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The Imitation, Surpassing, and Challenge of Artificial Perception to Natural Perception

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ABSTRACT
Perception, as the most fundamental process in cognition, serves as the foundation for human understanding and cognition of the external world and the self. In recent years, emerging artificial perception technologies have surpassed human sensory limitations, expanding human cognition of the world and the self. This transition from natural perception to artificial perception poses new challenges to human cognition. Artificial perception technology not only mimics human sensory capabilities but also transcends traditional modes of perception, possessing distinct characteristics from natural senses. By integrating artificial technology with human brain interaction, artificial perception creates a novel form of human perception. However, a unilateral enhancement of human perception through artificial means may not necessarily achieve cognitive enhancement; instead, it may disrupt and interfere with innate human natural perception and existing logical reasoning.

KEYWORDS
Natural perception; Artificial perception; Brain-computer interface

Natural perception has inherent limitations and constraints in the construction of human cognition due to the constraints of human physiological structure and sensory organs. The information perceived through natural perception needs to be processed and interpreted by the brain to form a complete cognitive process. Artificial perception, on the other hand, represents a new form of human sensory capability constructed through technological means. It not only compensates for the inherent limitations of natural perception but also enhances or alters human sensory capabilities. As a product of the convergence of nanotechnology, electronics, and computer science, artificial perception has evolved from imitating biological senses to its current state, exhibiting functionality comparable to or even more powerful than biological senses. The emergence and development of artificial perception technologies challenge traditional philosophical understandings of perception, prompting us to reexamine questions about how the perceptual subject constructs perceptual and cognitive experiences through sensory activities.

1 Imitation of Natural Perception by Artificial Perception

Perception serves as the foundation for human cognition and self-understanding. For a significant portion of human history, perception referred exclusively to the process through which humans utilized their innate sensory systems to comprehend and interpret the surrounding world. We gather and process external stimuli through our sensory systems, including vision, audition, somatosensation, gustation, and olfaction. These inherent sensory systems transform stimuli into neural signals, which are then conveyed through the nervous system to undergo processing and interpretation in the brain.

Through this natural perception, we gain insights into various aspects of ourselves, including our bodies, emotions, and cognitive abilities. This information aids us in determining our self-identity, self-capabilities, and other self-related cognitions. We use bodily sensations to understand our physical states, emotional experiences to grasp our emotional conditions, and cognitive perceptions to comprehend our cognitive processes and abilities. It can be argued that this highly adaptive and flexible form of natural perception serves as the foundational basis for human cognition.

It's worth noting that natural perception has certain limitations and constraints when it comes to the construction of human self-awareness. These limitations stem from the physiological structure of humans and the constraints imposed by sensory organs. Moreover, the information perceived through natural perception still requires cognitive processing and interpretation by the brain to form a complete cognitive process. As a result, both our perception and self-awareness need to be enhanced and deepened through various means, including rational thinking and scientific research.

To overcome the limitations of natural perception and to enhance or alter human perceptual capabilities, artificial perceptual technologies, which aim to mimic the abilities of natural perception, have emerged.

Artificial perception is a novel form of human perceptual capability constructed through technological means. It differs from traditional sensory extensions and purely machine-based perception. This mode of perception is achieved through various technological tools such as sensors, computer vision, speech recognition, biometric identification, and more. It can be used to assist individuals with sensory impairments, enhance perception in healthy individuals, and even support the pursuit of "superhuman" or "beyond-biological" "hyper-perception" abilities. Artificial perception can be categorized into two broad types: broad artificial perception and narrow artificial perception. Broad artificial perception includes sensory extension technologies like telescopes and microscopes, which have artificial perceptual components but still rely on the human sensory organs to form perception. These are considered "extended perception" rather than strict artificial perception. In contrast, narrow artificial perception involves perception formed through modern technologies like brain-computer interfaces. This type of perception can bypass the sensory channels of the biological body. For instance, cochlear implants, a form of narrow artificial perception, convert sound vibrations into electrical signals and stimulate the auditory nerve, thus enabling artificial hearing without reliance on the natural auditory system. This artificial perception is generated within artificial systems and eventually results in perceptual experiences in the human brain. Artificial perception can be further categorized into two different types: one that aids, repairs, replaces, or enhances human perception and ultimately forms perception in the human brain, and the other that entirely occurs within machines and doesn't involve human sensory participation. This paper primarily discusses the former, often referred to as "narrow artificial perception." It is the result of collaboration between the biological body and artificial technologies, including artificial intelligence. In contrast, pure machine perception solely involves internal information processing within computers and doesn't encompass true "perception" capabilities.

Compared to natural perception, artificial perception is a form of simulation of natural perception achieved through technological means, such as computers and sensors. The technical methods of artificial perception are often based on research into natural perception, particularly the study of sensory organs. While both artificial and natural perception involve the collection and processing of information from the external environment, artificial perception technology addresses the limitations of human natural perception. It provides additional sources of perception and sensory information, thereby expanding human cognition of the self and the world. For example, Brain-Computer Interfaces (BCI) are devices that extend human cognitive processes, and functional integrated BCIs are considered an extension of cognitive systems. (Fenton, Andrew, et al., 2008) Artificial perception also creates a new form of the connection between knowledge and action. It doesn't require bodily or muscle movements, which is different from the traditional knowledge-action linkage based on the physical body and natural perception. Scholars like Steffen Steinert argue that this is a shift from "doing things with hands" (performing actions physically) or "doing things with words" (instructing others or machines) to "doing things with thoughts."

Research in artificial perception spans across various disciplines, including human-computer interaction, machine learning, neuroscience, and cognitive psychology. BCI technology serves as a primary means of achieving artificial perception. This technology, which emerged in the 1970s, has rapidly advanced with the deepening understanding of the nervous system and computer technology. The first international BCI conference defined BCI as "a communication system that does not depend on the normal output pathways of peripheral nerves and muscles" (Wolpaw, Birbaumer, 2000). This means that external stimulus signals, using artificial technology, bypass natural sensory organs and directly influence the brain to form perception. In recent years, extended perception BCI technologies have been put into use. For instance, they can convert infrared and ultrasonic signals into electrical stimuli, allowing us to "see" infrared radiation and "hear" ultrasound. This enables the human brain to process a broader range of sensory signals, not limited to those obtained through evolution.

Sensors, as a key technology for realizing artificial perception, are typically used to detect and collect information from the external environment. Examples of sensor systems include cameras, radar, and lidar used in autonomous driving. When sensors are applied to the human subject and associated or integrated with BCI, they become a part of artificial perception systems. In other words, artificial perception is built upon sensor technology. Sensors convert detected sensory data into human perceptual information, such as converting visual data into human visual information or soundwave data into human auditory information.

The revolution in sensor technology is bound to bring new breakthroughs to artificial perception. Some technologically advanced countries consider it a top priority, even as a pioneering technology that can revolutionize humanity in the future. Scientists have already developed various artificial sensors. These sensors work by simulating the functioning principles of biological sensory receptors through the creation of materials that respond to stimuli or the construction of biomimetic structures. Research in this field spans multiple disciplines, including optics, mechanics, and chemistry. These artificial sensory technologies can convert various types of stimuli into signals, including electrical, optical, or magnetic signals, thereby performing the functions of stimulus perception and signal transmission, similar to the process of stimulus transduction within living organisms. In the biological sensory pathway, signals are first collected and filtered from various sources by peripheral systems, and then transmitted to the central nervous system for perceptual signal processing. Peripheral afferent neurons, which transmit information from the periphery to the central nervous system, are a crucial link connecting widely distributed receptor networks and the central nervous system.[1]

When artificial sensory devices become new human senses, often referred to as "sensory prosthetics," they include devices such as artificial cochlear implants and retinal implant devices. Through this technology, people can not only regain basic sensory information acquisition abilities, but also expand the domains of perception that were previously intact in unprecedented ways. Nowadays, well-known companies such as MindMaze, Neurable, Neuralink, and Kernel Co have received significant funding for the development of artificial sensory projects. The mainstream

1 For a detailed discussion on this topic, please refer to: Kim, Y., Chortos, 'A. et al. A Bioinspired Flexible Organic Artificial Afferent Nerve'. *Science*,2018:998–1003.

commercial application directions are in the fields of healthcare and virtual reality. For example, the semi-charitable project BrainRobotics by a Harvard research team aims to develop intelligent prostheses for people with disabilities. These prostheses stand out in that they can directly convert the user's intentions into limb movements by reading the user's brainwave signals. This enables individuals with disabilities to independently perform many actions without relying on traditional limb functionality. They can control these functional products simply by using their brain's intentions. The development of this technology holds significant potential for improving the quality of life and independence of individuals with disabilities.

In the realm of artificial sensory perception, there is a category known as "sensory substitution technologies." One company, BrainPort, has developed an artificial sensory device that uses touch to substitute for vision. Blind users can stimulate areas on their tongues to achieve a form of "seeing" based on what the device's camera "sees." When blind individuals use this artificial sensory device, a tiny camera placed in their mouths captures signals, which are then converted into various small stimulations on the tongue. These stimulations create a perception of the surrounding environment. Through learning and practice, blind users can ultimately transmit these different signals from the touch area in their brains to the visual cortex. While this alternative form of artificial vision does not fully restore sight to blind individuals, it has already provided them with increased freedom of movement and interaction with their surroundings.

Currently, natural perception still possesses advantages that artificial perception cannot match. Firstly, natural perception exhibits a high degree of adaptability and flexibility, capable of adjusting and adapting to changes in the environment and different stimuli. Artificial perception, on the other hand, requires pre-programming or training to recognize and process various types of information. Its development relies on ongoing optimization and updates to algorithms and models. The computational power of human-made computers still struggles to reach the level of natural perception, which is based on millions of years of evolution and encompasses multi-sensory fusion, perceptual plasticity, and subconscious information processing. Moreover, natural perception exhibits a high degree of integration, where different sensory organs can communicate and collaborate. Natural perception is a coherent experience of integrating various sensory information, with different sensory organs complementing each other to enhance our overall perception of the world. Artificial perception often relies on data fusion and similar techniques to integrate information from different sensors. The complexity, sensitivity, and accuracy of natural perception are challenging to simulate using computers. Therefore, the current methods of information integration in artificial perception are unable to match the real-time, highly integrated experience of natural perception.

2 Transcendence of Artificial Perception over Natural Perception

While both artificial perception and natural perception involve the collection and processing of information from the external environment, artificial perception technologies excel in compensating for the limitations of human natural perception. They offer a broader range of sensory inputs and sensory information, thereby expanding human cognition of both the self and the surrounding world.

Despite the long evolutionary history of humanity, our biological senses still exhibit many limitations. For instance, human eyes can only perceive light within a wavelength range of 380 to 760 nanometers, and human ears can only capture sounds within a frequency range of 20 to 20,000 Hertz. Similarly, olfaction, taste, and touch have their own detection thresholds. Artificial perception technologies, based on the simulation of sensory perception, integrate advanced sensing technologies, signal transmission, big data, and intelligent algorithms to enhance the capabilities of artificial senses. Artificial perception expands the detection range and limits of these artificial senses. For instance, research teams have developed various types of artificial sensors to detect ultraviolet, infrared, and other forms of light, thus extending the detection range beyond that of the human eye (Yokota, Fukuda, et al., 2021).

Attempts to enhance human abilities can be traced back to various periods in human history. These enhancements involve extending human capabilities through various physical means. Contemporary technological innovations have made a wider array of human enhancements possible, such as expanding our senses through sensory technologies (e.g., night vision goggles), improving physical abilities through hardware (e. g., exoskeletons), or enhancing cognitive capabilities through human-computer "closed-loop" systems, which is characteristic of the field of cognitive enhancement. Cabrera (L. Y. Cabrera) defines human enhancement as: "Any intervention designed to improve one or more core capacities of an individual to overcome the limitations inherent to the human condition, including but not limited to, medical interventions, is a human enhancement within the paradigm of post-humanism" (Cabrera, 2015). Artificial perception is one of the means of enhancing human capabilities that aims to "overcome the limitations inherent to the human condition," enabling human subjects to transcend the biological species-typical framework and further become "posthuman" or "transhuman."

As a form of cognitive enhancement technology, the author believes that there are currently two types of artificial perception technologies, which can be termed "qualitative enhancement artificial perception" and "quantitative enhancement artificial perception" based on the ultimate enhancement effects achieved.

Quantitative enhancement artificial perception technologies can be traced back throughout the history of traditional science and technology. Broadly speaking, any human-made object that can enhance human "performance" has a cognitive enhancement effect: the appearance of telescopes extends human vision, loudspeakers enhance the frequency and amplitude of human sound, books and electronic recording devices expand human cognitive capacity in terms of memory, mathematics and logic strengthen thinking abilities. However, through these technologies, what humans gain is "quantitative enhancement" of perception: without telescopes and loudspeakers, humans can still see things and hear sounds, and without books and recording devices, humans can remember a certain amount of experiential content using their brains. We cannot deny the convenience that such technologies provide to human society and the improvement of human self-awareness, but these quantitative enhancement technologies do not change our natural physical attributes, and thus, they do not alter the concepts organisms can obtain about the world.

However, qualitative enhancement artificial perception is different. It is a new phenomenon that emerged in the era of artificial intelligence after the computer revolution. For example, artificial perception technologies can convert infrared and ultrasonic signals into electrical signals, allowing humans to "see" infrared waves and "hear" ultrasonic waves. As a result, the human brain can process a broader range of cognitive signals. In a very short period of time, humans gain abilities that might have taken a long time through natural evolution or could never have been obtained. If quantitative enhancement technologies can be described as "we invented things that make us smarter," then qualitative enhancement technologies can be seen as "we invented things that change our nature." Through qualitative enhancement artificial perception, the human subject can perceive the external world more comprehensively and extensively, further exploring, receiving, and deciphering information in the environment. By using advanced artificial perception devices, the human subject can delve deeper into the context they are in, analyze contextual data, or monitor their physiological state in real-time. This optimizes response time and improves judgment and behavior in real-life situations. For example, brain-computer interface technologies used for artificial vision will eventually allow the human subject to perceive light beyond the natural perceptual spectrum, including ultraviolet, infrared, and even magnetic fields (Hansson, 2015).

Currently, despite certain technological limitations in the breadth of perception, contemporary cognitive technologies have significantly improved the depth of individual perception. By utilizing increasingly miniaturized and precise sensors, these sensors can be seen as limitless extensions of perceptual antennae. Artificial perception technology devices can capture extremely subtle perceptual information well within the range of human perception, and transmit this information to the human sensory organs by amplifying the signals. Moreover, current artificial perception device technologies not only expand the subject's visual and auditory spatial perceptions but also enable multi-sensory spatial perceptions, including the extension of various sensory channels such as touch, kinesthesia, olfaction, and taste. To some extent, these technologies have already facilitated the interaction and integration between multiple sensory channels, thereby providing a richer and more comprehensive perceptual experience.

3 Challenges of Artificial Perception to Natural Perception

The development of artificial perception technology challenges traditional understandings of natural perception. On one hand, both natural perception and artificial perception can be seen as forms of perceptual experience. Therefore, the emergence of this new technology prompts us to reexamine questions about how the perceiving subject constructs perceptual experiences through perceptual activities. On the other hand, artificial perception raises a series of epistemological questions about perception. In delving into these issues, we can gain a better understanding of the nature of perceptual experience and how we interact with the external world. It allows us to reconsider the essence of perception and the definition of the perceiving subject, while also providing guidance for the development and application of artificial perception technology.

The first challenge posed by artificial perception to natural perception is the issue of the unity of the experiencing subject. The construction of perceptual experiences involves the complex interaction between the subject, the external environment, and the nervous system. Human perceptual experiences can be seen as a continuous process of interaction with the external environment, where information is received, and responses are generated. The unity of the experiencing subject ensures the continuity and stability of this process; otherwise, a person's perceptual experiences would be a mere collection of unrelated experiential elements. Human cognitive processes involve more than a simple superposition of individual sensory inputs; they entail the interaction of multiple sensory inputs that collectively form a more comprehensive, integrated, and unified cognitive experience.

Artificial perception challenges the unity of the experiencing subject by introducing a new way of constructing perceptual experiences. It no longer relies on the natural sensory organs but introduces novel sensory stimuli as "new organs" that supplement human cognitive processes. The concept of "Extended Cognition" in the 4E cognitive theory suggests that human cognition can be extended through tools and technology, enhancing the cognitive abilities of the subject. In this view, the cognitive process can transcend the boundaries of the skull and skin, with a part of the world being considered as part of the cognitive process. Once we acknowledge that artificial perception can be seen as a form of extended cognition, it raises questions about whether the artificial perception devices used in cognitive activities constitute a part of the experiencing subject and whether they disrupt the unity of the experiencing subject. Artificial perception technology indeed provides individuals with additional means and pathways for self-awareness, allowing them to gain deeper insights into their bodies, behaviors, emotions, and more. However, what happens to a person's self-awareness when previously imperceptible information and phenomena become perceivable and understandable through artificial perception? As mentioned earlier, artificial perception creates a new form of the subject's knowledge-action relationship, and the application of this "thinking to act" artificial perception technology may lead users to question their own subjectivity: Are they the true agents of action? Research has shown that "if they do not have the feeling of being an agent, they may not attribute the motor actions mediated by the brain-computer interface to themselves. This can result in a lack of a sense of agency and categorizing the events mediated by the brain-computer interface as events not under their control, even though they have initiated or controlled the events. At this point, they do not consider themselves as the agents." (Steinert, Bublitz, et al, 2018)

The second challenge posed by artificial perception relates to the issue of the quality of perceptual experiences in comparison to natural perception. Qualia are often used to describe the subjectivity or qualitative properties of experiences. In the philosophical literature, these unique experiential qualities are often described as "what it is like to be a bat," referring to the experiences of a bat. Traditional philosophy of mind suggests that qualia are aspects of experience that cannot be readily explained or reduced to physical processes or materialism. These experiences with distinctive qualitative characteristics are not easily explained by brain states and external sensory inputs; they require descriptions in terms of dynamic processes that involve the constant interaction of the mental, the physical, behavior, and the environment. In artificial perception, "sensory substitution technologies" enable individuals, especially those with sensory disabilities, to replace lost or damaged sensory functions by utilizing intact sensory channels to perceive information and the environment in novel ways. These technologies employ algorithms and devices to convert information from one sensory modality (e.g., vision or hearing) into information for another sensory modality (e. g., touch or smell). Users can adapt to and learn these new modes of perception. However, do the natural and artificial paths of perception generate the same neural experiences when presented with the same external stimuli? Is the qualia experienced by the auditory system when receiving visual information through a sensory substitution system an entirely new form of perception? One viewpoint suggests that the neural system processes information from different modalities by focusing on the content itself, ignoring the differences in information sources. In other words, as long as the information content transmitted by two modalities is the same, the neural system generates identical neural experiences. However, opposing arguments suggest that differences in the processing and interpretation of information between natural and artificial perception pathways can lead to different neural experiences. Even if natural and artificial perception generate identical neural experiences, their subjective experiences and meanings may differ.

The third challenge of artificial perception pertains to the issue of embodiment in contrast to natural perception. Presently, second-generation theories of cognitive science propose that perception is an experiential process grounded in the human body. This embodied cognition perspective establishes subjectivity upon the unity and boundedness of the physical body, suggesting that our self-awareness, as human beings, partly derives from the interconnection of individual sensory information in our experiences (Raymond, 2005). Within this perspective, the sense of self as the causal foundation of behavior is a compelling testament to one's fundamental self-awareness, indicating that we can consciously move our bodies, being the "author" of our physical selves and actions. Subjective bodily experiences provide the foundation for human cognition. Cognition is not purely internal, symbolic, computational, or disembodied. Our self-awareness and identity as humans are closely tied to physical bodily activities. Artificial perception challenges this notion of embodiment. Artificial sensory inputs, such as through neuroprosthetics or sensory substitution devices, often bypass natural sensory modalities or reconfigure sensory experiences in a way that is no longer directly connected to the physical body. In these cases, the sense of embodiment may be shifted or distributed differently, as individuals experience sensory inputs or motor control through devices that are not part of their biological bodies. This raises questions about the nature of embodiment in the context of artificial perception. Does a sense of embodiment persist when our sensory experiences are mediated by technology, and if so, how is it altered or transformed? Understanding the implications of these challenges for our understanding of self, identity, and cognition remains a subject of ongoing philosophical and scientific inquiry.

However, with the current possibility of artificial perception, natural body senses are no longer an absolute prerequisite for perceiving the external world. In the context of artificial perception, does perception still possess embodiment? Virtual reality technology, for instance, allows individuals to enter entirely fictional environments without relying on natural senses, effectively simulating sensory experiences. Such disembodied forms of perception raise the need to reevaluate the process of perception construction, the processing and interpretation of sensory information. In other words, human-computer interaction essentially combines embodiment with mechanization, leading us to reconsider the concepts of the "body" and "embodiment" and expand the effectiveness of the concept of embodiment. Moving beyond the confines of the body is a crucial pathway to achieving intelligence and cognitive evolution. With the extension of our concept of embodiment through artificial perception, could we move towards a cognitive perspective that combines both embodiment and disembodiment? Embodiment, in this context, suggests that cognition is not restricted to the physical body but is intertwined with external tools and technology. It's a fusion of embodiment and mechanization that allows us to broaden the perspective of what constitutes an embodied cognitive system. The computational-representational approach is indeed a vital component of human cognitive capabilities, but exclusively explaining cognition and sensation in terms of the body alone is not a feasible path. Similar to the fusion of scientific and humanistic interpretations, only a synthesis of both perspectives can provide a more comprehensive philosophical understanding of cognitive mechanisms. In this evolving landscape, cognitive processes may no longer be exclusively defined by the boundaries of our biological bodies and can be extended or enhanced by artificial perception technologies.

Lastly, it is worth considering that artificial perception is likely to interfere with natural human perception. While the importance of artificial perception in enhancing cognitive abilities is evident, it also affects the natural perception that serves as cognitive input. Unlike traditional natural sensory inputs and outputs involving nerves, muscles, and hormones, artificial perception provides new pathways for input and output to the central nervous system. At present, neuroscience and neurobiology still lack a comprehensive understanding of the fundamental aspects of human brain function and causal explanations for perception, and the neural signals output by artificial perception cannot be interpreted in isolation.

Natural perception is characterized by its holistic and coordinated nature, and artificial perception, if it acts as a sole substitute or enhancer, could lead to abrupt changes in the inputs of certain sensory information. The human sensory system functions as a balanced whole, with different natural senses inputting information to the brain in equilibrium, staying within the physiological limits of the brain. Artificial perception can replace and enhance natural perception, but it operates as an external force beyond this equilibrium. Blindly substituting and increasing sensory inputs could disrupt the original holistic and coordinated nature of perception. Additionally, if one natural sensory function is lost, the others tend to compensate and strengthen, indicating a multisensory, cross-channel information processing system where sensory signals from touch, hearing, or vision are interconnected, ultimately forming an "information packet" of multisensory combinations. Single-channel artificial perception can only input isolated sensory signals, which might disrupt the process of experiential reshaping in other sensory channels. Therefore, while artificial perception can significantly expand our perceptual experiences, it should be used with caution to avoid disturbing the balance and coordination that natural perception offers. Balancing both artificial and natural perception remains a crucial challenge in harnessing the full potential of enhanced human cognition.

4 Conclusion

Artificial perception, as a newly constructed human perceptual ability through technological means, not only compensates for inherent limitations in natural perception but also enhances or alters the perceptual capabilities of human subjects. It starts with mimicking natural perception and currently has the potential to surpass human natural perception. In this process, artificial perception inevitably poses challenges to both natural perception itself and the human subject. Maurice Merleau-Ponty reminded us in "The Eye and the Mind" that all technologies are "technologies of the body"（technique du corps），making our metaphysical structure of flesh tangible and expanded. However, human flesh is fragile, prone to injury and aging. The research in modern technologies like artificial intelligence might be seen as human attempts to transcend the body using technology.The question arises: do we need "body-based" or "body-transcending" science and technology? Will emphasizing the embodiment of cognition and contextuality limit the development of technology by constraining it within the body? Is the human body gradually transforming into a carrier for information processing? Due to space limitations, these questions require further exploration in a dedicated discussion.

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