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27 June 2026

A Metaverse-ready Virtual Conference Environment with LLM-based Recommendations for Contents and Networking Opportunities

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***Abstract*—The rise of Metaverse as a persistent, immersive digital ecosystem is transforming the ways in which users collaborate and interact within shared Virtual Environments (VEs). Among the most promising applications in this context there is the development of virtual conferencing environments that facilitate remote participation in meetings, presentations, and networking events. These platforms offer significant advantages, including the reduction of travel-related environmental impact, decreased organizational costs, and improved accessibility for international audiences. Nevertheless, research and development in the area of virtual conference systems remain limited, with few solutions incorporating personalized, user-centered support mechanisms aimed at improving experience and engagement.**

This study presents the design of a Metaverse-ready virtual conferencing system that enables multiple remote participants to convene in a shared 3D space. The platform is augmented by a novel LLM-based recommender system that analyzes user profiles and interaction data to suggest relevant content, such as presentations or shared media, and to identify potential networking opportunities with other attendees. Through the integration of personalization into the conference experience, the system seeks to increase user engagement, improve the relevance of presented material, and facilitate more meaningful social interactions.

***Index Terms*—Metaverse, Virtual Conferencing, LLM-based Recommender Systems, User Personalization, Accessibility**

I. Introduction

The concept of the *Metaverse*, a persistent, immersive, and interconnected virtual space, has gained traction with advances in Virtual Reality (VR), Augmented Reality (AR), and Artificial Intelligence (AI) technologies [1]. Once centered on entertainment, Virtual Environments (VEs) are increasingly leveraged for professional, educational, and collaborative purposes.

A key application is *virtual conferencing*, offering an immersive alternative to traditional video platforms. While demand for remote collaboration surged during the pandemic, conventional tools such as Zoom or Microsoft Teams often lack immersion, engagement, and social presence [2], [3]. Metaverse-based conferencing, by contrast, supports embodiment and co-presence through avatars in shared VEs, enabling more intuitive and natural interactions [4], [5].

Beyond engagement, such environments provide a sustainable and inclusive alternative to physical conferences, reducing travel-related carbon emissions [6] and lowering economic and accessibility barriers to foster participation from a wider global audience [7]. To address these challenges, we developed a Metaverse-ready VR conferencing system featuring animated avatars, interactive presentations, and 3D content. An integrated *LLM-based recommendation system* leverages user profiles to suggest relevant materials and networking opportunities, enhancing content discovery and professional connections [8].

Grounded in this platform, the study investigates how personalized LLM-based recommendations can support engagement and content discovery in immersive VR conferences, and how adaptive, user-centered features may facilitate meaningful social interactions. The main contributions of the study are the design and implementation of a multi-user VR conferencing platform and the integration of a personalized LLM-driven recommender system.

This personalized, user-centered approach aligns with research demonstrating that personalization and social relevance improve user experience and task outcomes in immersive contexts [9]. The inclusion of adaptive systems within these environments points toward a promising path for more human-centered interaction design in the Metaverse.

This research was supported by a 2024-2025 Internship for Students grant from IEEE Consumer Technology Society (CTSoc)[1], which co-funded the development of the virtual conferencing environment. The conceptualization and implementation of the LLM-based recommender system occurred within the context of IEEE Digital Reality activities, exploring how immersive and intelligent technologies can support meaningful digital interaction and collaboration.

II. Related Work

The rise of immersive technologies and the Metaverse paradigm has led to the development of numerous virtual environments (VEs) aimed at supporting social interaction,

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[1]IEEE Consumer Technology Society: https://ctsoc.ieee.org/

collaboration, and academic exchange. Various platforms and studies have explored ways to replicate or enhance real-world conferencing experiences within virtual spaces. For instance, tools such as Mozilla Hubs, AltspaceVR, and VRChat have been employed to host remote academic workshops, poster sessions, and keynote talks. Research prototypes have also demonstrated how multi-user environments can facilitate group interaction through avatars, spatial audio, and interactive content sharing [10]–[12]. These systems typically focus on enabling co-presence and engagement in remote or hybrid settings, with particular attention to usability, embodiment, and emotional connection.

Several studies have evaluated how immersive virtual spaces can be adapted for professional or academic scenarios. Radianti et al. [10] provide a comprehensive review of immersive VR applications in higher education, highlighting improvements in engagement and collaborative learning outcomes. Similarly, Uribe et al. [12] analyzed social interaction patterns within a metaverse-based academic event, showing that spatial proximity, avatar embodiment, and voice-based interaction contribute significantly to spontaneous conversations and group cohesion. These findings suggest that immersive VEs can replicate many aspects of informal networking typically found in physical conferences.

Other works have explored the use of VR platforms to support large-scale educational or scientific events by simulating real-world structures, such as auditoriums, poster halls, and breakout rooms. For example, Nagao [11] presents a virtual university campus, envisioned as an educational Metaverse where on-demand VR lectures are delivered in virtual lecture halls, multiple digital campuses are interconnected, and AI tools support automated evaluation and training. Similarly, MetaLibrary [5] illustrates a domain-specific immersive application, providing a social VR environment designed for reading, discussion, and collaborative engagement. These platforms demonstrate how spatial cues, embodied avatars, and recommendation mechanisms can be combined to enhance information discovery and engagement within focused immersive settings.

Despite these advances, relatively few works have integrated personalization features, such as recommender systems, into virtual conferencing platforms. Notable exceptions include Chen and Yang [13], who proposed a hybrid recommender system embedded in a social VR environment to facilitate user-to-user connection by leveraging behavioral data and graph-based analysis, and Javdani Rikhtehgar et al. [14], who explored content recommendations in a 3D museum-style VR space, guiding users toward relevant exhibits based on past interactions and stated preferences. While these studies demonstrate the potential of recommender systems in immersive environments, they mainly focus on either user connections or content navigation within narrow, domain-specific contexts.

III. Methodology

The overall architecture (shown in Fig. 1) is composed of three main parts: multi-user architecture, social virtual environment, and the LLM-based recommender system.

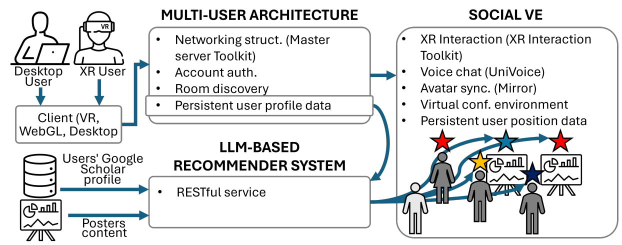


Fig. 1: Overall architecture.

A. Multi-user Architecture

The developed platform was designed as a multi-user immersive application for hosting academic conferences in a VE, built using Unity game engine version 2023.2.13. A client-server architecture was implemented using the Mirror networking library[2], where a central server manages multiple user connections in real-time. Clients can connect using either immersive VR devices or desktop interfaces, as the application is fully multi-platform, supporting both PC-based VR headsets and desktop access via mouse and keyboard (either through a dedicated executable or a WebGL browser version, thus ensuring accessibility across a wide range of hardware setups without compromising functionality).

The networking structure was further supported by the Master Server Toolkit[3], which enables the creation of multiple parallel rooms hosted under a single master server, allowing scalability and session-based partitioning. For voice communication, the system integrates UniVoice[4], a spatial VOIP solution that enables realistic audio proximity between users.

Upon joining the application, users are prompted to choose their preferred platform, i.e., immersive VR connected to a PC or desktop, and to customize their avatar, selected from a pool of models downloaded from Ready Player Me[5]. The VR functionality was implemented using the Unity XR Interaction Toolkit, which ensures consistent input handling across VR headsets. A realistic avatar design was adopted to enhance users' sense of embodiment and maximize social presence in immersive interactions, as shown in previous studies [15].

To support key Metaverse features such as persistence, privacy, and security, the system assigns each user a unique internal ID and links associated data to their authenticated account via the Master Server Framework. Stored data includes the chosen avatar, the user's Google Scholar profile id, and their email and password retained in encrypted form, enabling secure authentication and persistent access to the virtual conferencing system.

User-related information remains stored exclusively on the Master Server, ensuring it is not exposed to external systems or third parties. This controlled environment guarantees that

[2]https://mirror-networking.com/
[3]https://github.com/aevien/master-server-toolkit
[4]https://github.com/adrenak/UniVoice
[5]https://readyplayer.me

personal data is utilized exclusively for authentication and personalized content recommendations. Although the current setup relies on implicit user consent, future iterations will introduce explicit opt-in mechanisms and user-accessible privacy controls to enhance transparency and regulatory compliance, laying the groundwork for a robust and trustworthy Metaverse infrastructure.

Additionally, to further support a seamless user experience, the system logs avatar positions every 15 seconds. This allows participants to rejoin the virtual environment at their previous location, preserving session continuity.

B. Social Virtual Environment

The base 3D structure of the VE inspired by real-world conference venues was derived from the "Conference-room" 3D model by natgeo, available on Sketchfab[6]. The experience begins in a central lobby that acts as the main hub, where users are introduced to the VE and can freely move to thematic areas of the venue.

The VE comprises several distinct areas:

- *Presentation Room*: This area replicates a classical conference setting with a central stage and auditorium seating, as illustrated in Fig.1 a. Selected users can upload and present academic papers, including slides or media content, visible to all attendees.
- *Poster Hall*: This is a dedicated space for poster sessions, where each poster board is interactive, as illustrated in Fig.1 b. Users can approach a board and activate its content through explicit input. This action allows them to upload a poster file directly from their local PC via a file explorer. Once uploaded, the poster becomes visible and accessible to all the other users in the VE.
- *Workshop Room*: This is a smaller, more intimate room designed for hands-on workshops or smaller group sessions, as illustrated in Fig.1 c. This room facilitates focused discussions and encourages interactive learning, often moderated by a presenter or group leader.

The VE layout was defined to support a smooth flow between formal presentations, exploratory browsing of research content, and casual social interaction. The use of spatial audio, embodied avatars, and clearly delineated architectural zones is designed to immersion, co-presence, and user engagement throughout the experience.

C. LLM-based Recommender System

To enhance user experience and guide navigation within the VE, an LLM-based recommender system was used. The system is designed to suggest relevant academic posters as well as other users within the VE while exploring different virtual rooms.

The backend of the recommendation engine is implemented as a Python server and built on Groq[7] API, utilizing the LLaMA3-70B-8192[8] model, a high-capacity transformer-based language model optimized for semantic reasoning and embedding-based similarity tasks. The recommendation system operates as a RESTful service that interacts with the game engine through two main endpoints.

Upon room initialization, the metadata (title, abstract, keywords) of any preloaded posters is sent to the backend server. Similarly, when a user uploads or removes a poster during a session, the corresponding metadata is transmitted or deleted via a `POST` request. Since poster images are managed locally, only metadata is exchanged with the backend.

Each time a user enters a virtual room, identified by his or her Google Scholar ID, the client sends a `POST` request containing their ID and the Scholar IDs of all current participants. This enables the server to maintain an up-to-date list of active users. The client then issues a `GET` request, and the server responds with semantic affinity scores between the user's academic profile, the available posters, and other participants in the room.

Internally, the system computes embeddings for both the user profile (inferred through the Scholar ID) and the poster content. It then calculates pairwise similarity scores, typically using cosine similarity, to determine relevance. The top results are returned to the game engine, allowing the VE to dynamically highlight recommended posters and users.

This affinity is visually represented within the VE through a star-shaped interface element positioned both above each poster and above each user avatar. The star changes in scale and color, with a gradient from cold colors (indicating low affinity) to warm colors (indicating high affinity), providing intuitive visual cues of semantic relevance of both posters and users.

By providing content suggestions aligned with participants' research interests through visual relevance cues, the system facilitates navigation and networking, thereby enhancing interaction and engagement within the virtual conference environment.

IV. Conclusion and Future Work

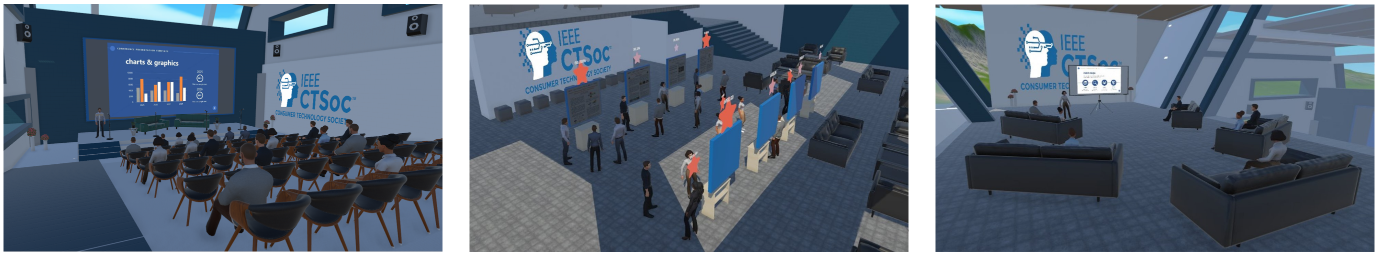
This work introduced a novel virtual conferencing platform that merges immersive 3D environments with LLM-based recommendation capabilities to enhance engagement, content discovery, and social interaction. A core innovation lies in the integration of the LLM-based recommender system, which leverages Google Scholar profiles and poster metadata to deliver personalized content suggestions, aiming to replicate the serendipitous interactions of in-person conferences while mitigating information overload. Overall, the work contributes to research at the intersection of immersive VEs and adaptive user support, showcasing LLM's potential to enrich the Metaverse as a dynamic academic space.

Current prototype implementation confirms the platform's technical viability and interactive potential, though further studies are needed to assess functionality and effectiveness

[6]https://tinyurl.com/2uznvkvr

[7]https://www.groq.com/

[8]https://ai.facebook.com/blog/large-language-model-llama-meta-ai/



(a) Presentation Room: immersive conference hall with stage and seating.

(b) Poster Hall: interactive boards with real-time poster uploads.

(c) Workshop Room: collaborative environment for small group activities.

Fig. 2: Virtual spaces featured in the virtual conference environment.

across diverse domains and user groups. Upcoming user evaluations will investigate engagement, navigation, and recommendation quality, and will include controlled comparisons with simpler baselines and existing conferencing platforms.

From the research perspective, future developments could focus on multimodal profiling, combining explicit metadata with behavioral data (e.g., proximity, gaze) to refine recommendation precision, as well as enhanced social features such as real-time matchmaking, topic-based hubs, and LLM-powered conversation starters to foster spontaneous collaboration. Adaptive VE layouts and emotion-sensitive environmental responses may also be introduced to further personalize the user experience.

Alongside these technical directions, ethical and privacy considerations must be explicitly addressed. The use of Google Scholar IDs and personal metadata requires clear consent models, transparency mechanisms, and compliance with regulations such as GDPR. At the same time, scalability challenges will need careful attention, as large-scale deployment raises issues of server load, latency in multi-user VR, and accessibility barriers due to the need for headsets or powerful hardware. Exploring cloud-based solutions, lighter client versions, and adaptive interfaces will be crucial to ensure inclusivity.

Finally, positioning the platform within the broader ecosystem of virtual conferencing tools will require systematic comparison with established solutions such as Zoom, Gather.town, and FrameVR. Such comparisons can highlight the system's unique contributions, strengths, and current limitations, informing both future research and practical deployment strategies.

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