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From Virtuality to Spatial Fusion: A Phenomenological Account of Vision Pro through Body Schema and Technological Mediation

Wu Jing

Faculty of Humanities and Arts, Macau University of Science and Technology, Macau, China
3230007343@student.must.edu.mo

Abstract: *Grounded in a phenomenologically oriented methodological stance, this study integrates body schema theory with postphenomenology's perspective on technological mediation to offer an interpretive analysis of the mode of spatial-computing presence manifested by Apple Vision Pro. By performing an epoché of established categories such as "virtual vs. real" and "digital twin vs. simulation," the research develops phenomenological descriptions and analyses of intentional structures around key interaction mechanisms, including gaze, gesture, spatial anchoring, occlusion, and perspective. Through imaginative variation, it further distills the stable elements of the device's experiential structure. The study argues that spatial computing does not generate a virtual space or a twin space; rather, it configures a condition of "spatial fusion" in which the digital and the physical can be freely superimposed. Within this condition, cyborg practice unfolds with the body as interface, while the body schema coordinates perception and action at a pre-reflective level. Digital technology, as an auxiliary presence for perception, co-constitutes with the body a new constitutive condition.*

Keywords: *Spatial Computing, Body Schema, Phenomenology, Cyborg, Vision Pro*

1. Introduction

In recent years, few wearable technologies have attracted as much attention as Apple's Vision Pro. Since Apple Vision Pro was first unveiled at WWDC 2023 (Apple Worldwide Developers Conference), the global VR industry has been abuzz, as if a genuine dawn of "virtual reality" had finally come into view. The device has been widely framed as an "epoch-making" product. Reports also suggest that it sold more than 200,000 units during the pre-order phase. Yet Apple has repeatedly insisted that Vision Pro is not "virtual reality," but spatial computing.

Apple argues that, just as the Mac ushered in the era of personal computing and the iPhone ushered in the era of mobile computing, Vision Pro will lead us into an era of spatial computing. The claim that a single wearable device can define a new era has prompted intense debate in both academia and industry. The iPhone's role in consolidating mobile computing is now difficult to dispute: a vast mobile application ecosystem developed in tandem with it. Many objects of sustained interest in communication studies—social media, digital news, and the like—can be understood as formations enabled by that ecosystem. In the face of the surging arrival of spatial computing, then, where should communication studies position itself, and from what standpoint should it begin to think?

Communication studies has long been guided by paradigms of rationalism, cognitivism, and computationalism. Even though Marshall McLuhan once struck a thunderous blow by warning us not to be distracted by the "juicy piece of meat" in the thief's hand, that is, media content, but to keep our eyes fixed on the thief, the medium itself, the field has nevertheless remained largely oriented toward explaining how media content reshapes people's short-term attitudes and behaviors. Yet this research tradition, which privileges ostensibly objective mechanisms while neglecting the organismic dimension of communication, appears to be gradually unsettled by the rise of mobile networks, virtual reality, and artificial intelligence. From different directions, these three technologies foreground the importance of the body across diverse domains of social life, such that "the body returns to the world of communication" [1]. The central claim of embodied cognition likewise lies in the body's constitutive role in human cognitive and intelligent activity, and an increasing number of communication scholars now treat the body as an indispensable perspective in communication research.

Against this backdrop, when Apple announces the arrival of an era of spatial computing, what kind of space does spatial computing cultivate? Is it a "twin space" akin to the metaverse, or an entirely new spatial form? How, then, does the body interact with such a form of space? Proceeding from the principle of "linking concrete causes to concrete effects rather than pursuing abstract universal laws" [2], this article brings together phenomenological perspectives and posthumanist thought to examine how spatial computing may produce a real space that is fundamentally different from the metaverse. It further asks how cyborg subjects enact practices with the body as interface within this space, and whether such practices might crystallize into a cyborg body schema. On this basis, the article looks ahead to how the entanglement of technology and the body may reconfigure the relationship between humans and the world.

2. Research Trajectory: a Phenomenologically Oriented Interpretation of Technological Experience

Methodologically, this article adopts a phenomenologically oriented path of interpretive analysis. The object of inquiry is not "Vision Pro's objective properties as a technology," but rather how it is experienced—through use and imagination—as a new mode of presence. More specifically, the analysis asks how a condition of "spatial fusion," in which the digital and the physical can be freely superimposed, comes to acquire its reality within a continuum of perception and action.

To avoid defining the object of study a priori through established technological classifications, the article begins by carrying out epoché in the phenomenological sense. That is, it temporarily refrains from making an ontological judgment about spatial computing, and instead returns to its experiential appearing, examining how it is given meaning within the life-world (Lebenswelt) [3].

In terms of theoretical resources, this article takes Merleau-Ponty's concept of the body schema as its central analytic lens. It understands the body as a situated mode of existence that is entangled with the world and "knows" space through practice. This makes it possible to address how, when interaction is organized as a "eye–hand–voice" mode of natural input, the body schema coordinates perception and movement at a pre-reflective level, and—together with technological mediation—co-constitutes new experiential structures [4].At the same time, drawing on postphenomenology's account of technological mediation, the article approaches Vision Pro as a mediating apparatus that redistributes attention, visibility, and operability. In this way, it argues that "the body as interface" is not a metaphor but a reconfiguration of relations at the level of experience [5].

With respect to materials and evidentiary support, this article draws on two kinds of textual materials as "experiential clues". The first consists of phenomenological descriptions and conceptual elaborations of key spatial-computing functions found in prior scholarship. The second comprises Apple's public statements that articulate spatial computing and the interaction mechanisms of Vision Pro. It should be noted that this study is theoretical and interpretive in nature. It does not presuppose participant interviews or experimental data; rather, it seeks to disclose the experiential structure of spatial computing by offering a phenomenologically inflected restatement of publicly available technical vocabularies and interaction mechanisms.

3. Spatial Computing: Becoming Reality Itself

Spatial computing has been brought to the center of the technological stage by Apple Vision Pro. Prior to this, the technological form that Vision Pro exemplifies was more commonly described as mixed reality (MR), augmented reality (AR), virtual reality (VR), or XR, an umbrella term encompassing VR, AR, and MR as varieties of immersive/extended reality. What, then, is spatial computing supposed to mean? After interviewing a number of leading figures in the tech industry, The Washington Post reported that "technology experts" have been unable to reach a unified definition of spatial computing [6]. My aim in tracing how "spatial computing" emerged as a technical term is not to enter the definitional dispute itself, but to clarify the technological telos and developmental trajectory implied by the term. In doing so, we may arrive at a clearer understanding of what Vision Pro's spatial computing signifies for us, and where it might be headed.

The term spatial computing first emerged in the field of geographic information systems (GIS). There it referred to techniques for computing and analyzing maps and other geolocation data in order to enable positioning, measurement, and related spatial operations. As a macroscopic phenomenon, geographic space spans temporal and spatial scales that exceed the range of immediate human intuition. Spatial computing addressed this limitation by using computational technologies to process large-scale geospatial information and then outputting representations and results that render such vast spatiotemporal scales tractable.

In the mid-1990s, T. Caelli and colleagues edited an edited volume titled Spatial Computing: Issues in Vision, Multimedia and Visualization Technologies. Rather than offering a strict definition of spatial computing, the collection foregrounded a set of core technical concerns, above all the question of how space might be visualized in richer and more automated ways. In this sense, spatial computing was, from the outset, oriented toward serving human spatial perception; yet its technical scope largely remained limited to the digital representation of physical space on a screen. If contemporary spatial computing were to stop at this point, it would echo a worry raised by Agnes Heller: that computer technologies tirelessly sublimate the representational world while discarding the bodily knowledge and cultural roots through which meaning is lived. Spatial computing's development, however, goes far beyond this.

Computation's denial of physicality has gone about as far as it can; it is time for a reclamation of space as a computational medium [7]. In his MIT master's thesis, Greenwold sets out this ambition and argues that it is more feasible than constructing a purely virtual space. A computational system grounded in real space, he suggests, need not build an exhaustive model of the world in order to function, whereas a fully virtual environment would require comprehensive modeling without omission[7]. On this basis, he defines spatial computing as "Spatial computing is human interaction with a machine in which the machine retains and manipulates referents to real objects and spaces" [7]. In the ideal case, these real objects and spaces carry prior significance for the user.

For example, Greenwold notes that a system "that allows a user to create virtual forms and install them into the actual space surrounding him" counts as spatial computing; so does a system "that allows a user to place objects from his environment into a machine for digitization" [7]. He further distinguishes spatial computing from adjacent domains such as 3D modeling and digital design by insisting that the forms and spaces it works with must be pre-existing and carry real-world valence. On this view, it is "not enough that the screen be used to represent a virtual space—it must be meaningfully related to an actual place" [7].

In this sense, spatial computing is less a single technology than a technological spectrum that brings together XR (VR/AR/MR), 3D graphics and modeling, computer vision, the Internet of Things, sensing and embodied interaction, and, increasingly, AIGC. It has thus been described as a broad concept that connects digital reality and physical reality within the actual world [8].

Accordingly, spatial computing is not aimed at creating a digital twin space that runs parallel to the real world (as in many metaverse imaginaries). Rather, it emphasizes the fusion of digital technologies with the physical environment in order to intensify, and extend, human experience of real space. A "twin space" refers to mapping the elements, relations, processes, and patterns of a natural (physical) space into a virtual environment, thereby constructing a digital domain capable of simulating, emulating, reconstructing, regulating, and optimizing the natural space through forms of intelligent contro[l] [9]. By contrast, spatial computing seeks to forge a tight linkage between space in the computer (digitally represented space) and the computer in space (as a physical presence situated in the environment).This conception does not treat information and materiality as two fully segregated and independent modes of being, nor does it confer upon information an inherently superior position—more perfect, freer, or richer—than the material world. Put differently, spatial computing is not about producing a flawless imitation of reality, nor about fabricating a mere "sense of reality." It aims, instead, to become reality itself. When three-dimensional space connects to a four-dimensional "bubble" in Liu Cixin's The Three-Body Problem, we do not agonize over which is real, because both are real in their own right. In this respect, the vision of spatial computing resonates with Agnes Heller's posthuman ideal: a posthuman in another form, one that seeks to realize the potential of information technologies without fantasizing about unlimited power or disembodied eternity, and that affirms—and even celebrates—finitude as a human condition, with human life rooted in a complex and heterogeneous material world [10].

4. Body Schema: a Situated Mode of Existence

"As inhabitants of a physical world, prolonged familiarity makes its properties seem self-evident to us." We participate in this world in ways that allow us to anticipate its regularities—for instance, where an object will fall, how a familiar shape will appear from another angle, or how much force is needed to push an object against friction. Yet, as Ivan Sutherland observes, we lack comparable familiarity with phenomena that lie beyond everyday bodily attunement, such as "the forces on charged particles," forces in non-uniform fields, the effects of nonprojective geometric transformations, and motions with high inertia and low friction. A display connected to a digital computer, he argues, offers an opportunity to become familiar with concepts that cannot be realized in the physical world; it is, in his well-known phrase, "a looking glass into a mathematical wonderland" [11]. As the first person to build a head-mounted display, Sutherland, in that now-classic lecture, looked ahead to what he called the "ultimate display." Although he could not yet specify the form such an ultimate display would take, he foregrounded, from the outset, the indispensability of embodied perception. Humans perceive and anticipate the world through direct participation in the physical environment. At the same time, he envisioned the possibility that humans might enter a reality of higher dimensionality: a new physical world made possible by digital technologies, one in which the human body could not be absent.

"I am my body. The body is a living body that exists-in-the-world; it is a holistic existence in which the parts of the body mutually implicate one another. It is intimately fused with things through action and practice. Therefore, the body is also body schema: bodily existence is a situated mode of existence" [12]. Merleau-Ponty's thought not only grants the body a remarkably central status; it also lays bare the body–space relation. The body's interior is holistic: my perception of the body's parts is given as a whole, and the body's actions are, in an equally holistic way, tightly interwoven with the world. For this reason, he describes the body in terms of a body schema, underscoring its intimate linkage to the practical field of action and perception [4].It is worth noting that the term also has an earlier neurophysiological lineage. The neurologist Henry Head, in his work with Gordon Holmes, proposed the idea of a postural schema: a largely non-conscious, dynamically updated organization of posture and movement that enables orientation and coordinated action [13]. In this sense, the body "makes perception possible" in multiple ways while also constraining our intentional perception and action. For example, when we pick up a cup to drink water, the shape of the grasping hand forms automatically. When we step over a puddle, we do not need to measure its diameter with a ruler; we spontaneously adjust the length of the stride. All such bodily comportments operate independently of reflective consciousness.

The body schema's non-conscious, environmentally adaptive, and action-regulating a priori character is precisely what makes the body irreducible to machine replacement. Hoffmann and colleagues' analysis of robotic body schema points out that, in robotics, we have to a large extent neglected the phenomenologically reflective dimension of body representation and instead concentrated on relatively low-level, pre-reflective computational mechanisms—such as plasticity in body modeling and coordinate transformations. In contrast to body schema, body representations in robots tend to be fixed, explicit, precise, centralized, and objectifying, and these traits constrain robotic deployment, leaving robots able to operate only in highly limited, tightly controlled environments [14]. As of today, no robot can move with the same ease as a human being and fully merge into the world it inhabits. A fundamental reason lies in the absence (or incompleteness) of a genuinely body-schematic organization in robots. If the body is taken as the ground of existence, then what new possibilities might this open up?

In 1985, Haraway published her influential "Cyborg Manifesto," in which she defines the cyborg as a hybrid of machine and organism—for example, bodies fitted with dentures, prosthetic limbs, or pacemakers[15]. Such bodies blur the boundaries between human and animal, organism and machine, and material and immaterial [12]. Haraway opposes the liberal humanist conception of the subject that treats the body as a "fashion accessory" of the mind; instead, she insists that human beings must remain rooted in the body in order to act and to live [15]. In this respect her position resonates with phenomenology. For Merleau-Ponty, the body is neither a mechanical apparatus nor merely flesh; it is a situated mode of existence that co-emerges and interweaves with the world. Accordingly, changes in the body's spatial situation call forth corresponding bodily adjustments. The body schema, too, is reorganized and renewed through the acquisition of new habits, re-coordinating with and becoming integrated into new situations.

5. Vision Pro and the Body Schema: Cyborg Embodied Practice

The core competitiveness of Vision Pro lies in its mode of human–computer interaction realized through spatial computing. Once users put on Vision Pro, they enter a real space in which digital techniques and physical presence are fused. Within this space, users can move freely and act autonomously; through iris recognition, eye tracking, gesture control, and generative techniques that rework the perceptual field, spatial interaction is produced with the body as its medium. As Emmanuel

Alloa puts it, “the body, as medium, is both the center of the world and the bearer of its appearing” [16].

How, then, does the cyborg enact practice within the situation configured by spatial computing? In what ways does the functioning of the body schema shape this embodied practice? And how does spatial computing, by recruiting the schematic capacities of the body, bring forth a new constitutive condition? The analysis that follows addresses these questions by bringing Vision Pro’s interaction mechanisms into dialogue with the operative functions of the body schema.

The body-schema system has three primary functions. First, it processes information about posture and movement, information that is continuously supplied by a wide range of inputs, including proprioception. Second, the body schema is characterized by motor-neural activity, motor habits, or motor patterns, which may be innate or acquired through learning. Third, through interactions among modules, the body schema enables communication between proprioception and other forms of perception [17].

Since the release of Vision Pro, the most widely discussed aspect has been its interaction modality centered on gesture control, eye tracking, and voice input. Here, “the medium becomes part of the human body. … The basic meaning of the interactive interface changes, shifting from an interface as a tool to an interface as a skin or biomembrane—namely, an organic user interface” [18]. For example, the action of opening an app by coordinating eye movement with a hand gesture is almost identical to the postures and movements we employ in physical space. When we reach to grasp an object, our eyes naturally orient toward it and the hand extends to carry out the action; the same is true when an infant reaches for an object. This action sequence is pre-conscious (or pre-reflective): it does not require us to activate reflective awareness to instruct the body what to do. Rather, the body moves in accordance with the situation. Here the body schema is at work, processing proprioceptive and motor information. In a similar way, when we intend to open an app in Vision Pro, our gaze naturally falls on the icon. The icon immediately “lifts” from the background, and the index finger and thumb form a pinch gesture; the app then opens. At this moment, proprioception (for instance, the felt orientation of the eyes toward the app) participates in bodily movements that proceed without being thematized by consciousness. This kind of spatial interaction—unfolding without the aid of any additional tool or intermediary—allows the body to appear in space as natural, unstrained, and agentic.

When you open a video in Vision Pro’s Photos app, you may find that you can see different angles of the scene by shifting your gaze and moving your body, almost as if you were inside the video. We often call this state “immersion.” But what, exactly, counts as immersion, and how is it achieved? The metaverse, VR, AR, 3D imaging—virtually every technical route in this family claims to pursue it. Which route, then, is more likely to deliver immersion?

If we simply turn our heads and look at the real world in which we are constantly immersed, an answer is already at hand: immersion, at its core, involves a forgetting of bodily existence. When we walk, for example, we do not experience ourselves as needing to command the body to walk. We simply step forward; modules of gravity-sense, gait, and speed interact automatically, and each step is, in this sense, immersive. As key functions of the body schema, proprioception, motor perception, and modular interaction help consciousness, to some extent, to detach from direct attention to the body, thereby allowing us to be absorbed into a situation. The distinctive immersive quality of video viewing on Vision Pro lies precisely in how effectively it recruits these capacities of the body schema.

Vision is an extension of the body: when visual conditions shift, we automatically adjust posture in pursuit of the clearest possible view. Visual information and bodily movement mutually regulate one another without the need for reflective prompting, enabling us to forget the body’s presence. This is akin to the way an experienced driver takes the automobile as an extension of the body, scarcely needing to deliberate about the car’s motion. When we watch a video on Vision Pro and adjust our bodily orientation, the viewing angle within the video-world changes accordingly. The experience resembles driving: as the car moves, the scenery framed by the windshield shifts in tandem. Through the operation of the body schema, the body and the surrounding situation become mutually interwoven, producing immersion.

In Vision Pro’s guided introduction video, several scenes are presented. A butterfly flutters through the air; when you extend your hand, it comes to rest on your palm. In an online meeting, other participants appear within your surrounding space. You can show them your presentation slides while interacting with them at the same time, and you are free to move your body; all participants orient toward the same displayed content in the same direction as you do.With the development of digital technologies, many of the barriers to multi-space interaction have long been broken down. We can casually initiate a WeChat video call and thereby establish a linkage between distant locations. Yet we

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never take the other person to be beside us, because we are not truly "together".

In embodied perception, the background plays a decisive role: an indeterminate background is a condition of possibility for bodily perception. As Dreyfus puts it, "There is a basic figure–ground phenomenon, which is essential to any perception: whatever is prominent in our experience and engages our attention appears against some more or less indeterminate background. This background never needs to be made determinate, yet it lets the determinate thing show up as unified and bounded, and it thereby affects how that determinate thing appears" [19].

This is precisely why the butterfly in Vision Pro can feel so real when it comes to rest on our palm: we find ourselves co-present within an indeterminate, shared background that reawakens bodily perception. As Merleau-Ponty emphasizes, "It is the very definition of the phenomenon of perception… The perceptual 'something' is always in the midst of other things; it is always part of a field" [4].

The holistic and situational character of perception is rooted in the body schema, because bodily existence itself is holistic and situational. Spatial "situatedness" is the unfolding of our embodied being-in-the-world: the butterfly and I, and likewise I and other meeting participants, belong to a newly configured constitutive condition within which perception and action are reorganized and coordinated.

6. Conclusion

Spatial computing does not aspire, as metaverse imaginaries often do, to create a "twin universe" projected from the real world. Rather, it seeks to configure a new world in which the physical and the digital can be freely superimposed—a mode of existence that is real in its own right. Within this world, the physical environment remains the ground of all existence. The body schema can operate with ease, while information technologies function as an auxiliary to embodied perception rather than a substitute for it.

One Vision Pro user offers an evocative imagination: one day, I will share a drink with a friend who lives thousands of miles away through Vision Pro; they will be right beside me, and we will drink and talk together—and all of it will be real. This is indeed worth anticipating. Instead of moving into a virtual world in order to approach the real, why not live directly in the real?

Rationalism and empiricism share a preference for a "pure" mind and a corresponding prejudice against the body. On this view, the body is treated like any other object, defined by extension and composed of organs that merely lie side by side in space. Human cognition and intelligent activity can therefore be explained entirely as cerebral processes realized in the brain, which can in turn be translated into computer programs and simulated by machines. This is precisely the intellectual provenance of the liberal humanist conception of the subject.

In the novel Neuromancer, the posthuman body is described as "a body made of data." William Gibson offers a vivid formulation of this idea: "The posthuman constructs concrete form (the body) as a material proof of thought or information; this is an inheritance of the liberal tradition rather than its abandonment" (Heller, 2017).

Phenomenology reminds us that the body is not a mechanical assemblage of organs. It is the ground of perception and the very basis of human existence. As Ouyang puts it, "By assimilating the world through the body and its senses, we can transform what is unfamiliar, heterogeneous, and invisible into what is sensuous, visible, and intelligible. In this way, a bridge of communication is built between human beings and the world, creating relations and meaning" [10].Yet the development of modern technology often seems to exceed our control. With an involuntary, fearful kind of exhilaration, human beings wait for the body to be cast aside.

Spatial computing may open up another possibility. Rather than presuming the mind to be superior to the body, it continues to take the body as ground, enabling free interaction among human beings, the physical world, and the digital world through computational technologies. In this way, human perception can be extended into a broader range of perceptual activity. Can we regard this as an opportunity to deconstruct the liberal humanist subject? Perhaps it allows us to cultivate a more genuine sense of anticipation for a posthuman era.

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