment to commence the development of an application tailored for the Hololens 2. Upon importing the three distinct file formats into the working environment, it is observed that, upon loading the OBJ format, the rigging data are absent. Nevertheless, the geometric structure and texture of the model remain unaffected. Upon loading the DAE format, it is noted that the model is imported into Unity as a previously configured prefab, with both animation and rigging data seamlessly retained. Furthermore, the geometric structure and textures of the model remain intact, ensuring comprehensive preservation of its visual and textural attributes. Upon loading the FBX format, it is observed that all aspects including animation, rigging, model quality, and textures are preserved, maintaining the integrity of the entire model. It is noteworthy that the FBX format is also loaded into Unity in a previously configured prefab state.

The subsequent step involves positioning the uploaded three models within the environment and making requisite adjustments. We ensure that the objects are accurately scaled and positioned in relation to the first-person camera view, as depicted in Figure 3.

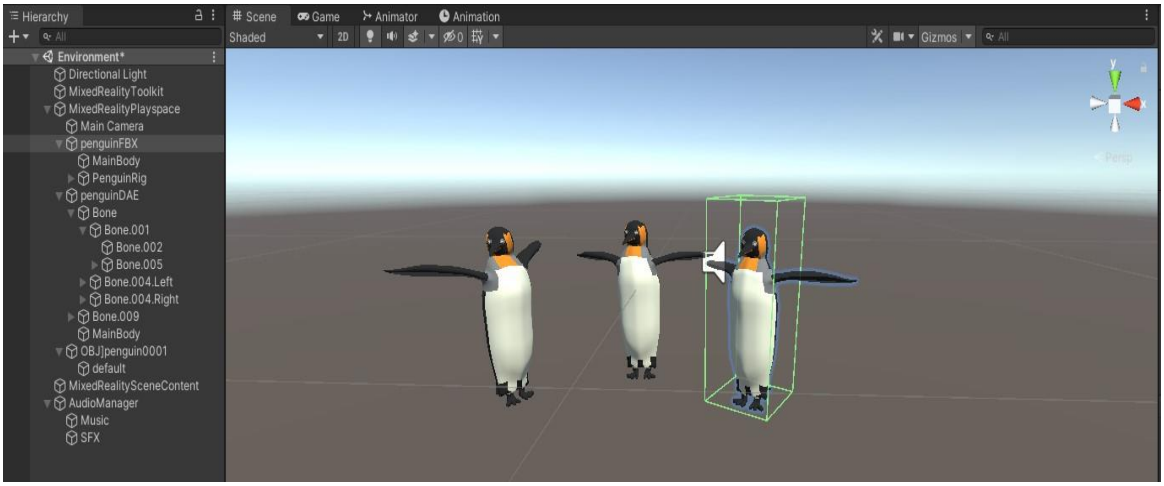

Figure 3. Positioning the DAE, OBJ and FBX (left to right) models within the environment

Additionally, we may incorporate background sound into the environment to complement the theme, ensuring it’s proportionality integrated. Once all the environment editing within Unity is finalized, we will proceed to the next phase of the project. The subsequent step involves building the environment developed in Unity for preservation and debugging purposes. We will generate the release version of the program tailored for the Hololens platform within the Build Settings menu. Consequently, Unity will automatically generate the solution file and other essential components within the designated folder.

Utilizing a selected deployment methodology, we proceed to deploy the program onto the Hololens 2 platform. This involves the intricate task of modifying the generated solution file within Visual Studio 2019. Here, the exact IP address of the Hololens 2 unit is entered into a specified menu, thereby establishing a reliable communication link between host Personal Computer (PC) and the Hololens 2 device, as illustrated in Figure 4.

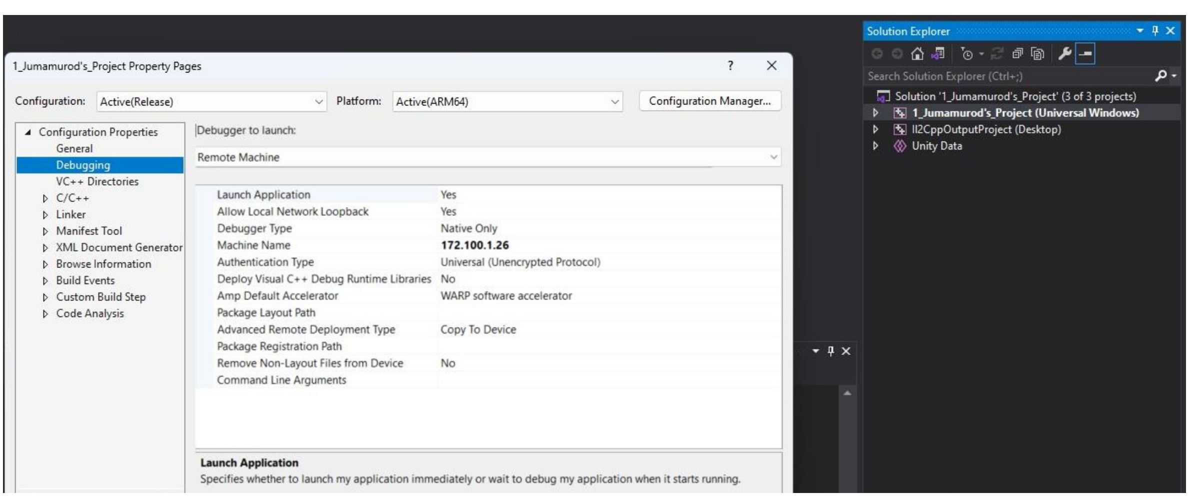

Figure 4. Debugging solution file for deployment

After meticulous adjustments within Visual Studio 2019, we transition to the conclusive phase of deployment. Following a stipulated duration, our meticulously crafted program is seamlessly transferred onto the Hololens 2 platform. This pivotal process culminates in the opportunity to rigorously assess and evaluate the performance of our developed model within the immersive environment of the Hololens 2 device. In the preceding discussion, we delved into the comprehensive process of crafting content tailored for head-mounted displays utilizing specialized software programs. We meticulously outlined the intricate steps involved in developing and refining content, ranging from initial modeling and animation tasks to fine-tuning various parameters to achieve optimal performance. Additionally, we explored the critical phase of exporting content in diverse file formats, such as OBJ, DAE, and FBX each carrying distinct advantages and considerations. Moreover, we transitioned into the domain of application development within the realm of Mixed Reality. By seamlessly integrating the meticulously crafted content into Unity, we embarked on customizing the environment to suit the targeted platform, specifically tailoring settings for the Hololens 2 device. Furthermore, we navigated through the process of incorporating supplementary components from the Mixed Reality Toolkit, augmenting the development environment with essential tools and resources. As the culmination of our endeavors, we ventured into the pivotal stage of deploying the developed application onto the Hololens 2 platform. This involved intricate tasks such as configuring communication settings between the host PC and the target Hololens 2 device through Visual Studio 2019. Subsequently, through a meticulously orchestrated deployment process, our meticulously crafted content seamlessly transitions into the immersive realm of Mixed Reality, allowing us to rigorously evaluate and test its performance within the dynamic context of the Hololens 2 environment.

4. RESULTS AND DISCUSSION

Exporting our model in OBJ file format provides benefits such as broad compatibility and a straightforward structure, but also comes with drawbacks, including a limited feature set and no support for rigging, as detailed in Table 1.

Table 1. Advantages and disadvantages of exportation in .obj file format

Advantages	Disadvantages
Widely supported	Limited features
Simple structure	Large file size
Text-based format	No rigging support

Based on our empirical observations, when exporting to the OBJ format, numerous imperfections were detected within the model concerning animation and rigging. A distinct file was generated for each frame to maintain animation integrity, resulting in the loss of rigging data. Consequently, the file size expanded in our scenario. To reconstruct the animation, it became imperative to retrieve and reconfigure the produced model for every frame within the Unity environment.

During the export process to DAE format, various advantages and disadvantages were observed in comparison to the OBJ file type. This envisioned features in the DAE format have been retained. The DAE format provides advantages such as support for rigging and animation, flexibility, and extensibility. However, it also has disadvantages, including increased file size and compatibility challenges, as detailed in Table 2.

Table 2. Advantages and disadvantages of exportation in .dae file format

Advantages	Disadvantages
Comprehensive feature set	File size amplification
Rigging and animation support	Increased complexity
Interoperability and Open standard	Compatibility challenges
Flexibility and extensibility	Export/Import complexity

We successfully exported animation and rigging with minimal loss. However, potential drawbacks include the possibility of larger file size due to Collada's Extensible Markup Language based (XML-based) structure and comprehensive data encapsulation, compared to other 3D file formats.

Our third and final file format is FBX. The FBX file type represents both advantages and disadvantages when compared to the previously mentioned file formats. Advantages include a robust feature set, support for rigging and animation, and optimized file size. Disadvantages include the proprietary nature, increased complexity, and loss of precision when exporting mock-ups and animated 3D models in FBX format, as outlined in Table 3.

Table 3. Advantages and disadvantages of exportation in .fbx file format

Advantages	Disadvantages
Comprehensive feature set	Proprietary nature
Rigging and animation support	Increased complexity
Ubiquitous adoption	Interoperability challenges
Optimized file size	Precision lost

In our experimentation, employment of the FBX format resulted in smaller file sizes compared to the two aforementioned formats, while adequately supporting the requisite file properties. Nevertheless, it's important to note that the application in its current state is still in its nascent stages. In more extensive applications, certain drawbacks of the FBX format as mentioned earlier may become more pronounced.

Through the conduct of this investigation, we have successfully attained the subsequent outcomes. We have created the inaugural prototype of the virtual zoo endeavor. Within this prototype, we meticulously crafted a three-dimensional representation of an Emperor Penguin, endowing it with animations designed to mimic the behavior of its real-life counterpart in a specified manner. We have examined the distinctions among the various file formats applicable to inclusion in scientific research endeavors. Throughout the course of our scientific inquiry, we endeavored to utilize file formats such as OBJ, DAE, and FBX to serve our objectives.

What is the purpose of our experience? By creating virtual replicas of zoos, we can efficiently utilize land and other resources, minimizing the need to relocate animals from their natural habitats. Establishing sanctuaries for animals allows for better conservation efforts, maintaining ecosystems as they are. Additionally, virtual zoos can be established in urban and residential areas to provide both entertainment and educational opportunities. This perspective offers a broad overview of the concept and suggests that it necessitates more in-depth examination and implementation in specific contexts. To achieve this goal, we utilize the Hololens 2 device for visualizing the application during experimentation. The Unity game engine is employed for developing the environment tailored for Hololens 2, while Blender modeling software is utilized for creating 3D models. Programming is conducted in C#, and deployment is managed through Visual Studio 2019 software. Additional components include the Mixed Reality Toolkit. During the development of an application for Hololens 2, our objective was to practically examine the distinctions between three different file formats. Through practical utilization of the OBJ file format, we discovered its suitability for implementing straightforward geometric shapes. In practical application, we determined that the OBJ file format is particularly advantageous for implementing simple geometric shapes, especially when dealing with static objects. Its benefits include manageable file sizes, support for textures, and a straightforward, comprehensible geometric structure. We've found that the DAE and FBX file formats are better suited for our application. Our aim is to simulate the virtual counterparts of real animals and their movements by utilizing rigging and animation techniques within the application. The DAE file format effectively preserves the targeted object bones, animations, and overall model quality. In the initial version of our application, where relatively simple models methods were employed, we observed that the DAE format occupied a larger file size compared to FBX. However, due to its XML-based structure, manual editing is relatively straightforward. The FBX file format has likewise maintained the desired features. It holds an advantage in terms of file size compared to other formats. However, as the complexity of the application increases, FBX may exhibit some limitations. Indeed, FBX files can encompass various data types such as geometry, animations, materials, textures, and more. This extensive data inclusion can occasionally lead to larger file sizes compared to simpler formats, potentially affecting performance and storage demands. Based on the experiment, we can present the following outcomes (Table 4).

Table 4. Outcomes from experimentation

File format	Extension	Texture	Animation	Rigging	Format	Size (bytes)
Collada	.dae	Yes	Yes	Yes	XML-based	856.832
Filmbox	.fbx	Yes	Yes	Yes	Binary	765.164
Wavefront	.obj	Yes	No	No	Text-based	62.875.760

5. CONCLUSION

Through the systematic investigation into the development of virtual zoos and the analysis of various file formats applicable to scientific research endeavors, several significant conclusions have been drawn. Firstly, the creation of virtual zoo environments presents a promising avenue for conservation efforts and educational outreach. By leveraging technology such as the Hololens 2 device, Unity game engine, and Blender modeling software, it is feasible to replicate the natural habitats and behaviors of animals in a virtual setting. This approach offers opportunities to minimize the need for physical zoos, thereby reducing the impact on natural ecosystems and promoting sustainable conservation practices. Secondly, the selection of appropriate file formats is crucial for optimizing the efficiency and effectiveness of virtual zoo applications. The practical examination of OBJ, DAE, and FBX formats revealed distinct advantages and limitations associated with each. While OBJ excels in handling straightforward geometric shapes and static objects with manageable file sizes, DAE and FBX are better suited for simulating complex movements and behaviors of animals through rigging and animation techniques. Despite differences in file size and performance implications, each format serves specific purposes within the virtual zoo environment. Furthermore, considerations must be made for scalability and performance as the complexity of the virtual zoo application increases. While FBX offers efficiency in file size, its extensive data inclusion may lead to performance challenges in larger and more complex environments. Conversely, DAE preserves model quality but may require additional optimization efforts to manage larger file sizes effectively. In conclusion, the development of virtual zoos represents a valuable opportunity to blend technology with conservation efforts and education initiatives. By leveraging advanced tools and methodologies, such as those explored in this investigation, it is possible to create immersive and realistic experiences that foster a deeper understanding and appreciation for wildlife while promoting environmental stewardship. Continued research and innovation in this field will be essential to realize the full potential of virtual zoo environments in advancing conservation goals and enhancing public engagement with nature.

ACKNOWLEDGEMENT

This research was supported by the MSIT(Ministry of Science and ICT), Korea, under the ITRC(Information Technology Research Center) support program (IITP-2024-2020-0-01846) supervised by the IITP(Institute for Information & Communications Technology Planning & Evaluation), This research is supported by Ministry of Culture, Sports and Tourism and Korea Creative Content Agency (Project Number: RS-2024-00401213), The present research has been conducted by the Excellent researcher support project of Kwangwoon University in 2022.

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