TEHRAN UNIVERSITY OF MEDICAL SCIENCES

IJOH INTERNATIONAL JOURNAL OF OCCUPATIONAL HYGIENE

eISSN: 2008-5435

IRANIAN OCCUPATIONAL HEALTH ASSOCIATION IOHA

PROSPECTIVE

Human Factors and Ergonomics Research Agenda for Metaverse

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Received 2023-03-23; Revised 2023-04-18; Accepted 2023-05-03

This paper is available on-line at *http://ijoh.tums.ac.ir*

ABSTRACT

Metaverse is not a product of today's age but has gone through several phases and stages over a long period of history, where efforts to improve the service and accompanying developments continue daily. Considerable efforts are currently being made by researchers, designers, developers, decision-makers, and others to enhance the metaverse, and many metaverse platforms are now available. Metaverse is used in various fields and on the other hand, it will bring challenges. In order to achieve better performance and maintain human well-being when using Metaverse, interactions should be considered from different aspects. Therefore, future research is needed to examine people's interactions with metaverse environments and platforms with a comprehensive approach. In the end, research agents of human factors and ergonomics were presented to investigate user interactions with Metaverse.

KEYWORDS: *Metaverse, Virtual Reality, Human Factors. Ergonomics, Research Agenda*

INTRODUCTION AND EMERGENCE OF THE METAVERSE

The progress of technology in recent decades has been significant and has affected the lives of humans and other creatures in the world. One of these developments that have fallen on the tongues today is Metaverse. The term metaverse was first used in 1992 in Neal Stephenson's novel Snow Crash. In this novel, Metaverse is a world where humans interact with each other and software agents in 3D virtual space as programmable avatars [1, 2]. There are many definitions of the metaverse that differ depending on the perspective and purpose. Mystakidis (3) defines the metaverse in the Encyclopedia: "The Metaverse is the post-reality universe, a perpetual and persistent multiuser environment merging physical reality with digital virtuality. It is based on the convergence of technologies that enable multisensory interactions with virtual environments, digital objects, and people such as virtual reality (VR) and augmented reality (AR). Hence, the Metaverse is an interconnected web of social, networked immersive environments in persistent multiuser platforms."

Metaverse has made significant progress in the past decade. In 2014, major companies such as Sony, Samsung, and Google unveiled VR headsets. In September 2017, IKEA launched an augmented reality program called IKEA Place, which aimed to solve the problems of buying furniture. Apple added Lidar to iPhones in 2020 for AR and Mixed Reality (MR) headsets. Facebook changed its name to Meta in 2021 to emphasize its role in the development of the Metaverse [4, 5]. The potential market for the metaverse in the

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United States is $8.3 trillion by 2022 [6]. Another survey in March 2022 found that about half of respondents from the UK and one-third of respondents from the US perceived the Metaverse as something being built and eventually controlled by Facebook. On the other hand, 35% and 29% of the English and American respondents, respectively, understood Metaverse as a version of the real world [7].

Recently, various metaverse-based platforms (e.g. Roblox and ZEPETO) have attracted considerable attention. Meta's launch of Horizon Worlds in 2021 and Horizon Workrooms in 2022 provides a vision of how the Metaverse could potentially shape many aspects of how we work and socialize. It has also created an increasing level of questioning and debate by academics and practitioners about the many social implications of the metaverse for many people around the world [8, 9]. In spite of these developments, knowing the aspects of human factors and ergonomics (HFE) of metaverse as well as human interaction in this environment seems essential. For this purpose, in this article, the technological advances, applications, and challenges of the metaverse are reviewed, and finally, the applications and research agenda of EHF for human interaction with the metaverse as a new trend in research are presented.

TECHNOLOGICAL ADVANCES, APPLICATIONS, AND CHALLENGES

In fact, technological advances in the past decades have enabled the development of the metaverse. Hardware technologies such as VR headsets, Haptic and software such as Blockchain, Artificial Intelligence (AI), 3D reconstruction and the Internet of Things (IoT) are the main developments that have enabled the use of metaverse. Park and Kim (10) and Dwivedi, Hughes (11) have explained this technology well. on the other hand, One of the reasons for attracting and paying attention to Metaverse is its various and countless applications. Metaverse can affect people's daily life and if it is used correctly, it can provide a more comfortable life for people. Metaverse has been widely used in various fields such as education, games, health care, business and marketing, social life, and office, and many studies have investigated these applications [3, 10, 11]. Using any new technology, in addition to benefits and applications, also brings challenges and limitations. Different classifications for metaverse challenges are presented in different literature sources. In this study, the challenges and limitations of Metaverse are divided into three main parts: health and safety, hardware and software limitations, as well as ethical and security issues. In HFE, metaverse health and safety challenges are more important.

Health and Safety

When users use metaverse platforms and environments, almost all of their focus and attention are involved in doing the work (they are immersed in doing that activity). This issue can cause many cognitive errors in them and may even eventually lead to an accident. Distraction is one of the cognitive errors that most users of Metaverse experience, for example, when the user is intensely engaged in playing Metaverse games, he may bump into an object, fall down, or be injured. Continuous presence in metaverse environments and platforms can cause fatigue (physical and mental), anger, and even spasms in every muscle of the body (eyes, hands, neck, etc.). Another challenge related to users' health is the psychological effects of Metaverse on people; For example, for a person who lives alone, the existence of metaverse platforms may be good for him and he no longer feels lonely, but for a person who is very busy, it causes him to have more mental conflict and get confused in doing daily tasks; Therefore, depending on the lifestyle of people, the effect of metaverse on their mental health can be different.

HUMAN-METAVERSE INTERACTION

Users create an image of themselves called an avatar to appear in the virtual space. Avatar means "an embodiment, incarnation, or manifestation of a person or idea." In older platforms, mouse, keyboard, touch screen, etc. were used to control avatars. New metaverse platforms such as Horizon Workroom provide ways to automatically record human movement and reconstruct it in the virtual world using head and hand movements. Avatars act as a representation of the user in the metaverse [12, 13]. Users interact with avatars using equipment such as VR headsets, and avatars interact with other avatars and other objects in the metaverse environment. The sum of these interactions leads to the human-metaverse interaction. In order to maintain health and achieve desirable human performance, this interaction must be optimal. In the definition of EHF, it is a field that seeks to understand the interaction of humans with other elements of the system, and ultimately the goals of this field are to improve performance and well-being through optimal design [14]. In order to achieve these goals when people interact with the metaverse, extensive research is needed in this field.

RESEARCH AGENDA

Although research has been conducted on perceived discomfort, fatigue, and physical burden when using metaverse equipment, especially VR headsets. But mostly in the short term and in the laboratory. On the

Table 1. Research agenda in terms of three HFE domains for metaverse

Domains	Research Agenda
Physical ergonomics	What is the effect of using Metaverse on the musculoskeletal discomfort of users in the short and long term? Is the equipment used for Metaverse anthropometrically compatible with users in different countries? What is the estimate of the biomechanical loads entered into the users' spines when attending Metaverse? How is it different from when users use mobile phones? How does the physiological activity of users' bodies change when they interact with Metaverse?
Cognitive ergonomics	What are users' mental workload changes during and after using Metaverse? What is the level of perception and attention of users during and after using Metaverse? How does human reliability change during and after using Metaverse? What is the effect of using metaverse on stress, depression, and mood?
Organizational ergonomics	What will work systems be like after Metaverse becomes popular? What effect will metaverse have on working times and schedules? Will organizations consider the participation of users and employees when building their version of Metaverse?

other hand, limited and insufficient research has been done on the cognitive aspects of people when using VR headsets. Therefore, future research needs to consider people's interaction with metaverse environments and platforms with a holistic approach. For example, our knowledge of the state of musculoskeletal discomfort, attention, mental and physical fatigue, mental load, and feelings of users when they are in Horizon Workroom for a long time is not enough. Therefore, future research is needed to fill these knowledge gaps. Table 1 presents some research agenda in terms of three HFE domains (Table 1).

CONCLUSION

Sooner or later, Metaverse will expand and users will use Metaverse platforms and environments. In order to achieve optimal performance and human well-being, it is very important to know and understand the interaction of humans with the metaverse from the point of view of HFE. Since the metaverse is an emerging phenomenon, there will be a need for extensive research that considers user interaction with the metaverse. Finally, some research agendas were presented in terms of the three areas of HFE.

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