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Digital sensitivity. The human being, artificial intelligence (AI), and new technologies

Sensibilidade digital. O ser humano, a inteligência artificial (IA) e as novas tecnologias.

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Abstract

Contemporary debates on artificial intelligence and human–machine interaction largely interpret technological development through functionalist and computational frameworks. Within these paradigms, cognition is treated as information processing and digital augmentation as the optimization or extension of pre-existing human faculties. Perception, in particular, is assumed to be a stable biological substrate that technology can enhance without fundamentally altering. Prevailing accounts rarely address how digital infrastructures reorganize the conditions under which reality becomes perceptible, meaningful, and actionable. By focusing on efficiency, performance, and "human-centric innovation" (as in the rhetoric surrounding Industry 5.0), current models risk obscuring the socio-historical and political mediation of sensitivity. This article introduces the concept of digital sensitivity to reconceptualize perception as a situated and historically mediated mode of world-disclosure rather than a discrete sensory function. The paper argues that the progressive integration of AI systems, distributed

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sensing networks, and digital platforms amounts to the emergence of a virtual artificial sense—an infrastructural layer of mediation that precedes and orients individual awareness. This development does not simply extend biological capacities; it transforms the structure of subjectivity and redefines how humans orient themselves within the world. The human–machine relation must therefore be understood as a process of co-constitution rather than augmentation. Reframing digital technologies as ontological mediators rather than neutral instruments has significant consequences for debates on agency, responsibility, and governance. Recognizing this shift allows us to move beyond polarized narratives of technological optimism or dystopia and toward a deeper reflection on how digitally saturated environments reshape human existence.

Keywords: Digital sensitivity; Artificial Intelligence (AI); Human–machine interaction; Ontology of technology; Embodied cognition; Industry 5.0; Socio-technical systems; Philosophy of AI; Digital prosthesis

Resumo

Os debates contemporâneos sobre inteligência artificial e interação humano-máquina interpretam, em grande parte, o desenvolvimento tecnológico por meio de estruturas funcionalistas e computacionais. Dentro desses paradigmas, a cognição é tratada como processamento de informação e o aprimoramento digital como a otimização ou extensão de faculdades humanas pré-existentes. A percepção, em particular, é considerada um substrato biológico estável que a tecnologia pode aprimorar sem alterá-la fundamentalmente. As abordagens predominantes raramente questionam como as infraestruturas digitais reorganizam as condições sob as quais a realidade se torna perceptível, significativa e acionável. Ao se concentrarem na eficiência, no desempenho e na "inovação centrada no ser humano" (como na retórica em torno da Indústria 5.0), os modelos atuais correm o risco de obscurecer a mediação socio-histórica e política da sensibilidade. Este artigo introduz o conceito de sensibilidade digital para conceituar novamente a percepção como um modo situado e historicamente mediado de revelação do mundo, em vez de uma função sensorial discreta. O artigo argumenta que a integração progressiva de sistemas de IA, redes de sensores distribuídos e plataformas digitais equivale à emergência de um sentido artificial virtual — uma camada infraestrutural de mediação que precede e orienta a consciência individual. Esse desenvolvimento não se limita a ampliar as capacidades biológicas; ele transforma a estrutura da subjetividade e redefine a forma como os humanos se orientam no mundo. A relação humano-máquina deve, portanto, ser entendida como um processo de co-constituição, e não de mera ampliação. Reenquadrar as tecnologias digitais como mediadoras ontológicas, em vez de instrumentos neutros, tem consequências significativas para os debates sobre agência, responsabilidade e governança. Reconhecer essa mudança nos permite ir além das narrativas polarizadas de otimismo ou distopia tecnológica e

caminhar rumo a uma reflexão mais profunda sobre como os ambientes saturados de tecnologia digital remodelam a existência humana.

***Palavras-chave**: Recepção sensível; Inteligência Artificial (IA); Interação homem-máquina; Ontologia da tecnologia; Cognição; Indústria 5.0; Sistemas sociotécnicos; Filosofia da IA; Prótese digital*

Introduction

Today's contemporary debates on technological change, are the humans machine interaction, digital innovation, and artificial intelligence, have focused on human–machine interaction and Information and Communication Technologies (ICT), spanning cybernetics, human–computer interaction, embodied intelligence, and socio-technical systems. The present work approaches digital innovation and artificial intelligence from an ontological perspective, asking which conception of reality and sensitivity is implicitly assumed in current human–machine relations.

Against dominant functionalist approaches, the paper argues that enhancing individual senses alone does not create "superhuman" abilities or boost productivity. Instead, it can result in overload or disorientation, neglecting overall human development. Industry 5.0, which focuses on collaboration between humans and machines, sustainability, and resilience, often sees technological augmentation in simple, data-driven terms. What is the original contribution of this work? Drawing on critical views, this article highlights that human sensitivity is embodied, emotional, social, and influenced by power. Intelligence emerges from lived practices and shaped perception, not as a purely computational process. Individuals and societies must retain control over technology.

The central hypothesis of the paper is that subject, object, and their relation jointly constitute a transformed perception of reality. This paper argues that their integration into a unified artificial digital prosthesis would reveal how digital technologies reshape human orientation toward the world technologies, while existing technologies tend to enhance sensory modalities and fragmented cognitive functions.

From this perspective, the paper theoretically fills the mainstream speech gap and demonstrates that concentrating multiple digital functions within a single integrated object does not merely expand sensory input but reconfigures the conditions under which reality becomes perceptible and actionable; it changes the human perception of being.
A virtual artificial digital sense could cause an ontological shift that would not amount to a simple enhancement of biological senses but to a transformation in how humans orient themselves within the world. By integrating AI-driven knowledge and digital functions that are continuously available, human capacities may be re-articulated.

Methodology

The study contrasts two ontological frameworks underlying AI and digital technologies: the dominant mainstream model and an alternative point of view. The paper proceeds descriptively and analytically, outlining current models of human–machine interaction and identifying their implicit ontological assumptions. Following Heidegger's conception of ontology as the phenomenology of being (Di Somma 2017), this article adopts a critical–theoretical approach (PETERSON et Ali. ,2010) as an interdisciplinary method that interrogates the legitimacy of social, political, and economic power structures.

The study could be understood as a discussion paper or to evaluate and interpret the results, draw inferences and conclusions from it (Creswell, J. W., & Creswell, J. D., 2018; Eco, U., 2015; Swales, J. M., & Feak, C. B. , 2012). The methodology procedures are based on a structured bibliographic analysis of philosophical, technological, and socio-technical literature showing two approaches. The discussion is organized into two parts: an analysis of the prevailing ontological framework and the development of an alternative account of digital sensitivity.

Rather than forcing a synthesis of the two approaches, as a dialectic method states, the paper maintains a productive tension between these perspectives,while the alternative framework appears to offer greater explanatory power.

A conclusive synthesis will require future empirical research and systematic observation of technological developments and their social and experiential effects. That is a limit of the current paper.

DISCUSSION

Russell's *The Scientific Outlook* book written in 1931 (Russel 1982), warns against the dehumanizing effects of a purely technical, scientific society predicting that scientific governance could lead to limits on individual freedom and education.

That warning was agreed by many writers in the past century. Recently interdisciplinary literature has examined the epistemological and ontological implications of scientific and technical rationality (Card, Moran & Newell 1983; Bødker 1991; Brooks 1991; Clark & Chalmers 1998; Lee C. P., Dourish P., Mark, G. 2006;Nahavandi 2019; Wiener 2019; Taisch 2021; Floridi 2022; ; Mourtzis 2022; Turkle 1984,1995, 2011, 2015).

Shared doctrine concerning the universal characteristics of artificial intelligence as the foundation of all AI systems, and of digital innovation, aimed at increasing human intelligence and knowledge. The ontology of human–machine relations articulated by many contemporary scholars cited above conflates the human being with an epistemological construct of the human–machine as a superhuman or supermachine designed for industry and markets. The mainstream thereby neglects the foundational conditions of human existence as such. We argue that the senses, the body, or digital automated machines are not merely channels of perception but constitute one filter through which we perceive, understand, and interact with reality, grounding knowledge in concrete, lived experience.

1 – THE MAINSTREAM

The literature on Information and Communication Technologies (ICT), especially artificial intelligence (AI), and digitalization have roots in cybernetics. Alan Mathison Turing is widely regarded as one of the founders of computer science and artificial intelligence, concepts already theorized in the 1930s. Wiener (WIENER, 1948, 2019) defined cybernetics as the study of control and communication processes in animals and machines, introducing key notions such as feedback, self-regulation, and adaptive interaction, which later became foundational across disciplines concerned with human–machine interaction.

A review of the literature on the human–machine relationship

A crucial milestone in the development of Human–Computer Interaction (HCI) was marked by Stuart Card, together with Thomas P. Moran and Allen Newell pioneering work proposing cognitive models to explain how users process information and interact with computerized systems (CARD et Ali., 1983). A step further was made by Susanne Bødker. When she argued that interaction with machines cannot be understood solely by examining interface-level actions; instead, it must be situated within the broader social context and the activity in which the user is engaged (Bødker 1991). Similarly, Lee et Ali. (Lee etAli. 2006) extended the analysis beyond usability to include the technical, social, and cultural dimensions of interaction, emphasizing the situated and collaborative nature of system use.

With that point of view, a key contribution of new technologies related to the overall contribution to human intelligence is the theory of the extended mind. This influential thesis in the philosophy of mind and cognitive science was introduced by Andy Clark and David Chalmers (1998). It challenges the view that cognition is confined within the boundaries of the brain and body (the limits of skin and skull), proposing the concept of active externalism: under certain conditions, external objects and tools can become constitutive—rather than merely causal—components of cognitive processes, thereby extending the mind into the world. Clark and Chalmers argue that, despite differences in access to information, the functional role that information plays in guiding action can be essentially equivalent. Functional continuity thus serves as the criterion for cognitive extension, without, however, transforming the subject of cognition itself (AVENI 2025a).

However, recently, neglecting a broader research on human-machine interaction, the main speech about human-machine interaction was improved followingMichael Rada (RADA 2015), who introduced the term Industry 5.0 in contrast to the fully automated vision of Industry 4.0. For Rada, the human–machine relationship is not competitive but co-creative: technology should amplify human capabilities rather than replace them. At present, however, there is no fully shared definition of Industry 5.0 (Mourtzis et al., 2022; Madsen & Slåtten, 2023).

The mainstream of integration Human-machine is sustained by academics about production and labour. The definition of Industry 5.0 remains contested (Taisch, 2023; Aveni, 2023). However, the concept is related to Industry 4.0, which emerged in Germany in 2011 within the federal government's High-Tech Strategy and was officially presented at the Hannover Messe. Industry 4.0 was conceived as the continuation of the industrial revolution. Accordingly, Industry 4.0 technologies are reoriented toward collaborative robots (cobots), AI as decision-support systems, adaptive human–machine systems, advanced personalization, flexible and localized production, and extensive use of data clouds.

The literature shows that Industry 5.0 did not emerge from a single seminal academic publication, unlike Industry 4.0. Michael Rada (RADA 2015) proposed Industry 5.0 as a new human-centric industrial vision based on the 6R principles (Recognize, Reconsider, Realize, Reduce, Reuse, Recycle). This early formulation has been cited in later works as a historical reference, and Rada is generally recognized as the first scholar to explicitly use the term "Industry 5.0." The European Commission further legitimized and disseminated the concept in 2021 through policy documents emphasizing its core dimensions: human-centric, sustainable, and resilient industrial systems.

In some academic accounts, Industry 5.0 is still described as a production model based on industrial process digitalization, advanced automation, and interconnection among machines, systems, and data, with efficiency, productivity, and optimization as primary goals. The key technologies of Industry 4.0 include the Internet of Things (IoT), cyber-physical systems (CPS), big data analytics, artificial intelligence, cloud computing, industrial robotics, and digital twins—many of which are also foundational for AI systems. Within this framework, humans are often positioned as supervisors or exception managers rather than central actors. More broadly, in industrial contexts, humans are integrated into technical systems whose ownership and governance lie with organizations and corporations, even though intellectual property remains formally attributed to human subjects.

The European Commission (EU, 2021) has contributed to institutionalizing the Industry 5.0 framework within European industrial strategies by shifting the focus from the individual human to society as a whole. According to the EU, the social legitimacy of Industry 5.0 rests on three pillars: Human-centricity – technology should serve and enhance human capabilities rather than replace them; Sustainability – reduction of environmental impacts and promotion of circular economy models; Resilience – the capacity to withstand crises such as pandemics, geopolitical shocks, and energy disruptions.

Table 1 – Industry 4.0 vs. Industry 5.0 (Comparative Framework)

Dimension	Industry 4.0	Industry 5.0 (EU framing)
Core Objective	Efficiency, productivity, optimization	Human-centricity, sustainability, resilience
Role of Technology	Automation and control	Support of human capabilities
Human Position	Supervisor / exception manager	Creative, responsible, ethical agent
Key Technologies	IoT, CPS, AI, digital twins	Cobots, adaptive AI, human–machine systems
Normative Orientation	Technical-economic	Socio-technical and policy-driven

Source: Author's elaboration. Alessandro@unb.br.

Representative definitions – across scientific and economic communities, Industry 5.0 is described as an industrial paradigm integrating advanced technology with social and environmental values, supporting human–machine cooperation (Digital Agenda; MDPI reviews). Nevertheless, the center of the debate remains predominantly economic, closely tied to production and labor productivity. Within these objectives, industry promotes a rapidly expanding market of technological tools—often framed as digital prostheses—alongside increasing interactions with developments in biotechnology.

According toMourtzis et al. (2022), the integration of digital human models, simulation, and collaborative robotics transforms the human–machine relationship into a problem of cognitive, rather than merely physical, coordination. Within Industry 5.0, humans are modeled as decision-making agents rather than simple operators. Marco Taisch (TAISCH 2023), aligning with the European Commission's perspective, critically discusses the concept of Industry 5.0 by linking the human–machine relationship to three pillars: human-centricity, sustainability, and resilience. In this framework, technology is conceived as an infrastructure that supports human autonomy, safety, and well-being.

The human-machine paradigma studied by Rodney Brooks (BROOKS,1991) investigated embodied intelligence and non-anthropomorphic collaborative robots, contributing to the development of cobotics. Brooks conceptualized the human–machine relationship as situated, adaptive, and non-symbolic interaction, anticipating several themes that are now invoked to support the concept of Industry 5.0. Saeid Nahavandi

(2019), in turn, introduced the notion of Human-Centric Cyber-Physical Systems (HC-CPS), in which humans are active components of control systems. By integrating collaborative robotics, artificial intelligence, and human factors, Nahavandi redefines the human–machine relationship as a symbiotic socio-technical system.

Today, digital tools are available in a fragmented offer across multiple devices such as smartphones, watches, and smart glasses. Through the Internet of Things (IoT), additional tools can be integrated with human users to control objects such as vehicles, household appliances, and automated systems. If all currently available digital tools were integrated into a single artificial device, this would not only expand sensory capacities and machine control but would also extend cognitive capacities. What, then, is the real, rather than imagined, limit of contemporary human–machine integration? To address this question, the next section examines empirical evidence concerning human–machine integration in a broad sense. This includes enhanced senses, prosthetic technologies, digital control instruments applied to humans and machines (understood here as IoT).

PhisicalDigital Human–Machine Interactions

Is a single, “omnipresent” tool for connection and access to hardware/software technically feasible today? With current technologies, it is technically possible to build a “ubiquitous” personal hub rather than a single monolithic object. Such a hub would consist of an integrated ecosystem perceived by the user as a unified system, composed of a personal central device (advanced smartphone / wearable computing, such as AI-enabled phones or AR glasses), a persistent digital identity (cloud and edge computing infrastructures), remote access to hardware and software resources (virtualization and computational streaming).

Table 2 – Key Technologies Enabling Ubiquitous Personal Digital Interaction

Layer	Core Technologies	Function	Current Maturity
Personal Interface	Smartphones, AR glasses, wearables	User access point to digital services	High
Computational Backbone	Cloud computing, edge computing	Persistent identity, low-latency processing	High
Connectivity	5G/6G, satellite IoT, edge AI	Continuous and ubiquitous connection	Medium–High
Security & Identity	Federated identity, zero-trust networking	Authentication, access control	Medium–High
Virtualization	Remote hardware/software access, streaming	On-demand computational resources	Medium

Source: Author's elaboration. Alessandro@unb.br.

For "anywhere" connectivity, enabling technologies already exist, including edge AI, federated identity systems, zero-trust networking architectures, and satellite-based IoT infrastructures (Chen, Hong & Jin, 2009; Fallatah, Barhamgi & Perera, 2023).

Thus, what is the current capacity of these technologies to interact with the five human senses and more? The idea of the five senses derives from Aristotle in *De Anima (*ARISTOTLE 1994). Aristoteles argue that sense is defined as a biological capacity that receives the form of the external world, that is, as a channel for receiving external reality. In the Aristotelian legacy, there are five senses (sight, hearing, smell, taste, touch) that register external events.

In general terms, based on observation of reality, the following assessment can be made:

-Vision: almost complete, but with significant limitations, including visual fatigue, restricted field of view, and lack of natural depth perception, particularly in digital or AR glasses.

-Hearing: highly advanced, though still limited in complex acoustic environments, often requiring expensive filtering devices.

-Touch: no genuine tactile feedback exists; virtual gloves function primarily in virtual or IoT-controlled environments and lack sensitivity to temperature and micro-pressures.
-Smell: absent, as chemical perception cannot be digitized.
-Taste: no form of digital interaction is currently available.

Table 3 – Digital Interaction with Human Sensory Modalities

Sense	Current Digital Interaction	Main Limitations	Ontological Status
Vision	AR/VR, screens, computer vision	Fatigue, limited field of view, artificial depth	Partial augmentation
Hearing	Speech recognition, audio synthesis	Noise sensitivity, filtering costs	Advanced augmentation
Touch	Haptic devices, virtual gloves	No temperature or micro-pressure feedback	Weak simulation
Smell	None	Chemical perception not digitizable	Absent
Taste	None	No digital encoding	Absent

Source: Author's elaboration. Alessandro@unb.br

DigitalSensitivenesshas huge implications in neuroscience. Today, instead of Aristotle's classic definition of five senses, neuroscience recognizes that human beings possess many additional senses, including internal and supplementary ones such as nociception (pain), proprioception (awareness of the body in space), balance, and interoception (perception of internal bodily states). Sensory processing is also characterized by multisensory integration.

The connection between humans and new technologies is not only mechanical and based only on machines. Biotechnologies, especially those linked to AI and digital innovations, increasingly enable the integration of digital innovation with brain functions. The starting point is disease research. Neuralink, for example, was founded to assist individuals with paralysis in using personal devices and recovering partial mobility through thought alone. The system connects the nervous system to a device known as a brain–computer interface (BCI), capable of interpreting neural activity.

The private sector is also expanding rapidly by integrating digital technologies and biotechnology for medical and rehabilitative purposes. The global market for digital prostheses and advanced prosthetic technologies—including CAD/CAM devices and 3D printing—has grown significantly due to the digitalization of workflows and the integration of technologies such as additive manufacturing, digital scanning, and artificial intelligence (Preti et al., 2025; Ghorbani Pashakolaie et al., 2025).

These studies indicate that prostheses have reached broad clinical and industrial adoption. In dentistry, digital technologies are transforming prosthetic manufacturing through CAD/CAM materials and processes that allow faster, more precise, and more cost-effective production compared to traditional methods. Among the most advanced research directions are brain–computer interfaces (BCIs), which enable prosthetic devices to be controlled through neural signals, overcoming the limitations of traditional myoelectric technologies.

According to sectoral analyses (Assobiotec – Digital Innovation Observatories, 2025; EY & Assobiotec-Federchimica, 2025; Global Industry Analysts, 2025), the international digital prosthetics market in 2024 is estimated at approximately USD 1.25 billion, with an expected compound annual growth rate (CAGR) of around 9–10% through 2032. These technologies reduce production times, improve prosthetic fit, and offer highly customized solutions for patients. Closely related, the market for 3D-printed prostheses is also reaching significant values and is expected to continue growing steadily.

Luu et al. (LUU et Ali. 2022) demonstrate that AI-enabled neuroprosthetic systems can translate neural signals into highly precise controlled movements of prosthetic devices, paving the way for more intuitive and natural prostheses. Entrepreneurs such as Elon Musk, through Neuralink, are pushing the industry toward a future in which implantable neural interfaces interact directly with digital and robotic devices, including assistive prostheses and robotic arms. Neuralink has already announced the implantation of brain chips in human subjects, with the long-term goal of restoring motor abilities and potentially expanding human capacities through direct brain–machine connections.

Neuralink has also launched clinical studies aimed at connecting BCI implants to the control of robotic arms (the "Convoy" study), with the objective of enabling not only digital but also physical autonomy. Musk's work focuses on neural systems that allow the control of computers, robots, and prostheses through thought alone, opening new frontiers for human–machine integration. Nevertheless, these developments remain embedded within socio-technical systems that treat innovation primarily as an extension of the body.

From an operational perspective, these technological impacts have contributed to the emergence of concepts such as human augmentation and physical AI. Human augmentation or the enhancement of human capabilities through digital technologies is becoming central across multiple industries, with significant implications for healthcare, sports, and assistive technologies e.g., intelligent prostheses and functional extension modules. (Hughes, 2018; Obaid & Muthmainnah, 2025).

With respect to biological prostheses and biotechnological transplant organs, a fundamental distinction must be made, as defined by EU and US production protocols. Biological prostheses used in cardiac surgery, orthopedics, and vascular surgery are devices or structures partially or entirely composed of biological materials or integrating living tissues with artificial supports. Biotechnological transplant organs, by contrast, are organs that are constructed, modified, or regenerated through biotechnologies rather than harvested from human donors. These include bioengineered organs (tissue engineering), organs under development (heart, lung, kidney, liver), 3D bioprinted organs, genetically modified xenotransplants (such as experimental pig heart or kidney transplants into humans), and organoids as "pre-organs" grown in vitro (USA 1938, EU 2017).

The convergence of these developments with AI and digital systems gives rise to the concept of the cyber-biological organ. Biological prostheses and biotechnological organs are increasingly digitally monitored, modeled through digital twins, and optimized using AI for growth, adaptation, and rejection prediction. This convergence marks a conceptual shift: from "replacement" to reconstruction, from "therapy" to enhancement, and from a natural body to a designed body. It also necessitates a redefinition of ownership (Aveni, 2024a, 2024b), raising critical questions: Who owns a biotechnological organ? When does an organ become a platform? These issues lie at the core of the author's ongoing research and exceed the scope of the present discussion.

2 – Alternative Reading of Digital Sensitivity

Senses are connected to intelligence, our capacity to perceive and act within the real world, and to knowledge. This connection is also relevant to the notion of Artificial Intelligence (AI). To address a new reading of the human-machine literature, a question must be raised: what is intelligence for humans? For Aristotle (Kelsey 2022), intelligence does not perceive but grasps universals and distinctions. Descartes conceives intelligence as a faculty of the *res cogitans*, separated from the body and autonomous from the senses, capable of attaining clear and distinct truths. The senses deceive; the intellect judges. But after many philosophical discussions with Hume and Kant till today, and the development of psychology, the debate is not over yet.

A literature review

A new, useful view of intelligence was argued by Gardner's theory (1995) of multiple intelligences. These incorporate phycologyandfunctions previously treated as separate faculties, yet still distinguishes intelligence from the senses, insofar as it involves symbolic processing. But why are intelligence and emotion (emotional intelligence) not considered senses? Because sense refers to the reception of information (what is there), intelligence to transformation, integration, and prediction (what to do with it), and emotion to affective and motivational evaluation (how much it matters). Thus, following Damasio (DAMASIO 2000), emotions are bodily signals, and value maps are indispensable for reasoning not senses, but evaluative systems. Emotional intelligence concerns recognizing, regulating, and using emotions; intelligence and emotion are different levels of interpreting reality, not arbitrary categories.

However, other authors such as Foucault, Merleau-Ponty, and Vygotsky dismantled the very idea that senses, intelligence, and knowledge are separate faculties. These authors radicalize an ontological rupture with today's mainstream. They started from the idea that knowledge does not rest upon the senses. Knowledge reorganizes what we call senses or sensitivity. Thus, perception is already interpretation; intelligence is situated practice; emotion is historically formed; and knowledge is a political fact.

According toMerleau-Ponty the body does not possess senses but only perception. Perception is not a sensory input processed by the mind, but a mode of being. There is no neutral pre-cognitive moment. For instance, the motor coordination is already known, in fact, a blind person using a cane does not "feel" the cane; the cane becomes an extension of perceptual bodily space. Thus, for Merleau-Ponty, the sense is not located in the organ, nor does intelligence come "after" perception; meaning emerges in action(MERLEAU-PONTY 1996, 2005, 2010).

Following Vygotsky (Vygotsky 1978), we do not perceive the world but culturally mediated worlds. The intelligence is not natural but historical, social, and mediated. Between stimulus and response stand language, symbols, and cultural meanings. Thus, language does not merely communicate; it reorganizes perception, structures attention, and creates new forms of memory. Symbols are a knowledge internalized social practice. Treating ICT as a single homogeneous innovation, as in some readings of Floridi (2022), therefore generates conceptual confusion between language, communication, symbols, and the tools used to communicate.

At the end, following Foucault (FOUCAULT 1998), the central issue is who defines what counts as knowledge. There is no innocent perception, nor innocent IA or communication. Every society and century has regimes of truth, tools of knowledge/power, and grids of visibility. We do not see reality as such because we live in the present, we see what is sayable and thinkable today. The body itself is not a neutral biological given, but disciplined, measured, and trained with the actual technology. The relevant question is not "How many senses do we have?" but "Who defines what counts as valid perception?". The sensitivity and knowledge are matters of social construction and dominant powers, so the intelligence is measured by manipulated metrics.

These authors do not deny the existence of the biological brain and the natural processes. They reject the claim, central to dominant in computational-representational neuroscience, that the brain alone is sufficient to explain cognition through neutral stimulus encoding. Mainstream neuroscience and Industry 5.0 assume that the brain processes data like a computer and that symbolic meaning is an internal property. From a critical perspective, this model is ontologically reductionist and even false.

In fact, Merleau-Ponty challenges the notion of stimulus: neuroscience assumes stimulus precedes perception as a cause and result, whereas stimulus is defined by behavior. The body selects what matters before neural encoding. Neuroscience measures only neural correlates of a pre-established structure of meaning. Vygotsky argues that the brain does not explain perceptual development. Higher mental functions emerge between people, through social practices and symbolic tools, and only afterward reorganize neural structures. Finally, Foucault identifies a fundamental blind spot: all knowledge about the brain is embedded in regimes of normalization. Clinical categories arise from institutional needs (schooling, labor, control).

But there is also another issue. The main literature of AI as "intelligence" is no neutral. The AI is presented as a technical, intentionless system based on objective data, and therefore impartial, for example, the use of AI in legal processes. This narrative reproduces the same assumptions as cognitive neuroscience and is subject to the same critique. If we start from a Merleau-Pontian perspective, AI has no body and therefore does not perceive; it classifies patterns without meaning. From a Vygotskian perspective, AI does not internalize social practices; it absorbs linguistic data but does not participate in normative life or learn through consequences. Human meaning arises from interaction, error, sanction, and correction. AI learns through correlations, optimization, and output. These are ontologically different processes. Finally, from a Foucauldian perspective, AI is power. In fact, it selects, classifies, predicts, and evaluates following a stated metric. It cannot be neutral because its construction embeds normative criteria and stabilizes hierarchies of the developers and their employers. AI's "objectivity" is power rendered opaque.

Thus, perception is situated (Merleau-Ponty), intelligence is socially mediated (Vygotsky), and knowledge is historically regulated (Foucault). AI can only reflect, amplify, and automate existing regimes of sense or the mainstream. The core error of cognitive neuroscience is mistaking correlation for foundation. The mainstream confuses measurability with explanation. The problem is not technical, but epistemological and political. We can resume that mainstream and alternate views of these authors are incompatible ontologies of cognition.

The differences are that at the epistemological level, mainstream AI equates validity with accuracy, treats error as noise, and seeks explanation through internal causal traceability (transparency). The critical view of Merleau-Ponty, Vygotsky, and Foucault understands reality as situated, error as normative effect, and explanation as genealogical reconstruction of categories and symbols. Politically, dominant governance models like GDPR in Europe locate responsibility at the individual or organizational level, enforce ex post control, and demand technical transparency. The critical model sees responsibility as distributed, power as structural, and opacity as systemic. Errors are not isolated events but effects of normalization (AVENI 2025b).

Different ontologies also imply different AI Governance. The dominant computational–functionalist ontology underlying AI and its regulation assumes: Cognition equal toinformation processing; Perception equal to input;Intelligence equal to abstract function realizable on any substrate; Context equal to external variable. By contrast, the critical ontology assumes: Cognition equal to situated practice; Perception equal to orientation toward action; Intelligence equal to relational emergence between subject and object; Context equal to constitutive, not external.

Current AI governance (i.e., European AI Act) adopts the ontology of cognitive neuroscience. It is incomplete because it is ontologically mistaken. It regulates tools, while AI functions as a new form of governance. Risk is treated as the probability of impact, but from a critical ontology, harm is structural and emerges from social use. Models do not explain or value social effects. These explain how a system works, but don't explain what makes it legitimate.

AI governance would require regulating practices rather than systems, social functions rather than algorithms, institutional responsibility rather than individual liability, and continuous ex post evaluation rather than ex ante risk assessment. But primarily, AI governance only exists with knowledge and education; individuals must perceive the innovation and digital systems and assume responsibility of the use of it. This is incompatible with current law, AI economics, and innovation rhetoric. Hence, AI governance is destined to chase the problem rather than resolve it.

Recent literature

Recent academic literature has engaged some of these critical positions. Rechowicz et Ali (Rechowicz et Ali , 2018) introduced the concept of digital senses as a theoretical and technological framework aimed at integrating the physical and digital worlds through extended multisensory stimulation. The authors define the real world as directly accessible through human senses and the digital world as mediated by artificial interfaces, arguing that the current dominance of vision and hearing in digital technologies constrains immersion, participation, and empathy. The article proposes digital senses as an open interdisciplinary research program, highlighting both technological challenges (stimulation of smell, taste, and touch; AI systems adaptive to emotional states) and theoretical gaps concerning the relationship between senses, experience, reality, and interpretation. But, at last, their approach remains implicitly functionalist, assuming that improved sensory orchestration, at last, will automatically produce empathy and understanding.

Ling (LING 2014) provides a review of the use of Digital Organisms (DOs) and artificial life as silicon-based tools for studying genetic evolution, proposed as an alternative to the limitations of real biological experiments (high costs, long timescales, destructiveness, and the impossibility of reproducing events such as mass extinctions). Ling emphasizes the structural limitations of DOs: while they are useful for testing specific evolutionary hypotheses, they are inadequate for observing evolution as an open-ended and non-deterministic process, failing to capture the full historical unpredictability of real biological evolution.

Another author,Carmen Rotondi (ROTONDI, 2023), analyzes how informed relationships between the physical, digital, and biological dimensions are radically transforming design practice and the sustainability paradigm. The author argues that we are entering a phase of bio-digital industry, in which digital and computational technologies intertwine with biotechnologies, enabling the design and fabrication not only of forms but of material growth processes inspired by biological mechanisms. The integration of physical and digital dimensions makes it possible to “write” behaviors directly into matter (reactivity, adaptation, transformation over time), while the inclusion of the biological dimension introduces living matter as an active component of the design process. This shift entails an epistemological transformation. The design no longer produces static objects but creates conditions for growth, accepting a structural degree of unpredictability.

About digital-human ecosystems, Tierra is one of the earliest and most influential experiments in Artificial Life (ALife), developed in the early 1990s by Thomas S. Ray (RAY 1992). The Tierra experiment demonstrates that evolutionary dynamics can emerge in computational environments, but it also reveals that digital life remains constrained by the formal and normative structures of the system in which it is embedded. Following these results, some authors (FILLINGS et Ali, 2016) critically examine the concept of information in biology, arguing that its extensive and often metaphorical use has generated theoretical confusion rather than explanatory clarity. The authors show how the notion of information has been applied across multiple levels of the biosphere—genetic, cellular, organismal, and ecological—without a shared and univocal definition, resulting in conceptual ambiguity and unwarranted inferences. In particular, they critique the metaphor of DNA as a “code” or “program,” demonstrating that gene expression depends on a complex network of cellular, environmental, and evolutionary interactions.

Biological information does not reside in a single structure but emerges from dynamic and relational processes distributed across time and space. Consequently, treating information as a transferable or conserved entity risks reifying what is in fact a set of functional relations. The article argues that "information" in biology is neither a substance nor an internal code inherent to nature, but a descriptive category dependent on processes, relations, and interpretive models, whose uncritical use generates conceptual reductionism.

AlsoGer Wackers (WAKERS 2025) critically addresses the use of the concept of information in the life sciences and cognitive sciences, showing how it is often employed metaphorically and reified without clear theoretical justification. Treating information as an intrinsic property of biological or cognitive systems leads to a form of computational reductionism that conflates description, model, and ontology. Wackers argues that information is not a natural property of biological or artificial systems, but a theoretical construct—useful yet dangerous if mistaken for an ontological foundation of cognition or life.

Thinking about a biological and cybernetic ecosystem, the Actor–Network Theory (ANT) is a theoretical framework developed primarily by Bruno Latour, together with Michel Callon and John Law, which analyzes social reality as the outcome of heterogeneous networks composed of both human and non-human actors (technologies, objects, texts, algorithms, institutions). According to ANT: (1) there is no sharp separation between subjects and objects; (2) any entity that produces effects within a network qualifies as an actor; (3) power and meaning are not given a priori but emerge through processes of translation, whereby actors stabilize relations and align interests; and (4) society is not a pre-existing structure but is continuously constructed and maintained by socio-technical networks. Latour uses ANT to overcome classical dichotomies such as nature/society, human/technical, and micro/macro, showing that scientific, technological, and political practices are the product of dynamic assemblages (Latour, 1992, 1999, 2005; Callon, 1986, LAW, 1999).

An important research for the present paper is Sherry Turkle's. She introduces a psychological and cultural approach to human–machine relations, exploring how individuals attribute meaning to technology and construct their sense of self through it. Drawing on psychoanalysis and symbolic interactionism, Turkle analyzes the psychological and cultural impact of digital technologies on identity formation and social relationships. In her early work (Turkle, 1984), the computer is interpreted as an "evocative object" capable of mediating processes of self-reflection and reorganizing the relationship between mind, machine, and subjectivity.

With the advent of the Internet and virtual environments, Turkle argues that identity becomes plural, fluid, and experimental, enabling individuals to explore multiple versions of the self through avatars, chat rooms, and digital spaces (Turkle, 1995), contributing to the contemporary debate on online identity. In later work (Turkle, 2011, 2015), she emphasizes that the promise of control, efficiency, and comfort offered by technology fosters a form of emotional dependency, whereby individuals increasingly prefer predictable interactions with machines over the complexity and unpredictability of human relationships.

An emerging idea of bio-artificial digital sensitivity (BDS).

An integrated artificial digital sensory prosthesis, if made, should not be understood as a *sense*, but rather as a *socio-technical actor* in the sense articulated by Actor–Network Theory (ANT) and discussed above in the last section. Through such a prosthesis, the human individual does not simply extend biological capacities; instead, human agency becomes integrated within a socio-technical assemblage that redistributes perception, action, and responsibility. As Latour argues in line with critiques of mainstream neuroscience, there are no neutral tools—only actors that make other actors act. A so-called "sensory prosthesis" or "digital sense" does not represent the world; it brings a specific operational version of the world into existence. It is therefore not a medium of representation but a producer of relevant reality (LATOUR 2005).

Within ANT, an entity qualifies as an actor insofar as it introduces differences, redistributes agency, and modifies chains of action. The digital sensory prosthesis thus operates as a full actor rather than an intermediary. The human subject does not decide *about* the world, but *within* a pre-structured space of relevance. The prosthesis translates complexity into knowledge, transforms events into risks or opportunities, and converts uncertainty into priorities. It functions as a device of *ontological translation*, not merely informational processing: it does not only manipulate data, but actively structures a new mode of knowing.

Current research and legal analysis on AI primarily focus on regulation and compliance, while largely neglecting *cognitive rights*, such as plural sensory regimes, contestability of evidence, non-optimal situations, unpredictability, and distributed responsibility. Designing prostheses aimed at augmenting biological senses would follow a linear model—world → artificial sensor → interface → biological sense → brain—rendering regulation ex ante extremely difficult.

More radically, a single external integrated digital prosthesis may function as a *new digital sense* complementary to biological senses. This is not a case of sensory extension or substitution, but of a unified external prosthesis that produces an autonomous perceptual channel, irreducible to vision, hearing, or touch. Such an artificial sense exists outside the body but remains epistemically unified. The resulting process can be described as: reality → technical system (multi-sensor + AI) → autonomous synthesis → unitary output (non-classical sensory form) → orientation and decision-making. In other words, the subject does not "see" or "hear," but rather *knows*, *anticipates*, and *orients*.

The integrated artificial digital prosthesis does not enhance the body or extend the senses; even the effect seems to be that one; instead, it redefines responsibility and transforms perception into delegation. While perceptual prostheses amplify experience, the unified artificial sense integrates and partially replaces experience with a new regime of reality construction. Early empirical manifestations already exist in predictive systems, ranking, scoring, and continuous alerting, where subjects no longer perceive directly but rely on automated orientation. Such an external artificial sense can be summarized succinctly: *I do not perceive; I am oriented.*

Thus, biological senses are defined by their evolutionary and bodily constraints, whereas algorithmic systems are designed to produce outcomes. In digital capitalism, their value lies in behavioral anticipation: the future becomes an asset, and the user a probabilistic profile. This marks a decisive distinction between algorithms and senses. While senses generate effects independently of purpose, algorithms are constructed to optimize predefined results.

An integrated artificial sensory prosthesis does not propose actions, recommend options, or merely inform. Instead, it defines the world in which relations acquire meaning. At this point, the digital product ceases to be merely economic and becomes epistemic. The central epistemological distinction can be summarized as follows:

- Senses → experience
- Perceptual prostheses → amplification of experience
- Integrated artificial digital prosthesis → amplification of orientation

Table 4. Fundamental difference between sense and prosthesis

Dimension	**Biological Sense**	**Perceptual Prosthesis**	**Integrated Artificial Digital Prosthesis**
Ontological status	Biological faculty	Technical extension	Socio-technical actor (ANT)
Relation to body	Intrinsic	Body-coupled	External, body-independent
Function	Perceive stimuli	Enhance perception	Structure relevance and orientation
Agency	Passive–active coupling	Augmented perception	Redistributed agency
Neutrality	Non-instrumental	Instrumental	Normative and performative

Epistemic role	Experience	Increased experience	Production of epistemic reality

Source: Author's elaboration. Alessandro@unb.br

However, the use of such a new device could also bring problems. Any typology of cognitive, social, and political risks must first clarify the nature of the normative gap that remains unaddressed by current legislation. Again, these risks cannot be reduced to errors or abuses; rather, they concern deeper structural transformations, including: perceptual heteronomy, namely the delegation of sense-making itself; interpretative atrophy (decline in effectivenes), marked by a diminished capacity to imagine alternatives; epistemic closure, which excludes what cannot be modeled; structural irresponsibility, whereby no single actor can be fully held accountable; the depoliticization of reality, redefined as a purely technical problem; and the colonization of the future, reduced to an exploitable probability, with innovation increasingly concentrated on economic ends alone. Below a summary of main cognitive risk to be faced by an artificial digital sense.

Table 5 - Cognitive risks

Level	Risk	Effect
Cognitive	Perceptual heteronomy	Delegation of sense-making
Cognitive	Interpretive atrophy	Reduction of the imaginable
Cognitive	Epistemic closure	Exclusion of novelty

Source: the author Alessandro@unb.br

CONCLUDING REMARKS

This study has examined the current paradigm of digital innovation and the human–machine relationship framed through biological senses. To interpret physical and symbolic reality are tools not merely for productivity or for the enhancement of human capacities. We cannot reduce the discussion to what technologies and AI decide, but rather to how they contribute to making the world appear as it does. Digital technologies mediate access to reality and actively constitute the field of what is known and knowable, within which subjects, organizations, and institutions exist and operate. From this perspective, the core problem is no longer only what AI decides or who owns it, but how knowledge itself is structured and how we can use new technologies.

In summary, the human-machine paradigm's goal should not be to integrate humans and machines in order to produce a super-empowered being or merely increase communication. Digital technologies contribute to defining reality for us prior to decision-making and what the information and communication's significance. They establish a cognitive space in a way comparable to biological senses, which provide empirical access to phenomena, and they integrate with a cognitive system that pre-exists and is not solely caused by technology. This integration enables a more reflective evaluation of the problems we seek to address and supports better decision-making, not only in relation to productivity and labor.

The analysis conducted through Actor–Network Theory makes it possible to conceptualize an artificial digital prosthesis, if it were to exist, as a fully fledged socio-technical actor endowed with its own agency, capable of redistributing responsibility, translating complexity into salience, and anticipating possible futures. If an integrated artificial digital sense were available, it would also enable engagement with virtual realities that biological senses cannot directly perceive or even imagine. This cognitive potential is probabilistic, depending on how and when it is used, and it reshapes our cognitive relation to reality. With AI and emerging technologies, we are therefore confronted with a new form of sensitivity that supplements those derived from biological evolution. The ontology advanced in this article addresses human evolution not merely in biological terms, but in terms of how humans reason and think.

For this reason, it is necessary to limit the positivist ambitions of the mainstream and to analyze sensitivity itself, in order to better understand what senses, intelligence, and knowledge are for humans, before proposing or arguing technological means to augment them. Those who promote the illusion that AI and digital or biological innovations will make us inherently more powerful, or that Industry 5.0 represents a definitive solution for production, often do so for instrumental purposes, using these narratives as tools of power to manipulate people less informed or less literate.

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