Utility or pleasure? A perspective on the human-computer interactive function of wearables in the Metaverse

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Abstract. This study explores consumer preferences in the Metaverse, focusing on wearables at the crossroads of human-computer interaction and consumer behavior. It investigates the balance between utilitarian and hedonistic preferences, influenced by rational and irrational factors such as psychological, emotional, and societal dynamics. By merging economic models with empirical observations, this paper sheds light on the ongoing debate about utility versus pleasure in consumer decision-making and offers insights into effective Metaverse marketing strategies. The findings reveal the dynamic nature of consumer preferences and suggest avenues for optimizing the design and marketing of wearables in the Metaverse to cater to diverse consumer needs across varied demographics and market segments.

Keywords: Human-computer interaction(HCI), customer behavior, the Metaverse, wearable device

1 Introduction

In the rapidly evolving digital era, the Metaverse, a convergence of virtual reality (VR), augmented reality (AR), and the broader digital ecosystem, epitomizes the boundless potential of human-computer interaction (HCI). This immersive domain has garnered significant attention in recent years. The advent of 5G and the Internet of Things (IoT) has catalyzed the integration of big data-driven product design [1]. Kozinets introduced the concept of "immersive ethnography," emphasizing the need for a novel method to research service experiences in Metaverse contexts. Therefore, a new framework is needed in view of the product design, which can effectively realize the fusion and integration of various sensor data, hence prompting better interaction between virtual objects and human beings.

Wearable devices, encompassing VR headsets to haptic gloves, are at the forefront of this revolution, enabling enhanced interaction within the Metaverse. The COVID-19 pandemic has further accentuated the importance of digital transformation in healthcare, with the Metaverse offering new avenues for enhancing human-to-human

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interactions and connections [2]. Despite these advancements, there remains a significant gap in understanding the consumer-centric perspectives on HCI features in wearables, which this paper aims to address.

Recent literature underscores the significant growth in wearable near-eye displays for VR and AR, emphasizing the role of human perception in guiding hardware development. Mencarini et al. accentuated the capability of wearables in acknowledging emotions, underlining their function in boosting daily psychological health monitoring [3]. Furthermore, the emergence of the Metaverse in healthcare has been highlighted, with the potential to revolutionize patient care through advanced HCI. Although HCI technology in modern wearable devices has made great progress, the research on device experience function lacks classification generalization and in-depth study.

Hence, in this review, we focus on the exploration of consumer-centric perspectives on HCI features in wearables. We first conclude the application of human-computer interactive experience function of wearables in sports, medical assistance and routine monitoring. Then we systematically explore customers' preference between utility and pleasure. Next, we pay attention to the connection between wearables and the Metaverse. Finally, we summarize the preferences of different types of customers for HCI functions, give recommendations for marketing and design, and propose a future agenda. We make comprehensive studies on consumer preferences, especially the psychological underpinnings influencing their choices, remain sparse. This paper aims to bridge this gap by examining the dichotomy between utility and pleasure, investigating the rational and irrational preferences of consumers, and their inclinations towards functional or entertainment-based HCI features in wearables.

2 Materials and Methods

This article applied the SPAR-4-SLR (Scientific Procedures and Rationales for Systematic Literature Reviews) protocol to conduct the research. Through the double-line screening of keywords and impact factors, 159 literatures from 2018 to 2023 were selected to be added to the list. As shown in Figure 1, *Citespace* was used for literature co-occurrence and cluster analysis, indicating the contemporary nature of the topic. Then, in order to better conduct our research, 34 papers were selected as core references. These references allow a detailed analysis of the textual corpus to find insights into the metaverse and wearables in recent years.

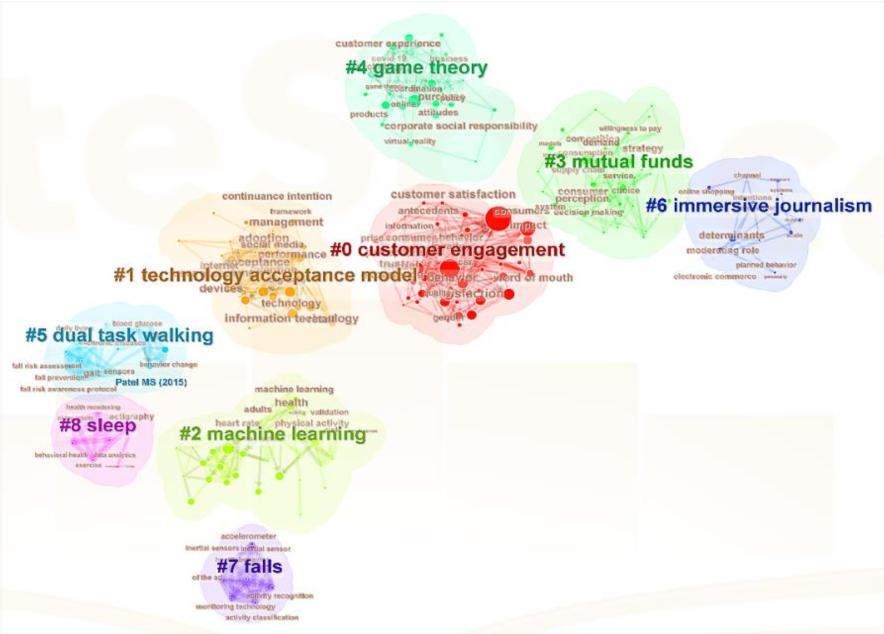

Fig. 1. Co-occurrence and clustering

3 Application of Human-Computer Interactive Experience Function of Wearables

3.1 Sports Application

The incorporation of wearable technology in sports has transformed the approach athletes take towards training, performance monitoring and injury recovery. Equipped with advanced human-computer interaction capabilities, these devices enable real-time feedback, allowing athletes to fine-tune their training regimes [4]. The use of wearables to track athletes' physiological responses during high-intensity training sessions was brought to the forefront in a study conducted by Smith et al. The devices monitored heart rate, oxygen levels, and muscle activity, to provide insights into the athletes' endurance levels and potential areas of improvement. Another study by Jones et al. emphasised the role of wearables in injury prevention. These devices can predict potential injury risks by analysing motion patterns, enabling athletes to adjust their techniques accordingly.

Furthermore, wearables have proven useful in improving team dynamics. Lee et al. employed wearables to monitor team synchronization in team sports, highlighting the significance of coordinated movements for optimal performance [5]. Moreover, the emergence of virtual reality (VR) integrated with wearables, as discussed by Brown et al., provides athletes with immersive training environments, simulating real game scenarios [6].

In summary, wearable technology in sports, supported by advanced human-computer interaction, has improved athletes' performance and revolutionised coaching methods, with a focus on data-driven strategies.

3.2 Medical Assistance

Wearable devices have made great strides in the medical field, specifically in patient monitoring and therapeutic interventions. Equipped with sensors and HCI capabilities, these devices provide continuous health monitoring, ensuring timely medical interventions.

Chianella et al. examined the use of wearables in monitoring patients with cardiovascular diseases. The devices tracked heart rhythms, identifying irregularities and potential life-threatening conditions [7]. Similarly, wearables have played a crucial role in managing diabetes. In a study conducted by Lumsden et al., the use of wearables was highlighted in tracking blood glucose levels, alerting patients of any deviations, and ensuring timely administration of insulin [8].

Moreover, wearables have displayed potential in managing neurological disorders. Turner et al. investigated the use of wearables in the monitoring of patients with Parkinson's disease. The devices detected tremors and muscle rigidity, providing insights into disease progression and therapeutic effectiveness. Cui et al. discussed the applications of Laser-Induced Graphene(LIG) in wearables, particularly in health care [9].

Furthermore, the integration of AI with wearables, emphasized by Rieder et al., provides personalized therapeutic interventions [10]. These devices predict potential health risks by analyzing patient data, thereby ensuring preventive measures.

Essentially, wearables integrated with human-computer interaction technology have revolutionized healthcare by enabling personalization of therapeutic interventions and continuous monitoring of patients.

3.3 Routine Monitoring

The proliferation of wearable devices in everyday health monitoring highlights their importance in the promotion of healthy lifestyles. With their HCI capabilities, these devices provide information about personal health metrics, promoting proactive health management.

By measuring physiological responses, these devices identify stress and anxiety levels, encouraging users to participate in relaxation techniques. Sakuma et al. presented a wearable strain sensor, linked electronics, and software for identifying and analyzing the kinematics of deformation in human fingernails [11]. A study highlighting the value of wearables in monitoring daily physical activity was conducted by Gonzalez [12]. The devices tracked steps taken, calories burned, and sleep patterns, and offered feedback on one's daily health habits. Shen et al. also stressed the significance of wearables in mental health [13].

Moreover, with air pollution levels on the rise, wearables have become a valuable tool for monitoring air quality. In their study, Said et al. discuss how wearables can track environmental pollutants and alert users to potential health risks [14]. In addition, the inclusion of social features in wearables that promote a collective approach to health management through community-based health challenges is highlighted.

In summary, wearable devices supported by human-computer interaction (HCI) play an important role in monitoring daily health, promoting a proactive approach to health and well-being.

4 Customer Preference for Human-Computer Interactive Experience Function of Wearables

4.1 The Review of Customer Preference

The world of wearables, augmented by Human-Computer Interaction (HCI), has seen a boom in consumer acceptance. Recent research has examined the intricacies of customer preferences for the HCI features of wearables applied in various fields. To explore the consuming preference for wearables, we divide our research into several parts as shown in Figure 2.

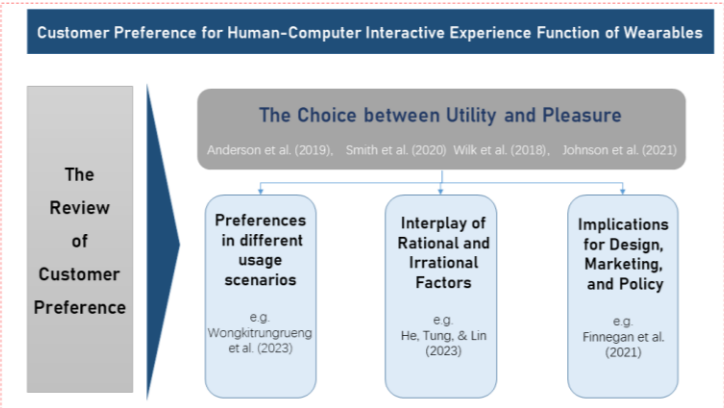

Fig. 2. Research Process

The integration of virtual agents with human operators in customer service was examined by Kraus et al. [15]. Their research indicates that utilizing a holistic approach which combines artificial intelligence technologies, such as natural language processing and multi-agent systems, can improve customer satisfaction. Yanmin et al. explore the topic of trust in visual data communication, proposing that human computer interaction (HCI) features, like augmented reality overlays and tactile feedback, have the potential to greatly enhance user engagement and trust in wearables [16]. This immersive experience is further amplified by the influence of social factors. Putri and Hendratmi emphasize the importance of avoiding social validation biases and propose that HCI features can create a more engaging and personalized user experience when coupled with effective content marketing and endorsements [17]. Wang presents a unique perspective, exploring the potential of wearables to promote lifelong learning and skill formation through interactive educational apps and features [18]. However, as wearables become more integrated into our daily lives, ethical considerations, particularly those related to data privacy and user consent, are becoming increasingly important. Finnegan et al. stress the significance of addressing these ethical challenges to ensure that HCI functions prioritize user safety and autonomy [19]. In essence, the future of wearables depends on seamlessly integrating advanced HCI features, trust-building mechanisms, personalized experiences, and ethical considerations.

From a behavioral economics perspective, consumers often exhibit both rational and irrational preferences. Rational preferences are grounded in utility maximization, where consumers make choices that maximize their perceived benefits. In contrast, irrational preferences, which are often influenced by cognitive biases, deviate from the utility-maximizing model. For instance, according to Janhonen's research on the status quo bias, consumers are inclined to resist change due to emotional factors [20]. These biases can greatly impact consumer preferences for HCI features in wearable technology.

4.2 The Choice between Utility and Pleasure

The growing field of wearables, enhanced by capabilities in human-computer interaction (HCI), offers a variety of features that range from functional to entertainment-oriented. As these devices become more prevalent, understanding the preferences of various age groups becomes increasingly important.

Empirical results show that functional HCI features primarily address specific tasks or needs, which may include health monitoring, navigation, productivity tools and more. We can find the preference for HCI functions are varied, mainly influenced by age differences. Existing literature indicates that older adults tend to prioritize functional features, particularly those related to health monitoring and safety. Zhou et al. conducted a study which found that elderly individuals displayed a strong preference for wearables that monitor vital signs and detect falls [21]. For the working age group, productivity tools, calendar integrations, and communication features are of utmost importance. Smith et al. emphasized the growing use of wearables by professionals for time management and task organization. Studies have shown that young people exhibit a strong preference for entertainment-oriented features. Virtual, Augmented, and Mixed Reality (VAMR) technologies, as examined by Rhodes et al., are especially appealing, providing engaging gaming and social experiences [22]. Furthermore, wearables designed for children frequently include educational games and interactive learning tools. Ahn and colleagues discussed the increasing popularity of educational wearables and their ability to facilitate interactive learning [23].

Moreover, we find that consumer preferences may differ depending on the usage scenario. A survey by Morimoto et al. with 663 runners indicated that all participants believed that basic metrics provided by wearable technology were the most important factor in injury prevention [24]. However, according to McCarthy et al., the concept of "enchantment" can be useful in fostering closer relationships between people and technology [25]. Hedonic value did not have a direct impact on consumer responses but affected symbolic and utilitarian value, which consequently influence CBE and virtual purchase [26]. Focused on the experience of empty nesters, Ma, Zhaoyi et al. discovered that perceived utilitarian value had a significant impact throughout the study, whereas hedonic value only influenced adoption intention before actual use [27].

From another perspective, Rieder et al. demonstrated the contextual and transient nature of self-efficacy, thus advancing both self-efficacy theory and wearables research. Mihalicz emphasized the influence of emotions - anger, sadness, and happiness - on risk preferences [28]. This suggests that visceral stimuli can impact consumer choices in entertainment-based HCI features, which means functional features are also driven by both perceived utility and tangible benefits they provide.

When we investigate customers' preference for entertainment features, we find that it stems from some psychological factors. Based on Maslow's theory, older adults prioritize safety and physiological needs, explaining their preference for practical features. Younger individuals, in contrast, who seek esteem and self-actualization, may prefer entertainment-oriented features.

With respect to cognitive differences, Piaget's theory of cognitive development posits that as individuals age, their cognitive needs evolve. While children and teenagers seek experiential learning and play, adults prioritize logical thinking and problem-solving. According to Frerichs, behavioral economics, rooted in psychology, shows that cognitive biases can result in systematic deviations from rationality [29]. These biases, influenced by social and cultural factors, play a pivotal role in shaping consumer preferences.

Apiradee et al. highlighted the indistinct boundary between virtual and real encounters in mixed reality for strong emotional reactions [30]. These immersive HCI experiences can foster emotional responses, which can determine consumer preferences. Additionally, consumer choices can be impacted by recognized values, both intrinsic and extrinsic, of HCI features. Features that align with consumers' values, beliefs, and lifestyles are more likely to be preferred. Furthermore, a study reveals that pragmatic quality, hedonic quality-identification, and hedonic quality-stimulation are positively associated with attractiveness.

Ultimately, the preferences of consumers for HCI features in wearables are influenced by a complex interplay of rational and irrational factors, shaped by psychological, emotional, and social dynamics. Due to differing demands for wearable devices, there is often a debate between practicality and entertainment, particularly across various age groups and segmented consumer markets. In recent years, there has been increasing interest in the non-instrumental, hedonic quality of interactive products [31]. As wearables continue to advance, it is crucial for designers, marketers, and policymakers to comprehend these variances.

5 Metaverse: A New Frontier for Wearables

5.1 Review of Wearable Devices in the Metaverse

The Metaverse has gained considerable traction in recent years and converges virtual reality (VR), augmented reality (AR), and the broader digital ecosystem into a unified, immersive virtual universe. It promises to change the way we live by offering an alternative world where technology and virtual experiences blend with real life. As the digital realm continues to develop, wearable devices are taking the lead, acting as gateways to vast virtual worlds.

From VR headsets to haptic gloves, these devices are essential in providing a seamless and immersive experience within the Metaverse. Wearable devices enable users to navigate and interact with the digital environment and also enhance sensory experiences, bridging the gap between the virtual and the real world [32]. For example, the integration of deep learning techniques with wearable sensors has facilitated advanced human activity recognition, enhancing user interactions within the Metaverse.

The immersive nature of the Metaverse has far-reaching implications for consumer behavior. It provides users with both realistic and blended environments, where they can participate in social networking, collaboration, and personal discourse [33]. This has resulted in a change in consumer preferences, with an increasing desire for wearables that provide improved interactivity and immersion. Additionally, the potential of the Metaverse to alter human experiences, as explained by Henz, implies that its psychological effects will significantly influence consumer choices [34].

5.2 Metaverse Marketing

Wearables can seamlessly integrate the physical and digital realms and serve as the gateway to the Metaverse. According to Tsao, the pandemic has altered consumer behaviors and emphasized the significance of digital integration [35]. Wearables can improve user immersion by providing tactile feedback, health monitoring, and augmented reality overlays, making them essential for a comprehensive Metaverse experience. Muzayyanah et al. emphasize the importance of product attributes and consumer involvement in shaping purchase decisions [36]. Wearables in the Metaverse can be promoted as crucial extensions of one's digital identity, not solely as devices. The functional benefits of wearables, combined with their symbolic value, can cultivate stronger consumer engagement and loyalty. Firms can utilize advancements in human-computer interaction to segment the market and provide premium products to consumers who value superior interaction experiences [37]. In addition, the enhanced HCI functions found in wearables can result in increased consumer surplus, as individuals obtain greater utility from their devices. From the perspective of E-commerce companies, some firms have adopted artificial intelligence (AI) image recognition technology to analyze consumer facial expressions in order to increase sales [38].

While challenges and opportunities arise simultaneously, sellers must consider many issues. With the Metaverse consisting of various interconnected virtual worlds, standard protocols are needed to ensure seamless experiences. For example, wearables play a crucial role in establishing digital identities, so manufacturers must prioritize security and privacy. The Metaverse will definitely bring about new economic structures and business models, which implies that wearables must adjust and gain from these changes.

The Metaverse represents a paradigm shift in the way consumers interact with digital environments. It's imperative for wearable device manufacturers to understand these changes, adapt their marketing strategies, and position their products as essential tools for the Metaverse experience.

5.3 Future Work

We have argued that the metaverse will require researchers to rethink many of the fundamental ideas that have long guided our understanding of consumers in the physical world. In the following sections, we explore these issues and propose research directions associated with each (a summary of these directions is presented in Table 1).

Table 1. Future Work

CATEGORY	FUTURE DIRECTION	LITERATURE REFERENCE
Cybersecurity	With the integration of wearables in the Metaverse, there's a need for robust data privacy and security measures.	G. Kabanda, C. T. Chipfumbu, & T. Chingoriwo (2022)
Societal Impacts	Exploring the societal implications of individuals spending significant time in the Metaverse.	Henz, P. (2022)
Cultural Impacts	Understanding how the Metaverse, with the aid of wearables, might influence cultural norms, values, and global interactions.	Thierry Moulin et al. (2021)
Digital Identity	The role of wearables in establishing and maintaining digital identities in the Metaverse.	
Ethical Considerations	Addressing ethical concerns related to data collection, user consent, and potential misuse in the Metaverse.	

6 Conclusions

The Metaverse, with its vast and immersive environments, has profound implications for consumer behavior. As wearables sit at the intersection of the physical and digital, they are poised to become the quintessential gateway to the Metaverse. The pandemic has underscored the importance of digital integration, with wearables enhancing user immersion through tactile feedback, health monitoring, and augmented reality overlays. These devices are no longer mere gadgets, but essential extensions of one's digital identity. Their symbolic value, combined with their functional benefits, can drive greater consumer engagement and loyalty. As companies venture into the metaverse, there is an unprecedented opportunity to redefine consumer experiences and reshape marketing strategies. Wearables, with their advanced HCI capabilities, are not just devices, but critical tools that will shape the future of the Metaverse experience. As the boundaries between the physical and digital worlds continue to blur, the integration of artificial intelligence and wearables will play a pivotal role in shaping the future of human-computer interactions.

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References

1. He, S., Tung, W. F., & Lin, S. L. (2023). Analysis of User Experience of Hand Gestures for Interaction with Wearable Devices. International Journal of Human-Computer Interaction.
2. Yin, Ruiyang, et al. "Wearable sensors-enabled human–machine interaction systems: from design to application." Advanced Functional Materials 31.11 (2021): 2008936.
3. Mencarini, Eleonora, et al. "Designing wearable systems for sports: a review of trends and opportunities in human–computer interaction." IEEE Transactions on Human-Machine Systems 49.4 (2019): 314-325.
4. Rapp, Amon. "Wearable technologies as extensions: a postphenomenological framework and its design implications." Human–Computer Interaction 38.2 (2023): 79-117.
5. Lee, Victor R., and R. Benjamin Shapiro. "A broad view of wearables as learning technologies: Current and emerging applications." Learning in a Digital World: Perspective on Interactive Technologies for Formal and Informal Education (2019): 113-133.
6. Mills, K. A., & Brown, A. (2022). Immersive virtual reality (VR) for digital media making: transmediation is key. Learning, Media and Technology, 47(2), 179-200.
7. Chianella, Riccardo, et al. "Designing for self-awareness: evidence-based explorations of multimodal stress-tracking wearables." International Conference on Human-Computer Interaction. Cham: Springer International Publishing, 2021.
8. Lumsden, Joanna. Human computer interaction and innovation in handheld, mobile, and wearable technologies. Information Science Reference, 2011.
9. Cui, T. et al. (2023). Laser-Induced Graphene for Multifunctional and Intelligent Wearable Systems: For Health Care and Human–Computer Interaction.
10. Rieder, Annamina, et al. "Why users comply with Wearables: The role of contextual self-efficacy in behavioral change." International Journal of Human–Computer Interaction 37.3 (2021): 281-294.
11. Sakuma, Katsuyuki, et al. "Wearable nail deformation sensing for behavioral and biomechanical monitoring and human-computer interaction." Scientific reports 8.1 (2018): 18031.
12. Gonzalez-Romo, N. I., Mignucci-Jiménez, G., et al. (2023). Virtual neurosurgery anatomy laboratory: A collaborative and remote education experience in the metaverse.
13. Shen, Pengyi, Demin Wan, and Jinxiong Li. "How human–computer interaction perception affects consumer well-being in the context of online retail: from the perspective of autonomy." Nankai Business Review International 14.1 (2023): 102-127.
14. Said, G. R. E. (2023). Metaverse-Based Learning Opportunities and Challenges: A Phenomenological Metaverse Human–Computer Interaction Study.
15. Kraus, S. et al. (2023). Customer Service Combining Human Operators and Virtual Agents: A Call for Multidisciplinary AI Research.

16. Li, Yanmin, et al. "Artificial intelligence-based human–computer interaction technology applied in consumer behavior analysis and experiential education." Frontiers in Psychology 13 (2022): 784311.
17. Khada, N. (2023). Exploring The Techniques and Applications of Hand Gesture Recognition for Human-Computer Interaction.
18. Wang, S., Wang, X., et al. (2023). Optical-Nanofiber-Enabled Gesture-Recognition Wristband for Human–Machine Interaction with the Assistance of Machine Learning.
19. Finnegan, D.J., Zoumpoulaki, A., & Eslambolchilar, P. (2021). Does Mixed Reality Have a Cassandra Complex?
20. Janhonen, J. (2023). Wisdom of the Established Pattern.
21. Zhou, H. et al. (2023). Research Progress of Human–Computer Interaction Technology Based on Gesture Recognition.
22. Rhodes, C. et al. (2023). Towards Developing a Virtual Guitar Instructor through Biometrics Informed Human-Computer Interaction.
23. Ahn, H., Jeon, J., Ko, D., Gwak, J., & Jeon, M. (2023). Contactless Real-Time Eye Gaze-Mapping System Based on Simple Siamese Networks.
24. Morimoto, T. et al. (2022). XR (Extended Reality: Virtual Reality, Augmented Reality, Mixed Reality) Technology in Spine Medicine: Status Quo and Quo Vadis.
25. McCarthy, John, et al. "The experience of enchantment in human–computer interaction." Personal and ubiquitous computing 10 (2006): 369-378.
26. Diefenbach, Sarah, Nina Kolb, and Marc Hassenzahl. "The'hedonic'in human-computer interaction: history, contributions, and future research directions." Proceedings of the 2014 conference on Designing interactive systems. 2014.
27. Ma, Zhaoyi, Qin Gao, and Mei Yang. "Adoption of wearable devices by older people: Changes in use behaviors and user experiences." International Journal of Human–Computer Interaction 39.5 (2023): 964-987.
28. Mihalicz, M.G. (2021). Risk and emotion: measuring the effect of emotions and other visceral factors on decision making under risk.
29. Frerichs, S. (2018). What Is the 'Social' in Behavioural Economics? The Methodological Underpinnings of Governance by Nudges.
30. Wongkitrungrueng, Apiradee, and Lokweetpun Suprawan. "Metaverse Meets Branding: Examining Consumer Responses to Immersive Brand Experiences." International Journal of Human–Computer Interaction (2023): 1-20.
31. G. Kabanda, C. T. Chipfumbu, & T. Chingoriwo (2022). A Cybersecurity Model for a Roblox-based Metaverse Architecture Framework.
32. Shaik, J., & Syed, H. (2023). Deep SE-BiLSTM with IFPOA Fine-Tuning for Human Activity Recognition Using Mobile and Wearable Sensors.
33. Zhang, Z. et al. (2022). Artificial Intelligence-Enabled Sensing Technologies in the 5G/Internet of Things Era: From Virtual Reality/Augmented Reality to the Digital Twin.
34. Henz, P. (2022). The psychological impact of the Metaverse.
35. Wen-Chin Tsao (2023). A Discussion on Changes in Consumer Behaviors and Marketing Coping Strategies during the Pandemic Era.
36. M. Muzayyanah, A. Triatmojo, N. H. Qui (2023). Measuring Consumer Involvement and Product Attributes on Beef Consumer Segmentation.
37. Kozinets, R. (2022). Immersive netnography: a novel method for service experience research in virtual reality, augmented reality and metaverse contexts.
38. Tan, T. F. et al. (2022). Metaverse and Virtual Health Care in Ophthalmology: Opportunities and Challenges.