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Exploring the Influence, Trends, and Future of Virtual Interaction Design in the Metaverse

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This paper aims to explore the relationship between the metaverse and virtual interaction design, and identify future directions and challenges in this field, with an emphasis on the transition from traditional desktop interaction paradigms to three-dimensional virtual interaction paradigms within the metaverse. We employ a systematic literature review and application case analysis to gather and analyze relevant data. Our findings elucidate the technical and societal characteristics of the metaverse, revealing its influence on digital lifestyles and its potential to transform virtual interaction design. Furthermore, we examine the interplay between the metaverse, extended reality, and virtual interaction design. Based on our analysis, we propose six potential trends for virtual interaction design in the metaverse and discuss seven key issues and challenges in the field, providing valuable insights and guidance for the design of virtual interactions in the metaverse.

Keywords: *Metaverse, Virtual Interaction Design, VR, XR, CHI, User Experience*

1. INTRODUCTION

1.1 Overview

The metaverse, defined as a virtual ecosystem comprising numerous virtual worlds and spaces, represents a parallel virtual space to the real world (Al-Ghaili et al, 2022). Harnessing artificial intelligence and virtual reality technologies, the metaverse fosters high levels of interactivity and sociability, enabling individuals to participate in diverse virtual interactive activities (Owens et al, 2011). Alongside the rise of the metaverse, virtual interaction design, an area focused on creating interaction methodologies and experiences in virtual environments, plays a vital role. It has the potential to enrich the metaverse by offering high-quality, human-centric user experiences across various virtual scenarios.

Virtual interaction design and the metaverse share a mutually reinforcing and dependent relationship. The metaverse provides an expansive, diverse, and intelligent space for the development of virtual interaction design (Hillmann, 2021). It can enhance human-computer interaction (HCI) experiences in a variety of scenarios, such as virtual socialization, virtual shopping, and virtual entertainment, through innovative interaction design. As a result, their combination may offer novel possibilities and opportunities for the digital world of the future.

1.2 Research Objectives and Methods

Aim of paper to explore the current applications and properties of the metaverse, the role of virtual interaction design within the metaverse, the reciprocal influence between the metaverse and virtual interaction design, as well as the challenges and future development trends in this field.

Next, relevant databases and search terms for the review were identified. The search was conducted in databases including WoS, Scopus, IEEE Xplore, and Google Scholar. The search terms included "metaverse", "virtual interaction design", "virtual reality", "interaction technology", "human-computer interaction", and combinations of these.

The literature was then screened based on inclusion and exclusion criteria. The included materials consisted of peer-reviewed articles, conference proceedings, and books that

focused on the metaverse and virtual interaction design, published in English. Any articles that did not have an explicit focus on these topics or did not contribute significantly to the research questions were excluded. Ultimately, 53 articles that met the composite requirements were identified and cited in the paper.

2. THE DEVELOPMENT, APPLICATION, AND CHARACTERISTIC OF METAVERSE

2.1 The Development of the Metaverse

Metaverse is a relatively new concept. Although the term "Metaverse" was first used by American science fiction writer Neal Stephenson in his science fiction novel "Snow Crash" published in 1992 (Mystakidis, 2022), its conceptual origin can be traced back to the early 1980s when science fiction writer William Gibson first proposed the concept of "Cyberspace" in his novel "Neuromancer". With the continuous advancement of technology, cyberspace gradually evolved into the concept of Metaverse, becoming a virtual three-dimensional digital world that can simulate the real world and allow people to engage in various activities and interactions (Ball, M., 2022).

Currently, there is no unified standard for the definition of Metaverse (Al-Ghaili et al, 2022). However, from the widely accepted definition, Metaverse is a virtual space based on VR technology and artificial intelligence technology. It is a collection of one or more virtual environments and a virtual, simulated, interactive digital world (TAÇGIN, 2022). From the perspective of the development history of the Metaverse concept, Metaverse can be divided into three stages: namely ① digital twins, ② digital natives, and eventually ③ co-existence of physical-virtual reality or namely the surreality(Lee et al, 2021). With the continuous advancement of technology and changing social needs, Metaverse will further develop and play an increasingly important role in future virtual interaction design.

2.2 Application Scenario of the Current Metaverse

According to a market analysis report from Grand View Research (2022), the global metaverse market size was estimated at USD 65.51 billion in 2022. It is expected to expand at a compound annual growth rate of 41.6% from 2023 to 2030. Therefore, the metaverse is a virtual world full of possibilities, and although it is currently in its early stages (Zeng, 2022), it has a wide range of applications in various Scenarios such as game,

education, healthcare, marketing and social media.

Metaverse Gaming

Electronic game technology is the most intuitive way to present the metaverse. It not only provides a creative platform for the metaverse but also enables the aggregation of interactive content and social scenes (Ning et al, 2021). The metaverse provides a more realistic and free game experience, allowing players to better immerse themselves. Well-known game projects include Roblox and Minecraft. Roblox has a total of 50 million games and accumulates 3 billion hours of monthly usage (Park et al, 2022). In April 2021, musician Travis Scott held five 10-minute virtual live concerts in the game "Fortnite", attracting up to 27.7 million participants. This is undoubtedly a classic example of successful integration of metaverse gaming and music culture.

Metaverse Education

The application of the Metaverse in the education industry can provide students with a more vivid and practical way of learning, such as virtual laboratories, virtual archaeology, and the reproduction of historical scenes (Kye, 2021). At present, most cases of virtual education practice are manifested in virtual spaces and immersive experiences, and there is little involvement in blockchain technology and decentralized applications. This reflects the focus of Metaverse education products, namely virtual campuses, digitized teaching, and virtual simulation training.

Metaverse Healthcare

Meanwhile, in the healthcare industry, metaverse applications can provide doctors and patients with more realistic experiences and treatment plans. For example, medical students can practice surgery simulations through virtual surgical practice devices, while patients can relieve pain and fear through VR (Mejia et al, 2022). Metaverse provides virtual training programs for the use of medical equipment.

Metaverse Marketing

Metaverse marketing is an emerging digital marketing strategy that uses the metaverse, a space composed of 3D virtual worlds, to promote products and services. By applying

traditional digital marketing strategies to virtual worlds, it encompasses various forms including brand promotion, product display, user interaction, and sales activities on metaverse platforms. Businesses can create virtual stores or display centers in the metaverse to showcase their products or services. This provides a new, immersive experience, enabling users to interact with brands in a novel way (Yoo et al, 2023). The metaverse can also serve as a new sales channel. Businesses can create new revenue streams by selling virtual goods in the virtual world, or by selling products from the real world through virtual stores. In addition, just like digital marketing in the real world, metaverse marketing offers abundant opportunities for data collection and analysis. This data can help businesses understand user behavior, preferences, and needs, thus providing a more personalized experience (Barrera & Shah, 2023).

The Nike brand has further expanded its global influence through its innovative metaverse marketing strategy in "Roblox". In November 2021, Nike unveiled a virtual space in "Roblox" called "Nikeland", mainly aiming to provide a new interactive platform to connect Nike with fans and promote experience sharing and competitive activities. Nike promotes the integration of sports and gaming elements in this 3D space, thereby innovating a new way of life (Demir, 2023).

Metaverse Socializing

The metaverse can provide users with more interactive and authentic social experiences on social media platforms (Wang et al, 2022). For instance, Facebook is developing a virtual social platform called Horizon Workrooms, which offers users a more intuitive and flexible social and collaborative experience.

It is evident that the metaverse has numerous applications in various fields and makes significant contributions to the industry. Metaverse applications provided people with novel interactive experiences, more intelligent work methods, and simpler living environments.

2.3 The Characteristics of Metaverse

According to the analysis of metaverse applications and literature, the characteristics of metaverse are diverse, including but not limited to simulation, hyper spatiotemporality, cross-platform, intelligence, openness, sociality, economy, and culture. Based on the

classification of characteristics, the eight characteristics can be divided into two categories: technical characteristics and social characteristics.

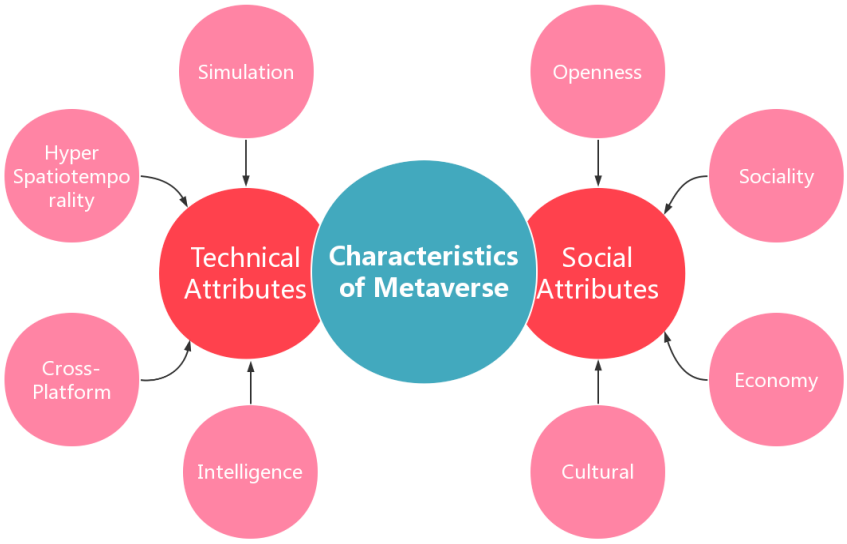

Figure 1 ： This figure illustrates the technical and social characteristics of the metaverse.

The Technical Characteristics of the Metaverse

The Metaverse is characterized by simulation, hyper spatiotemporality, cross-platform compatibility, and intelligence. The simulation aspect enables the Metaverse to create mirror and para-worlds that reflect and reimagine the real world, employing extended reality(XR) technologies such as virtual reality(VR), augmented reality(AR), and mixed reality(MR) for immersive experiences (Zeng, 2022; TAÇGIN, 2022; Mystakidis, 2022).

Hyper spatiotemporality in the Metaverse allows for flexible expansion and compression of time and space in the virtual world, enabling unique experiences such as super-fast travel and multi-dimensional space (Ning et al, 2021). The Metaverse's cross-platform compatibility ensures seamless experiences across devices such as head-mounted displays, smartphones, tablets, and computers (Karaarslan & Altundas, 2022).

Lastly, artificial intelligence in the Metaverse contributes to its intelligence characteristic, with technologies such as natural language processing, machine learning, computer vision, and speech recognition enhancing personalization and interaction (Huynh-The et al, 2023).

The Social characteristics of the Metaverse

The Metaverse is characterized by social properties including openness, sociability, economy, and culture, resulting from the application of related technologies and products. Openness in the Metaverse allows users to freely explore, interact, and contribute their creativity, further enhancing the shared virtual space (Zhang & Ren, 2022).

The Metaverse, as an emerging internet application, fosters interaction and collaboration among users, thereby facilitating knowledge sharing (Ning et al, 2021). Its economic potential is tied to the trade of virtual currencies and assets, paid services, advanced features, and advertising (Yoo et al, 2023).

The cultural dimension of the Metaverse enables various cultural phenomena, including virtual art, music, games, and more. Users' creation and personalization of virtual assets often reflect their individuality and cultural background (Zhang X. et al, 2022).

While various Metaverse products offer glimpses into this concept, no single product fully encompasses it. Current Influences and value are less profound than imagined, and a more advanced, connected system is needed to fully realize the Metaverse concept. This view aligns with scholars such as Zeng Jun (2022), Duan Haihan et al(2021), who suggest the Metaverse is still in its early stages of exploration.

3. DEVELOPMENT OF VIRTUAL INTERACTION DESIGN

3.1 Interaction Design

The development of interaction design can be traced back to the 1970s with the advancement of computer science and HCI field. It is a discipline that studies the interaction between humans and computers, aiming to optimize user experience, satisfaction, and commercial value by improving the interaction between users and systems (Preece et al, 2015).

The term interaction design was coined by Bill Moggridge and Bill Verplank in the mid-1980s(Moggridge & Atkinson, 2007), but it took 10 years before the concept started to take hold(Cooper et al, 2014). According to Verplank, interaction design is an adaptation of computer science terminology for user interface design within the industrial

design profession (Friesen, 2013). For Moggridge, it is an improvement on "soft-face," a term he coined in 1984 referring to the application of industrial design to products that include software(Pogrebin, 2010).

With the continuous development of computer and internet technology, interaction design has gained increasing application and attention. Interaction design draws on theories and techniques from traditional design, systems theory, and engineering disciplines. It is a comprehensive field with unique methods and practices, rather than a mere combination of parts. It is also a discipline of systems engineering, with methods distinct from those of art and engineering(Wang, 2012).

At this time, more and more designers and researchers are studying the process of interaction design. Interaction design includes various activities such as user research, requirements analysis, design thinking, prototype development, and user testing (Cooper et al, 2014).

3.2 3D Virtual interaction Design

Virtual interaction was understood as all digital interface interactions that are outside of physical product interaction design (Swan, 2001). 3D Virtual interaction is an important subfield of HCI, and it requires solutions to specific interface design issues related to using 3D input in VR, AR, wearable computing, and other platforms (LaViola, 2017).

The interaction environment of 3D virtual interaction is in which the user interacts with the computer is a 3D virtual environment generated by the computer (LaViola, 2017). Users enter a virtual environment through specific devices (such as head-mounted displays), or users can add a virtual environment in a real environment and observe and interact through specific devices (such as AR glasses, mobile phones, etc.). 3D virtual interaction includes not only the interaction in the virtual environment but also the situation of interacting with the computer in the real environment.

Virtual interaction design is a design method based on VR technology, involving the design of elements such as VR scenes and virtual characters (Wu & Duffy, 2012). It serves the field of 3D virtual interaction and is a subfield of interaction design, extending HCI research into virtual environments to provide a more immersive user experience. Virtual interaction design requires designers to understand the principles and characteristics of VR

technology, adapt to new VR hardware devices, and design a virtual interaction experience that meets user needs and expectations(Hillmann, 2021). In general, virtual interaction design is an extension and expansion of interaction design, emphasizing the immersive user experience in a virtual environment. It requires designers to master the application and development of VR technology to provide an excellent virtual interaction experience.

4. RELATED INTERACTION TECHNOLOGY IN THE METAVERSE

4.1 XR

Virtual interaction mainly includes the design and development of user interfaces, interaction techniques, and other interactive features of VR applications in virtual environments (Pirker et al, 2022). Although the concept of the metaverse is related to VR in the early stage, some scholars have started to include AR and MR in the research scope of the metaverse, and collectively refer to it as XR (Mystakidis, 2022). This is because the concept of the metaverse involves not only a virtual world, but also the interaction and fusion between the real world and the virtual world (Lee et al, 2021).

Interaction technologies based on XR including AR, VR, and MR, aim to achieve more seamless interaction between the real world and the virtual world. The metaverse needs to have a high degree of immersion and realism (Mystakidis, 2022). In the metaverse, VR puts users in a virtual environment that simulates real-world scenarios and operations, allowing users to interact directly with the virtual environment. VR technology includes devices such as head-mounted displays(HMD), controllers, and positioning tracking systems that can provide users with immersive virtual experiences. Users can use AR technology to overlay virtual elements onto real scenes, and can observe real scenes through cameras and see virtual elements in the scene. AR technology can be implemented using devices such as smartphones, tablets, and smart glasses. MR technology can insert virtual elements in real-time into the real environment, achieving a more realistic and intuitive interaction (Dwivedi et al, 2022).

Currently, many scholars are exploring and discussing the optimization of XR interaction technologies and methods from various angles. Zhao et al (2022) researched how to enhance the visual experience of XR in the metaverse from the perspective of vision and images, based on interaction tasks, user actions, feedback, and various sensory channels. Seo & Yoo (2020) explored a digital earth browser that supports geovisualization, as well

as VR, AR, and MR environments, and established a conceptual model to improve the interaction and operation experience of traditional geographic browsers. Banfi & Previtali (2021) described in detail the process of digitizing the restoration of archaeological sites and cultural heritage buildings through real-time 3D creation platforms, and discussed new levels of interaction between users and the digital world based on XR interaction technology, optimizing the way ancient relics are archived, narrated, and history is implemented.

4.2 Voice Interaction

Voice interaction, based on human speech recognition and natural language processing, has become an essential interface for various devices like smart homes, smartphones, and speakers (Li & Tang, 2019). With the metaverse's ascendancy, voice interaction, integrated with VR, AR, and virtual socializing, offers user convenience in interacting with virtual environments and enhances social experiences. For instance, users can swiftly switch scenes or control actions via voice commands, and enjoy natural conversations in virtual social settings.

ChatGPT presents new opportunities for linguistic interaction in the metaverse, acting as a personalized assistant to provide various services. Its adeptness at natural language processing equips it to offer efficient and reliable support across scenarios, such as game tips, shopping advice, or social conversations (Zhou, 2023).

In terms of academic studies, Chaves and Gerosa (2021) proposed a chatbot social characteristics model, offering design insights for researchers and designers. Li and Tang (2019) explored the blend of artificial intelligence's natural language processing with VR environments, crafting a VR and natural language processing setup using the Unity3D engine. Their work facilitated voice interaction in VR by translating speech signals into interaction commands. Moreover, Li et al (2023) enhanced the service capability of voice interaction recognition systems by optimizing the automatic speech recognition model and mobile robot system performance, testing the environment isolation and speech recognition capabilities of mobile robots.

4.3 Human Posture and Gesture Interaction

Gesture interaction and human posture recognition technology facilitate intuitive interaction with devices and applications through user movements. This approach offers an immersive user experience and holds significant potential in the metaverse (Xiao, 2018). These interaction technologies predominantly encompass sensor and computer vision technology. Sensor technology utilizes wearable devices to convert postures and gestures into digital signals for interactive operations. Computer vision technology employs cameras to capture user movements, which are then analyzed and recognized for interaction (Yang et al, 2019).

An early example of related interaction technology is the Kinect sensor produced by Microsoft, which implements human posture recognition, skeleton tracking, and gesture recognition technology, thereby providing a new way of human-machine interaction. Kinect can capture users' hand gestures, thereby enabling gesture control. For example, users can control the play, pause, fast forward, and rewind of television or movies through gestures. In addition, Kinect can recognize users' body poses, thereby enabling body tracking. For example, users can control game characters' movements and jumping through body poses.

Qin et al (2021) provide a new strategy for human-machine interaction of wearable gesture sensors by calculating the number of pulses generated based on the magnetic array in a unit time to determine the degree, speed, and direction of finger movement in real-time and converting sliding movements into touch separation, thereby improving the durability, low-speed signal amplitude, and stability of the system and achieving a more natural, intuitive, and real-time gesture interaction. Wu et al (2019) developed a new method based on a user-defined set of gestures and validated the usability of derived gesture sets. Through comparative experiments with virtual joystick controllers and ray casting technology, they verified the advantages of using bare-handed gestures in terms of required performance, error count, user preferences, and workload, and formulated some gesture interaction design guidelines, providing more references for the application of gesture interaction.

4.2 Multimodal Interaction

Multimodal interaction integrates various aspects of human perception, cognition, and behavior, including visual, auditory, and tactile senses as well as body movements, facial expressions, and verbal communication. This comprehensive approach provides a more natural, intuitive, and efficient form of interaction in the metaverse (Pustejovsky & Krishnaswamy, 2021). Gesture interaction, which relies on hand movements like waving or pushing, and voice interaction, which utilizes vocal commands, offer more intuitive and organic completion of interactive tasks. The efficacy of these modes, however, depends on the specific interaction scenario and requirements.

Wang et al. (2022) pioneered a framework which merges bottom-up approaches with AI multimodal processes, introducing human behavioral data into generative non-fungible tokens (NFTs) known as "multimodal interactive NFTs". This work showed the potential of NFTs in the art world, going beyond traditional 2D and 3D static content. Tan et al. (2020) further enhanced the field by mapping language tokens and related images contextually through vokenization and multimodal alignment, testing this model on a compact image caption dataset.

In addition to XR, speech, gesture, and multimodal interactions, emerging technologies like brain-computer interfaces, facial expression recognition, eye-tracking, heart rate monitoring, and skin sensor technology offer future potentials for the metaverse. While these technologies are currently in research stages and not yet fully integrated into mature metaverse products, their capacity to perceive users' physiological and psychological states may enable more intelligent and personalized interaction modes. As technology progresses and application scenarios expand, these tools are expected to significantly contribute to the future metaverse.

5. THE INFLUENCE BETWEEN VIRTUAL INTERACTION DESIGN AND THE METAVERSE

The metaverse, characterized by its vast, open, and exploratory virtual environment, offers ample development opportunities and sparks innovative concepts for virtual interaction design (Mystakidis, 2022). As such, virtual interaction design in the metaverse must consider factors such as user experience and requirements, providing both technical support and design insights to create a more personalized virtual interaction experience.

5.1 Factors between Virtual Interaction Design and the Metaverse

The metaverse broadens interaction design's scope, facilitating its evolution from single, predefined, closed systems to multi-scenario, personalized, and cooperative systems. Primarily, the metaverse is a platform integrating various interactive technologies. The development of these technologies and related hardware devices brings more diverse and intricate design challenges (Zhu, 2022). Secondarily, the increasing range of fields involved in the metaverse is causing virtual interaction design to veer towards a more tailored and diverse direction. Designers are required to contemplate how to offer users a rich variety of interaction modes and experiences in the metaverse, based on different fields and scenarios, while ensuring the interaction process remains natural and comfortable (Mourtzis et al, 2022). Additionally, the metaverse offers a virtual social space, promoting socialization and cooperation in virtual interaction design. This encourages users to interact and collaborate with others in virtual spaces, fostering collective value creation and sharing (Schlemmeri, 2011), a shift beyond traditional human-machine interaction.

The metaverse brings more extensive, diverse, and intelligent development space for virtual interaction design, promising a future filled with possibilities and opportunities. Simultaneously, virtual interaction design significantly influences the metaverse in several ways. Firstly, it enhances user experiences in the metaverse, affecting users' perceptions, satisfaction, and participation levels (Choi, 2022). For example, implementing natural language processing and AI allows for interaction methods such as speech recognition and emotion analysis, fostering more natural interactions in the metaverse (Park & Kim, 2022). Secondly, virtual interaction design propels the metaverse's development by promoting technological advancements and application scenarios. Lastly, virtual interaction design amplifies the metaverse's social aspect across various fields, such as healthcare, education, and entertainment (Al-Ghaili et al, 2022). In summary, virtual interaction design significantly Influences the metaverse, fostering its development, expanding its applications, and enhancing user participation and experience.

In conclusion, the metaverse's development encourages the transformation and innovation of virtual interaction design, making it more diverse, personalized, and collaborative. Intelligent technical means and socialization allow the metaverse's virtual interaction design to better meet users' needs and generate more value. Conversely, virtual interaction design significantly Influences the metaverse, fostering its development, widening its

application scope, and enhancing user participation and experience. Therefore, deeply exploring the relationship between the metaverse and virtual interaction design is crucial. This exploration will aid in understanding future virtual interaction design trends and provide innovative concepts and technical support for the metaverse's design.

Literature review suggests that virtual interaction in the metaverse is achieved and enhanced through virtual interaction design, which in turn is influenced and driven by the development of the metaverse. This interplay can be simplified and visually represented as in Figure 2. Detailed explanations of their mutual influence will be elaborated on in the subsequent sections of this document.

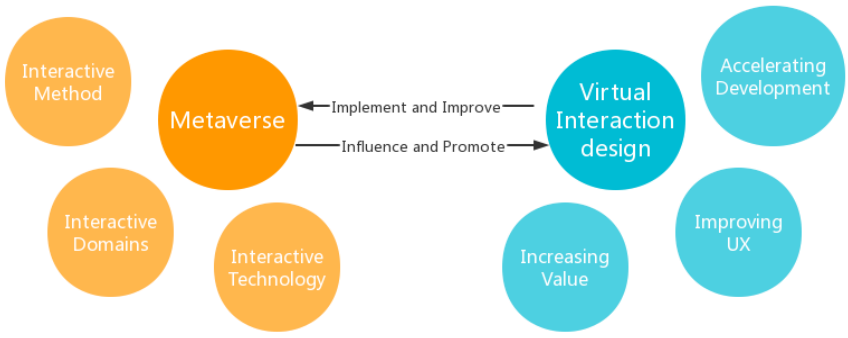

Figure 2：Detailed description of how the metaverse and virtual interactive design interact with each other

5.2 Development Trends of Virtual Interaction Design in the Metaverse

The development of virtual interaction design depends on the innovation of interaction technology and the pursuit of user experience. It will gain more design space in future metaverse products, and based on the development trends of interaction technology and the inherent nature of metaverse, the future development trends of virtual interaction design can be speculated. Based on literature analysis and summary, the author has organized the future trends of virtual interaction design in the metaverse and has created the table 1.

Table 1 the future trends of virtual interaction design in the metaverse

Development Trend	Key Aspects
Realism	Emphasizing the use of XR technology to enhance user immersion and create more realistic experiences (Al-Ghaili, et al, 2022)
Intelligence	Implementing artificial intelligence technologies for more personalized, intelligent, and precise interaction experiences. Simplifying life through applications such as "Senior public Transportation Simulation" (Park and Kim, 2022)
Social Interaction	Providing rich and diverse social interaction methods to meet users' needs. Increasing user emotional investment and improving user stickiness (Al-Ghaili, et al, 2022)
Innovative Content	Focusing on not only visuals and interactions but also storytelling. Encouraging artistic innovation (Lee et al, 2021)
Cross-platform Compatibility	Designing interactions to be compatible with a variety of platforms and devices. Ensuring interoperability of future metaverse technology (Chen et al, 2023)
Interdisciplinary Convergence	Expanding the metaverse and integrating more fields. Enhancing brand value and reputation through industry expansion and integration (Spajić et al, 2022)

In summary, the evolution of virtual interaction design in the metaverse is guided by a need to improve user experiences, adopt emerging technologies, merge physical and virtual realms, foster content innovation, ensure cross-platform compatibility, and advocate for interdisciplinary consolidation. The development direction of virtual interaction design lies in realism, intelligence, personalization, freedom, interconnection, and integration. As virtual interactions continue to pervade daily life, it becomes vital for designers to stay updated with these trends and constantly redefine the limits of this fast-paced and thrilling field.

6. DISCUSSION: CHANLLENGES AND ISSUES IN VIRTUAL INTERACTION DESIGN IN THE METAVERSE

The expansive virtual environment of the Metaverse mirrors reality with a variety of virtual scenes and objects, exhibiting a continual increase in its real-world likeness (Mystakidis, 2022). As the influx of individuals engaging in numerous interactive activities

within this space surges, the importance of virtual interaction design escalates. However, the Metaverse brings about challenges and issues that need addressing.

1. Technological Limitations: The Metaverse relies heavily on hardware for creating immersive experiences. However, current technology constraints limit virtual interactions. To counter this, technological advancements need to support quicker data transfer rates, improved graphic processing capabilities, and more sensitive transmission capabilities (Mystakidis, 2022). The development of robust computer systems capable of managing intricate physical simulations, high-definition rendering, and large-scale data transmission within virtual environments becomes paramount (Dionisio & Gilbert, 2013). Furthermore, sensors capturing real-time data, including users' movements, positions, gaze, and voice, are essential for shaping the digital environment of the Metaverse (Zhou, Y. et al, 2022).

2. Human-Computer Interaction (HCI) Technology: To achieve natural interaction, improvements in software technologies like natural language processing, computer vision, and machine learning are necessary (Zhou, Y. et al, 2022). Advances in HCI technology could improve user engagement and personalization, as well as provide a more realistic and interactive virtual environment (Park & Kim, 2022).

3. Diverse and Personalized Interactions: The surge in Metaverse users brings an increasing need for designing virtual interactions that cater to various user needs (Spajić et al, 2022). Accommodating the simultaneous interaction of multiple users presents significant technical and HCI challenges, including interaction complexity and user experience.

4. User Experience: While the Metaverse provides a unique VR environment, enhancing the user experience remains a challenge (Lee & Gu, 2022). Therefore, creating a virtual environment where users feel natural and emotionally involved becomes crucial.

5. Privacy and Security: The increasing interaction frequency in the Metaverse necessitates user data protection and the establishment of robust privacy mechanisms (Bermejo Fernandez & Hui, 2022; Al-Ghaili et al, 2022). Virtual interaction design must comply with relevant privacy regulations and security standards to ensure the safety of user data.

6. Cross-Cultural and Cross-Language Interactions: The diverse cultural backgrounds of Metaverse users pose the challenge of designing multi-language and cross-cultural

interfaces (Li J., 2022). It's crucial to consider how to allow users from different cultural and language backgrounds to interact and communicate more naturally.

7. Seamless Connection with the Real World: While the virtual world offers enhanced freedom and creativity, designers must consider how to seamlessly link the Metaverse with users' real-world lives (Dwivedi et al, 2022).

The implementation of Metaverse within virtual interaction design poses significant challenges, including those concerning hardware, technology, diversity, user experience, security, culture, and connectivity. These challenges require deeper exploration and research in the field of virtual interaction design. As the Metaverse continues to evolve and expand, these considerations must be kept at the forefront to create a seamless, immersive experience bridging the virtual and real worlds.

7. CONCLUSION

The Metaverse is characterized by simulation, hyper spatiotemporality, cross-platform capabilities, intelligence, openness, sociality, economy, and culture, thereby signaling the future direction of digital world development. The maturing Metaverse technology provides a strong foundation for XR and artificial intelligence, among other technological domains. The advancement of the Internet of Things fosters closer interaction between virtual world and the real world, enabling humans to engage with the physical world within a virtual space.

On the hardware front, the continuous improvements in XR devices enhance user experiences and offer more realistic interaction methods. In terms of software, multimodal interaction and AI technology contribute to a more intelligent virtual interaction design, bolstering the naturalness and realism of VR. Virtual interaction design serves as a linchpin for accessing Metaverse interaction experiences, forming a bridge between users and the Metaverse and thus becoming integral to its development.

The Metaverse expands the scope for virtual interaction design, providing a more diverse and intelligent development space. Concurrently, virtual interaction design improves user experience, spurring the growth of the Metaverse and facilitating the quick penetration of Metaverse products into various market segments. Future prospects indicate that Metaverse technology will continue to evolve, finding applications across numerous industries, such

as gaming, education, healthcare, and office environments.

As network upgrades and Web 3.0 development progress, the fluidity and efficiency of virtual interactions within the Metaverse are likely to improve. Such enhancements could lead to the Metaverse becoming a more integral part of everyday life, serving as a platform for both work and entertainment. Despite challenges in hardware, technology, diversity, user experience, and security, virtual interaction design is expected to innovate and progress towards realism, intelligence, personalization, freedom, connectivity, and integration. Consequently, the evolution of virtual interaction design, grounded in the Metaverse, will offer individuals increasingly diverse and rich digital experiences.

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