Spatial Experience for the Metaverse

Ville Paananen, Jonas Oppenlaender, Niels van Berkel, and Simo Hosio

1 Introduction

The proliferation of virtual content through the metaverse challenges our present understanding of spatial experience. Humans, in their complex embodied existence, are spatial creatures [12] and they take, share, and produce spaces, both physical and metaphysical. Spaces are an intrinsic part of humans, affecting language [63], power dynamics [67], rhythms [68], atmospheres [93], and aesthetics [69]. Additionally, the literature has developed notions of "space" and "place" to describe how humans form meanings with places [124]. To focus on the everyday experiences of the individuals, the concept of "human scale" is a helpful concept [34], referring to the idea that the built environment should be designed with the human body and its perceptual abilities in mind. This means that the physical characteristics of buildings, public spaces, and urban environments should be proportional to the scale of the human body and should encourage social interaction and comfort. Through these multiple viewpoints, our everyday spatial experiences present themselves as nuanced, holistic, and experientially rich. Introducing more complexity, the augmented, extended, and virtual content provided by the many visions of the metaverse introduces more interwoven layers into the everyday experience of space.

V. Paananen (✉) · J. Oppenlaender · S. Hosio
University of Oulu, Oulu, Finland
e-mail: villepaananen@outlook.com

J. Oppenlaender
e-mail: Jonas.Oppenlaender@oulu.fi

S. Hosio
e-mail: simo.hosio@oulu.fi

N. van Berkel
Aalborg University, Aalborg, Denmark
e-mail: nielsvanberkel@cs.aau.dk

P. Hui et al. (eds.), *Handbook of the Metaverse*,
https://doi.org/10.1007/978-3-032-03296-6_4

While the metaverse has gained great interest [66], its spatial dimensions have not been the focus as much as the technical or system-level approaches. As digital and physical spaces merge and overlap, understanding how humans make sense of space and how technology can be used to investigate it rises to great relevance. The well-known taxonomy of mixed reality by Milgram [80] can be used to explore how different modalities and virtualities lead to different spatial experiences. We see value in maintaining the relationship between the physical and virtual through the metaverse and enabling an exploration of the future possibilities for both through the overarching concept of the metaverse. We also suggest that the use of tools such as generative AI and experience sampling methods can support exploring both real and virtual futures.

In this chapter, we present our recent work concerning digitalized spatial experience. The presented studies cover a range of related aspects to support new ways to explore these human experiences in the future. We highlight how the latest generative AI technologies can be leveraged in conjunction with established methods, such as the Experience Sampling Method (ESM), to study the spatial experience of humans. Additionally, we propose future directions for researching in-metaverse experiences that consider the human scale and the everyday ways of experiencing spaces. This vision integrates physical and virtual spaces to build a more cohesive understanding of spatial experiences in the metaverse. Our contribution shows how diverse and personal spatial experiences can be fostered for designers to leverage virtual spaces for unique experiences beyond optimization.

2 Background and Motivation

As current technologies proliferate in our daily existence, our experience of spaces becomes increasingly blurred. And so, the study of spatial experience is a crucial aspect in shaping the development of the metaverse. The many visions of the metaverse enable users to interact with each other and the environment with realistic simulations. To create immersive experiences in the metaverse, it is crucial to understand how spaces are experienced, navigated, and used. The extensive existing research into principles of spatial experience can inform the design of virtual and augmented environments to be intuitive and engaging for users. Additionally, understanding the impact of individual and environmental factors on spatial experience can help make the metaverse more personalized and accessible for all users. In this way, the spatial experience in the real world has important implications for the future development of the metaverse.

2.1 Spatial Experience in the Real World

One of the most foundational writers on the way humans exist spatially is Martin Heidegger. In *Being and Time*, Heidegger describes how humans are situated in the world, and how engagement and context shape how we understand ourselves [42]. Later on, Heidegger emphasizes the role of dwelling as a fundamental way of being in the world [43]. Following Heidegger's work, Bollnow focuses on phenomenology to elucidate the nuanced ways in which humans understand, feel, and embody spaces [12].

The topic of spatial experience holds significance in numerous disciplines. The cognitive components of spatial experiences alone are important in fields such as psychology, geography, architecture, urban planning, linguistics, anthropology, biology, and computer science [81]. These various perspectives provide a comprehensive understanding of how people experience their surroundings. Factors such as a person's mood, cultural background, and physical abilities influence the spatial experience. At the same time, the environment also shapes the spatial experience. This interrelational quality of spatial experiences is one reason why they are difficult to understand comprehensively. Still, to enhance our understanding, different models have been created to demonstrate the impact of architecture on physical, mental, and sociocultural experiences [81].

While an exhaustive description of the current literature on human spatial experience is beyond this chapter, we highlight the complexity of spatial experience through different research efforts. Studies in psychology have revealed connections between spatial experience and the way the human brain processes information. It is widely recognized in psychology that humans have the ability to create internal mental maps of their surroundings, and recent research has uncovered additional information on the neural structure of these maps [36]. These findings emphasize the embodied nature of humans, which has growing significance in interactive systems [57]. In line with these perceptual systems and meaning-making, studies have found commonalities in human spatial experiences. For instance, taller buildings have been found to contribute negatively to psychological restoration [71], the geometrical features of spaces have been found to have an effect on human emotions [109], and even transparent glass—as mundane it is—is perceptually, behaviorally, and socially complex [76]. Further, in a smartphone-enabled study, home was found to correlate more with positive mood, and personality traits affect person's experience of spaces [104]. In the field of social neuroscience, Lederbogen et al. found that living in urban environments is a risk factor for social stress, which can be used to predict schizophrenia [65]. Applying the research from environmental psychology in urban design, Gehl focuses on the importance of movement, distance sensing, and vision in the perception of the urban environment [34]. The phenomenological approach of understanding how we perceive spaces has been found to be relevant for architectural design [92]. In the field of proxemics, the cultural aspects have been found to correlate with interpersonal distances and how humans use and take space [39]. Further, spaces can be understood as a structure for labor, power, or social meanings [67].

Then, enabled by computation and data, a research trend called *space syntax* [45, 46] has brought understanding what patterns, networks, visibilities, and distances are in the human configuration of spaces.

These examples reveal the scope of spatial experience: the experience of spaces is truly embodied, stemming from the human body through the perceptual system, motor abilities, and cognitive functions. As social beings, humans share spaces with each other, shaping how we use spaces and what meanings we assign to them. With the rise of computer systems, however, a need to be able to describe spaces in a machine-readable format has emerged.

Spatial Experience in HCI

The experience of space has been addressed in computing in many ways. Keeping in mind Heidegger's emphasis on context, a key work in ubiquitous computing highlighted how context has always been an important but too often overlooked aspect in software design [23]. Given how technologies that allow for applications to be built are constantly evolving, application use contexts change too. In the seminal papers on spaces and places in human-computer interaction (HCI) [40] and [27], the focus was brought to the understanding of humans' spatial dimensions and how the concepts of space and place can be used in design. Building on the works of Harrison and Dourish, Lentini and Descortis [70] developed five dimensions for understanding the experience of space: geographical, sensorial, cultural, personal, and relational. Through these dimensions, the richness of experiences in the urban environment is more readily understandable for developing ubiquitous computing systems. Similarly, proxemics, the study of interpersonal distances, was brought to HCI through the analysis of social and spatial contexts of technology [62] to highlight how modern technologies lack in terms of spatiality. In comparing HCI and architecture, Kirsh describes how the fields differ in understanding what interaction means and shows how HCI could serve well to employ more networked modes of interaction [58]. As such, the differences are fundamental: "*People don't read buildings the way they do HCI interfaces*" [58].

As technologies can now be built into our environments (e.g., public interactive touch screens [35]) or taken with us on the go (smartphones, augmented reality), new methods for understanding and digitizing also spatial understanding are being constantly investigated [9]. Location-based data mining from social media [22, 53, 54, 132] now allows for large-scale data analysis and crowdsourcing human experiences of places [18, 30, 51, 129] can further provide authentic experiences of spaces on the urban scale. Goncalves et al. explored how to build a collective subjective understanding of space using gamification and touch screens. In their work, people played a simple game on the screens to rank-order adjectives from the English dictionary to describe their immediate surroundings [35].

Following the rising popularity of spatial focus, the recently developed notion of Human-Building Interaction (HBI) aims to understand what challenges and opportunities are in the cross-section of architecture and HCI [2]. The limitations of traditional interaction patterns in terms of agency, intention, and control serve as a strong argument that we need to frame our thinking in a new way when thinking about spatiality in HCI. For example, proxemics has been suggested as an effective framework for describing how movements and orientations people have with devices can inform design [7]. Immersive technologies such as augmented and virtual reality open new opportunities to study spatiality in HCI. The immersive capabilities of VR enable users to experience different spaces, while AR augments everyday spaces with digital content. The recent focus on the metaverse brings places new needs on interactive systems to produce spatial experiences that are both coherent and meaningful.

2.2 *Toward a More Coherent Virtual Reality*

Moving our focus toward the metaverse, we can exemplify how the recent development in virtual reality (VR) has produced a pressing need for understanding its spatial qualities.

VR is perhaps the most obvious mode of interacting with the metaverse for humans. VR has potential beyond anything that has been possible earlier concerning transcending the bounds of physical reality [118]. Its focus in research and relevance for the metaverse points toward a trend with a profound impact on our future, revolutionizing also mission-critical industry operations, such as product development, factory design, and staff training [41, 95].

We can exemplify the spatial experiences in VR with *coherence*, a key factor in VR experiences. It refers to the degree that a virtual environment (VE) feels reasonable or predictable—the reasonable internal logic of the VE [113]. Coherence is a prerequisite for another key concept, Plausibility Illusion (PSI), i.e., the human sensation that the events unfolding in the environment are actually taking place. Poor coherence breaks PSI and deteriorates user experience, sometimes even causing stress and elevated heart rate in VR users [114]. Additionally, it has been suggested that presence and cybersickness have a negative correlation, although more evidence is needed to determine causation and the underlying mechanisms [127]. Minimizing these issues, and others such as nausea, headache, and disorientation—commonly referred to as cybersickness—is equally crucial for ensuring a seamless experience. While HMD development has decreased these issues as well as best practices for implementation [16], cybersickness is also dependent on individual differences, with e.g., gender [74]. While a thorough description of cybersickness and its impact on spatial experience in various VEs is outside of the scope of this paper, recent meta-reviews provide in-depth descriptions of these issues [16, 17].

As such, in VR research, coherence is a crucial concept. It refers to the consistency within the VE and how it aligns with users' expectations. The concepts of presence (also known as the place illusion) and plausibility illusion contribute to coherence. These concepts provide a way to evaluate the realism of VR applications. Place illusion refers to the feeling of actually being in the virtual environment, even when the user is aware they are not physically there. Plausibility illusion refers to the