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Multi-person interaction in collaborative virtual conference for Metaverse

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ABSTRACT

Virtual conferences have successfully solved the challenges of traditional face-to-face conferences that can't be carried out smoothly due to issues such as venue, transportation, and the pandemic. More importantly, as virtual conferences continue to develop and mature, they provide a virtual environment for multi-person collaboration, which is impossible to achieve with traditional face-to-face conferences. This technological innovation is expected to bring significant cost savings to various fields such as medical care, education, and industry. This paper proposes a unity-based multi-party collaborative virtual conference model. The model takes automobiles as the theme, which can realize the design and modification of the appearance of the automobiles by multiple people in the same space, and also supports operations such as the disassembly and installation of the automobile engine. This model is designed to deepen our understanding of multi-person collaboration capabilities in virtual conferences, a feature that is expected to significantly improve teamwork efficiency.

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1. INTRODUCTION

In the era of digital technology, virtual reality technology has rapidly emerged and reshaped the way people interact with the digital environment [1]. The Metaverse, as the most recent advancement in virtual reality, has garnered considerable interest. It not only offers an immersive virtual experience for individual users but also unlocks vast possibilities for multi-person interaction and collaboration [2]. Especially in virtual conferences and communication, the application potential of the Metaverse is gradually emerging [3], [4].

The primary objective of this paper is to delve into the intricate development of multi-person collaborative virtual conferences within the Metaverse, with a foundational emphasis on unity as the underlying platform. In this comprehensive exploration, we aim to investigate the practical implementation of unity's functions and resources, thereby constructing a dynamic virtual conference platform that seamlessly accommodates and facilitates multi-person collaboration. Our objective is to empower users to engage in seamless communication and cooperation within a richly immersive virtual environment, especially collaborative operation. This function will help save a lot of costs in the fields of medical care, education, industry, and other fields in the future [5].

2. RELATED WORK

The metaverse, often described as a collective virtual shared space, transcends the limitations of traditional two-dimensional digital platforms [6]. It provides a three-dimensional, immersive environment where users can interact with digital representations of themselves and others, offering a sense of presence and connection that was previously unattainable in the digital realm [7]. One of the most exciting aspects of the Metaverse is its potential to revolutionize communication and collaboration [8]. In the past, video conferencing and online meetings have often felt disconnected and impersonal. The Metaverse promises to change that by allowing participants to gather in virtual spaces that mimic real-world meeting environments [9], [10]. This not only enhances the sense of being together but also opens the door to creative and immersive ways of working together [11]. Since 2020 [12], the Metaverse has experienced substantial expansion, demonstrating its relevance not just within the realms of gaming and business-to-consumer entertainment, but also within business-to-business sectors, including telecommuting and virtual conferences.

Virtual conference platforms such as "Spatial" and Horizon Workroom provide basic remote collaboration functions. "Spatial" is a platform that helps team members interact, and it supports conferences in the form of avatars in a virtual environment [13]. "Spatial" users can share traditional document files, share computer screens with colleagues, and discuss work in the virtual environment. Post-it notes can also be posted in a virtual environment. Horizon Workrooms is a VR-based collaboration platform developed by Meta. It's optimized for the company's Oculus Quest 2, and its advantage is that it feels like meeting and working in the real world [14]. It supports virtual keyboards for chatting between users and can be extended to multiple screens. For example, a screen that is only shared in an existing online video conference [15]. However, multi-user collaboration in these platforms focuses more on document sharing and collaborative operations and lacks collaborative operations on more specific 3D objects [16].

Therefore, the focus of the virtual conference system design in this paper is primarily on enhancing collaborative interactions among multiple participants when manipulating 3D objects. The system utilizes automobiles and engines as interactive elements, introducing innovative concepts for multi-user collaboration within virtual conferences. These insights can serve as valuable references for forthcoming business practices and educational frameworks.

3. SYSTEM DESIGN

The design of a multi-person collaborative virtual conference system in this section is divided into three abstract layers [17]: application layer, framework layer, and engine layer Figure 1. The application layer is used to customize specific functions of a multi-person collaborative virtual conference system. The framework layer is used to concretize the functions of a multi-person collaborative virtual conference system. The engine layer supports device input/output (I/O), basic interaction schemes, core visualization and simulation capabilities, network communication facilities, and software and hardware component integration schemes [18].

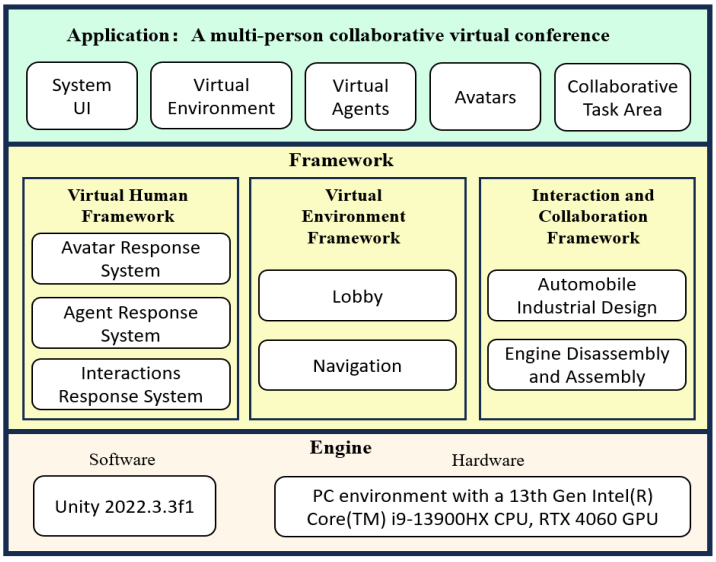

Figure 1. Overview of the three main layers of multi-person collaborative virtual conference

3.1. Application layer

The system provides the necessary system user interface (UI) and virtual environment for virtual conferences and preset virtual agents to enhance the immersion of the environment, allowing users to choose their avatars to enter the environment and complete collaborative tasks with other users' avatars. As shown in Figure 2, the system pre-creates some agents to perform specific tasks in virtual conferences to enrich the virtual environment and enhance immersion. The virtual environment includes a visual system UI that assists user interaction and a space that enables multi-person collaboration tasks. The system provides several sets of default avatar images. The avatars are selected and created by the user through the UI interface when entering the virtual conference.

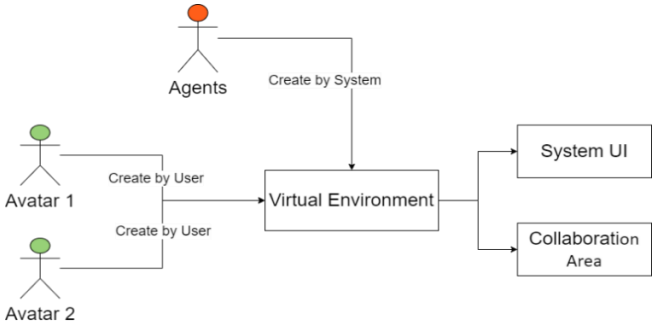

Figure 2. Composition diagram of multi-person collaborative virtual conference

3.2. Framework layer

The framework layer is used to specify the functions of the multi-person collaborative virtual conference system [19]. This system includes three frameworks: virtual human framework, virtual environment framework, and interaction and collaboration framework. This section will introduce the design of these three frameworks separately.

3.2.1. Virtual human framework

Figure 3 illustrates the framework of virtual humans. The system mainly includes two types of virtual humans: avatars controlled by the user and agents controlled by the system. Users can set their unique username and choose the appearance of their avatar from the given avatars [20]. By using the mouse and keyboard to control the avatar in real-time, the avatar has an intelligent pathfinding function that can consciously avoid obstacles. Therefore, the user only needs to use the mouse to click on the destination, and the avatar will automatically choose the shortest path to avoid obstacles to move. Agents are controlled by the system [21]. When adding an agent, the system will set the activity range and activity mode for the agent as needed, such as following a fixed path or randomly within a specified range. When the agent meets the avatar, the system also sets up a corresponding response for the agent to support the interaction between the agent and the avatar. The main interaction methods include text interaction or voice interaction.

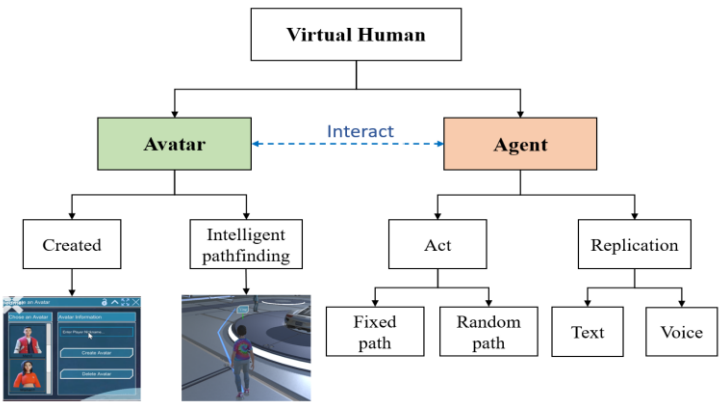

Figure 3. The framework of virtual human

3.2.2. Virtual environment framework

The virtual environment framework includes a lobby and navigation. The lobby menu provides the starting point for the application. The lobby supports the selection and management of target virtual environments as well as the configuration of users. Use the lobby menu to control lighting, music, and video playback in the lobby. The virtual environment of this system mainly includes three lobbies: the exhibition hall, the appearance design hall, and the disassembly and assembly operation hall. The user can select and control the avatar to enter the hall as needed. After the user creates the avatar, he enters the exhibition hall by default. The navigation window can help users view their location and find directions.

3.2.3. Interaction and collaboration framework

Virtual conference provides users with a virtual environment for interaction and collaboration [22]. In this system, the appearance design hall and the disassembly and assembly operation hall provide users with virtual environments for automotive industrial design and engine disassembly and assembly respectively. Professionals model the parts in advance and import the model into unity, using the massively multiplayer online (MMO) function to realize the multi-user design of the automobile's appearance or disassembly and assembly of the engine. Figure 4 shows the original model of the engine components.

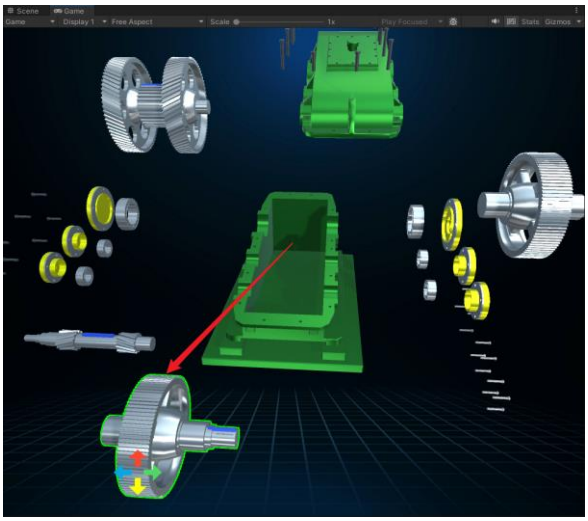

Figure 4. Original model of the engine components

3.3. Engine layer

We developed a multi-person collaborative virtual conference system in unity [23]. The unity version is 2022.3.3f1. This version is newer and more stable and is more suitable for project development. This is a game engine that supports realistic 3D rendering, virtual navigation, and multi-user control [24]. This engine allows us to combine personal exploration, collaborative communication, and VR-enhanced collaboration on the platform [25]. However, unity currently lacks built-in multiplayer interaction capabilities and needs to rely on plug-ins [26]. Therefore, this system uses the XDreamer plug-in. XDreamer is a cross-platform Chinese editing and running plug-in that can support multi-person collaborative operations and extends unity [27]. XDreamer supports visual programming, eliminates the need for more complex C# scripting, and is friendly to beginners who are less capable of complex interactions and programming. Software development is carried out in a personal computer (PC) environment. The CPU is 13th Gen Intel(R) Core(TM) i9-13900HX, the GPU is RTX 4060, and the RAM is 16 GB.

4. SYSTEM IMPLEMENTATION

In this section, we will delve into the intricate details of the implementation process for the key functions of our multi-person collaborative virtual conference system. The foundation of our system is laid with the meticulous creation of 3D models using the powerful design tool, 3D Max. The integration and rendering phase is a pivotal step in bringing our envisioned virtual space to life. Unity, a robust and versatile game development engine, takes center stage during this process. Through seamless integration, unity unifies the 3D models, ensuring a cohesive and immersive experience for conference participants. At the heart of our

multi-person collaborative functionality lies the innovative implementation of XDreamer. This cutting-edge technology serves as the backbone for enabling seamless collaboration among multiple participants within the virtual conference. XDreamer facilitates real-time communication, interaction, and synchronization, fostering a dynamic and engaging collaborative experience for users.

4.1. System UI and virtual environment

The Unity engine is utilized to design and develop the system UI and virtual environment. Through this UI, users gain access to virtual conferences and engage in interactions. The initial UI of the system is depicted in Figure 5. To embark on their virtual conference experience, users can initiate the process by selecting from three buttons: “Create Avatar,” “Chat,” and “Navigation.” Users need to generate their avatars before utilizing the chat and navigation functionalities. The virtual environment comprises three halls, each serving distinct purposes and equipped with corresponding operation buttons.

Figure 5. System UI

4.2. Virtual agents

Using the ethan role (NPC) tool in the XDreamer tool library, we can create a virtual agent to serve as a staff member in a virtual conference to enrich the virtual environment. By replacing the character model and bone parameters, the appearance of the virtual agent can be changed. The action setting function in the inspector of the eNPC tool can set the working mode, random activity range, and random dwell time for the virtual agent, which makes the virtual agent look more realistic. To enhance the presence of the virtual agent in the virtual environment [28], we have added conversation actions to the virtual agent, including text and voice conversations, which are currently preset. As shown in Figure 6.

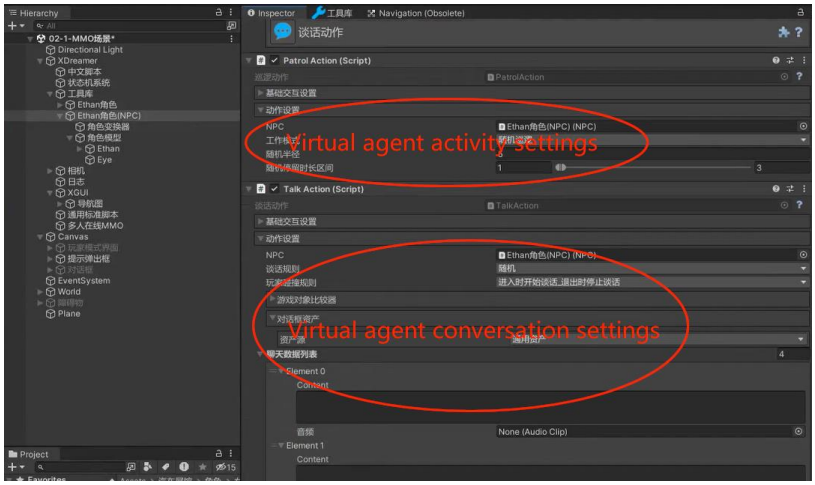

Figure 6. Implementation of virtual agent

4.3. Avatars

In addition to the detailed virtual agent creation process mentioned earlier, the XDreamer tool library further enhances user interaction with a comprehensive array of features. The system provides users with a diverse selection of six avatar types, each uniquely crafted using the Ethan character tool. Similar to virtual agents, users can achieve a variety of avatar appearances by seamlessly substituting character models and adjusting bone parameters. The incorporation of the AI navigation plugin in unity significantly contributes to the intelligence of avatar movement. Through careful delineation of collision objects in the virtual environment, precise specification of parameters governing avatar navigation, and the strategic baking of static objects, avatars navigate, and respond intelligently within the system. Figure 7 shows the setup of AI navigation and the baking process.

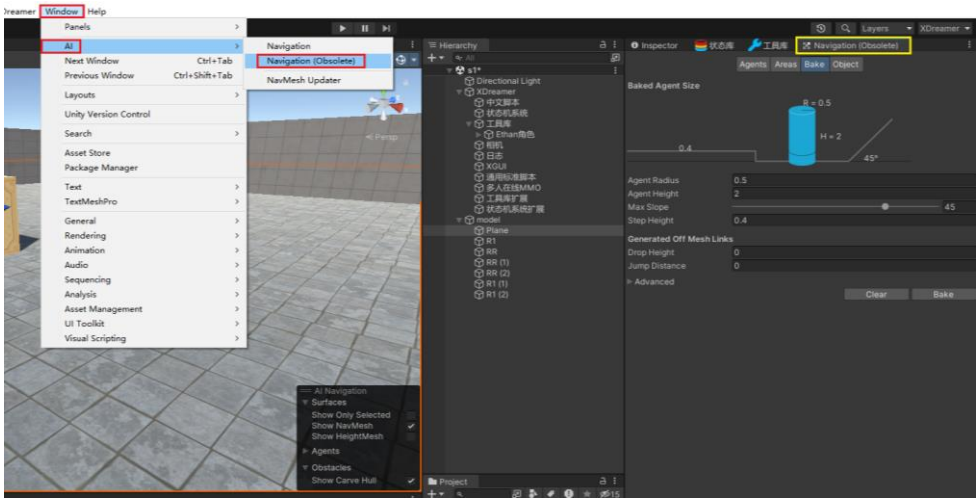

Figure 7. AI navigation plugin in unity

Furthermore, the system goes beyond individual avatar interactions, fostering a collaborative and social environment. Multiple users can actively engage in conversations through their avatars, although currently the system only supports text-based interaction. A MMO user chat window is integrated into the Xdream tool library, which provides a basis for establishing connections between users. This window serves as a centralized hub for communication, utilizing a sophisticated multi-user communication network system. All user information is efficiently transmitted to the server, which acts as a central hub, subsequently distributing the information to various clients for a synchronized user experience. A visual representation of this communication hub is depicted in Figure 8.

Figure 8. Chat window for users

4.4. Collaborative task area

The system unfolds its collaborative prowess through two distinct task areas. Figure 9 vividly illustrates the dynamic repercussions of interaction and collaboration within these two domains, each contributing to the user experience uniquely. In Figure 9(a), users can modify the automobile's appearance by simply dragging their preferred automobile stickers from the right navigation bar. Figure 9(b) provides a set of tools accessible via a dedicated button for disassembling and assembling engine components. The XDreamer disassembly and assembly module is employed to initialize all engine components, making each part a manipulable object, and configuring equipment part constraints in line with the engine's internal principles. The XDreamer state machine is then employed to execute logical control over the engine based on these principles.

(a)

(b)

Figure 9. Collaborative task area (a) automobile industrial design and (b) engine disassembly and assembly

XDreamer provides powerful visual scripting based on state machine support. There is no need to write code, and logic writing can be completed through wiring. Figure 10 serves as a crucial guide, delineating the intricate web of logical controls governing the assembly sequence of the engine model. The meticulous orchestration of these steps is paramount, as it lays the foundation for the process, whether one is dismantling or reassembling the engine. By strictly adhering to the prescribed sequence, it not only ensures the user's effective operation of engine components but also cultivates the user's deep understanding of the complex principles of disassembly and assembly.

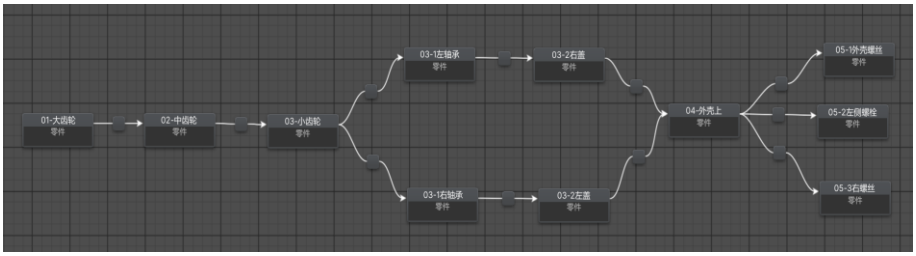

Figure 10. Logical control of the assembly sequence for the engine model

5. CONCLUSION

This paper successfully implemented a multi-person collaborative virtual conference system in Metaverse based on unity. Leveraging unity's extensive capabilities and resources, we have crafted a virtual conference platform that empowers multi-user interactions and cooperative endeavors. Within this platform, users can engage in collaborative discussions and interactions within an immersive virtual environment. Our system boasts a user-friendly interface while also offering the flexibility to be tailored and expanded to suit the diverse requirements of various users and organizations. Notably, our system places a particular emphasis on enhancing collaborative features within the realm of virtual conferencing, setting it apart from other existing systems. Centered around the theme of automobiles, our platform includes an exhibition hall for the presentation and exchange of automotive-related information, an appearance design hall dedicated to automotive industrial design, and a disassembly and assembly operation hall designed for instructive exploration of automobile engine principles and structures. This unique approach not only conserves valuable resources but also enhances the learning efficiency within the automotive industry and automotive-related educational fields. This is what distinguishes virtual conferences as an innovative alternative to traditional conferences. In the future, we are committed to enhancing the performance and functionality of our system. Building upon our existing platform, we envision the following improvements: i) Diversify virtual environments: We plan to expand the range of virtual environments, introducing themed conference settings tailored to the specific needs of various industries, ii) Smarter virtual agents: We will incorporate AI interfaces for virtual agents, empowering them to interact with users more intelligently and effectively, iii) Personalized avatars: We intend to introduce an avatar customization interface, allowing users to create personalized avatars that enhance their sense of realism and individuality, and iv) Seamless VR integration: By integrating VR equipment and sensors, we aim to achieve real-time responses to user actions. This will enable users to control their avatars more freely, moving beyond conventional keyboard and mouse interactions. We will also explore more metaverse concepts to further enrich the user experience, such as virtual economy and virtual social interaction. The multi-person collaborative virtual conference system in Metaverse based on unity represents the future development trend of remote work and communication. We eagerly anticipate its widespread adoption and the transformative impact it will have.

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