AI & SOCIETY (2025) 40:3333–3348
https://doi.org/10.1007/s00146-025-02191-3

MAIN PAPER

# Beyond cyborgs: the *cybork* idea for the de-individuation of (artificial) intelligence and an emergence-oriented design

**Federico Cabitza**[1,2] · **Chiara Natali**[1] · **Francesco Varanini**[4] · **David Gunkel**[3]

Received: 2 May 2024 / Accepted: 15 January 2025 / Published online: 1 February 2025


**Abstract**
This article contributes to the philosophical inquiry of Artificial Intelligence (AI) by reframing the question "Where is the intelligence of Artificial Intelligence?" into "Where does AI intelligently operate?". This rephrasing challenges our understanding of AI's role in social practices and its integration into the human experience. Central to this discourse is the concept of the '*cybork*' (a portmanteau of 'cyborg' and 'work'), which symbolizes not just a physical entity but a dynamic system of actions and interactions within a socio-technical landscape: work accomplished *with* machines. In this framework, intelligence in AI lies not in any function of isolated systems, but rather in the situated context of their use within collective and meaningful practices that give technology its sense and direction. Conversely, technology both enables and shapes these practices to the extent that distinguishing between the two can seem unnecessary, or even detrimental, to the optimal design of and for work practices. The *cybork* embodies this integration and entanglement, transcending the traditional boundaries between individuals and collectives, entities and actions. It reveals the inseparability and co-dependence of humans and technology, where technological artifacts become extensions of human capabilities, embody collective human history and development, and serve as both products and participants in societal practices, fundamentally shaping our interaction with the world.

**Keywords** Cybork · Cyborg · Socio-technical system · Extended cognition

## 1 Introduction

In this article we will try to outline a line of reasoning to answer the very well-asked question "Where is the intelligence of Artificial Intelligence?". Before we do that, we will argue that the most controversial parts of the above provocative question do not lie in the term 'artificial', nor in any idea of intelligence this concept entails, but rather in its ontological assumption (far echo of the socratic question about the essence of things,—*ti esti*). A better question to understand the phenomenon of study would be to ask "where does AI do what it intelligently does", because even asking where one can find AI in their surroundings would perhaps demand too much from our maybe natural ontological inclination.

Thus, our answer can already be anticipated by summarizing it as follows: intelligence (whatever is meant by this expression in the broad spectrum ranging from the ability to solve problems and adapt to and foster in one's surroundings) in the human–machine configuration lies in using and relying on Artificial Intelligence systems, or rather in the social practices in which these behaviors acquire a sense (both in the sense of direction and in the sense of meaning) and are instrumental to the success of such practices.

We could have proposed a more precise answer for our purposes, though still very obscure: intelligence lies in the *cybork* (sic). This term represents our proposal to seek a line of continuity with, as well as overcoming, Haraway's cyborg concept (Haraway 1985).

✉ Chiara Natali
chiara.natali@unimib.it

Federico Cabitza
federico.cabitza@unimib.it

David Gunkel
dgunkel@niu.edu

1 University of Milano-Bicocca, Viale Sarca 336, 20126 Milan, Italy

2 IRCCS Ospedale Galeazzi - Sant'Ambrogio, Via Cristina Belgioioso 173, 20157 Milan, Italy

3 Department of Communications, Northern Illinois University, 230 University Cir Dr, DeKalb, IL 60115, USA

4 Assoetica, Viale Andrea Doria 48/a, 20124 Milan, Italy

Like the cyborg, we aim to challenge modern, humanist demarcations between human and animal, mind and body, natural and artificial, and most notably, between human and technology. However, the cyborg concept still reinforces boundaries between individual and community, and between entity and act, being and doing. The *cybork* offers a different perspective, viewing the human–machine configuration not as a dyad of separate entities, but as an interactive process (mutual influence), a vibrant network continuously producing, and subjected to, a flow of signs, actions, and their traces.

The *cybork* is the doing and making of a community of actants, human beings and machines, the work done in and by a socio-technical system that is multifaceted and multiple and can in no way be reduced to its component parts. As Barad says, *relata* do not precede and pre-exist relations (Barad 2007); in the same vein, in the *cybork* there are no entities that meet, but continuous interactions aimed at producing and reproducing bodily and material configurations, a process of realization that is never complete and is constantly being updated. In the *cybork* it is possible to recognize "nodes of actions" that we easily conceive as human bodies and technical devices. We do this only for a convenience and shortcut of our animal senses, which have adapted and developed in characteristic environments where each coherent thickening of atoms could be either a predator, a food source, an obstacle, or a refuge. However, being content with what our senses see and touch (by their nature) is not sufficient, especially when we are concerned about design (i.e., constructing new worlds); what we see and touch could be not the right level of understanding, or the adequate theoretical level (i.e., of intellectual vision that sees other beyond—*'altro oltre'* appearance) from which to imagine better worlds (that is configurations), design them, realize them, and judge them (to either discard or improve them).

It is said that machines—but we can speak of tools, supports, prostheses and the like—*extend* human beings; they make them go beyond their limits; and create around them a new world of affordances and possibilities. It is correct, because every machine is a machination: not necessarily a material one, but a contrivance and resource that extends the human being in time and space, and increases their reach and grip in the solution space. In essence, it is an outgoing move. If we were not to add anything, we would still be in the territory of the cyborg. In the idea of *cybork*, instead, there is an understanding of the opposite, in-going movement, which is not strictly alternative but coexistent: any support is the materialization of a phylogenetic process of development occurred elsewhere, thanks to others: using the tool brings this community (or better yet, this collective history of acts) into the individual.

In using the tools that the human community gives to the individuals (and think of the first tool, language), their human nature is pulled out (they are educated) and, at the same time, humanity is imbued into the individuals, shaping their way of thinking, seeing and relating to the world and the others, being capable of exploiting the power of the society (still a technology of control over its members and the physical environment it consumes) and contributing to it.

There is no technology that is not "in use" (otherwise any device would be a mere object): as affirmed by Orlikowski, by paraphrasing Kent's insight on language (Kent, 1993), "technology becomes technology only when it is used" (Orlikowski 1995). More radically, *there is no technology that is not use*. When we see a technology work we see an orderly physical, material arrangement and a process (usually in terms of a pre-ordered constrained flow of energy and matter). Furthermore, technology is an intentional (i.e., goal-oriented), knowledgeable (i.e., knowledge-based), human behavior; something similar was also stated by Mitcham and Schatzberg (2009) when they stated that technology is a "human behavior (genus) involved in the systematic making or using of artifacts (species)". People often refer to this behavior as 'use,' likely because, as Nietzsche observed in a well-known passage[1], we are deeply fixated and obsessed with bodies and objects.

Moreover, use is always part of (and formed by) a practice. We adopt the rich meaning that this term has acquired in the works of scholars recognizing themselves as involved in the practice turn (Schmidt 2011; Kuutti and Bannon 2014) [?]: in this mold, practices are sets of material and routine activities that are intrinsically linked to the social and cultural context in which they take place. Also, practices are configurations of human and non-human actions, including those undertaken by natural agents, animals and technologies, that are organized through specific times and spaces. In particular we follow Gherardi, when she emphasizes that a practice includes not only what people do, but also *how* they do it, as well as the meanings, knowledge and skills that emerge, are expressed and internalized in such activities (Gherardi et al. 2009). A practice, for us, is then a recurring, knowledgeable and meaningful way of transforming (transforming, shaping-across) material and social configurations by whatever can do it. Thus, the *cybork* is the execution of a practice, and its collective behavior is a continuous passing-through (as the root of practice hints at[2]) the thickness of reality to get to the next configuration, where human and

[1] "[...] there is no *being* behind the doing, acting, becoming. *The doer* is merely made up and added into the action—the act is everything" (On the Genealogy of Morals, treatise I, 13, tr. W. Kaufmann) (Nietzsche 2023).

[2] Practice comes from the Attic Greek prattein "to do, act, effect, accomplish; come to an end, succeed," literally "to pass through, travel," from PIE *per(h)—"go through, cross,". See the Online Etymology Dictionary.

non-human acts intertwine, depend upon, and influence each other.

This leads to a collective, or better yet, de-individuated conception of technology (and in fact of human beings too). This holds true at different levels of description. Digital technology cannot be separated into single components within its complex networks of interconnected equipment and devices: only when all parts function together do they perform their role. Otherwise, nothing except their shape distinguishes them from a stone. Technology does not work without the human, who pulls the strings, or heads the helm, or taps the buttons, according to collective practice. Also, the human without technology would not exist, or better yet, would be a different animal. Humans and technology are inseparable, like *relata* do not exist outside their relation. In other words, human is a behavior.

This paper is structured as follows: Sect. 2 will anchor the discussion of the *cybork* within foundational and contextual concepts such as 'cybernetics,' 'cyborg,' and 'work,' while also exploring the origins and meanings of relevant terms such as 'system,' 'organism,' 'agency,' and 'prosthesis.' Section 3 will present philosophical reflections on the term, contrasting the concept of *cybork* with that of cyborg and examining their respective implications. Section 4 will explore the anthropological dimensions of the *cybork*, particularly in relation to labor and knowledge, framing it as a fusion of collective human work and technological augmentation. Finally, Sect. 5 will critically situate the *cybork* concept within socio-technical and extended cognition frameworks, and outline examples of its instantiation from the perspective of the sciences of the artificial (Simon 1988), or the science of design. Finally, Sect. 6 will conclude by summarizing the main arguments and proposing future directions for research on the evolving interaction between humans and technology as embodied in the *cybork* concept.

## 2 The philological perspective: narratives fueling the idea of the *cybork*

This section presents a philological introduction on the foundational and contextual expressions tied to our understanding and definition of the *cybork*. We begin from this perspective to explicitly highlight the main narratives that informed our conceptualization and to trace a genealogy of the *cybork* concept.

To set the stage to the *cybork* narrative, we present a foundational exploration of key terms—such as intelligence, systems, agency, technology, and others—emphasizing their etymological evolution and the dynamic nature of these concepts. This analysis is crucial for understanding the conceptualization of the *cybork*, a term that synthesizes these evolving ideas into a coherent framework reflecting the co-evolution of technology and societal structures. By tracing the historical and intellectual transformations of these terms, this section deepens our understanding of each concept and highlights their collective impact on the formation of the *cybork*.

The concept of *cybork*, far from emerging *ex nihilo* or as the byproduct of arbitrary ideational amalgamations, stands as a term that embodies a confluence of intellectual currents, all the while imparting novel dimensions to them by virtue of its inherently synthetic constitution. Rather, it synthesizes intellectual currents from fields like cybernetics, socio-technical system theory, and systems thinking. While many approaches similarly explore intelligence as a hybrid phenomenon, the *cybork* concept aims to advance this discussion by emphasizing the dynamic, practice-driven entanglement of humans and technology. Our intention is not to claim radical originality or resolve the complex issue of intelligence but to offer *cybork* as a useful theoretical tool. By doing so, we contribute to existing discourse, providing a term that helps clarify the evolving nature of socio-technical systems and the human-technological nexus. In this way, *cybork* serves as a bridge between disparate domains of knowledge and inquiry, enriching our understanding of these interactions and supporting further inquiry in this space.

### 2.1 Cybernetics

As quite clear, the first part of the term *cybork* comes from **Cybernetics**. As widely known, Cybernetics is the name that Norbert Wiener in 1948 gave to a multi-form and trans-disciplinary approach to the study of any complex system from the perspective of the self-regulatory and feedback processes that keep it together, if not thrive (Wiener 1961). Wiener chose this term from the Greek *kybernetiké*, the craftsmanship of the *kybernan*, i.e., the steersman, a term that in its turn the Latin translated into *gubernator*, which acquired its metaphorical meaning of head and commander thanks to his respected exhortations. Its formal entry into the Oxford Dictionary by 1987 reflects the gradual recognition of cybernetics as a distinct field of study, emphasizing the growing significance of this interdisciplinary domain in understanding complex systems.

While bearing a distinctly American appellation and the concerted effort toward systematization, the roots of cybernetic thought can be traced to the inherently multidisciplinary perspectives of German and Austro-Hungarian intellectuals who were compelled to flee to the United States in the face of Nazism (Rosenblueth et al. 1943). This historical migration of thought shaped cybernetics into a transnational and transdisciplinary field.

### 2.2 Cyborg

The term **Cyborg**, short for "cybernetic organism", was coined by Clynes and Kline (1960) to describe a new frontier in human evolution, wherein biological functions could be augmented or replaced by technological means. Their vision was primarily aimed at the enhancement of human capabilities to withstand the harsh conditions of space, proposing a symbiosis of human and machine that would transcend the limitations of the human body. Clynes and Kline's seminal work, "Drugs, Space, and Cybernetics: Evolution to Cyborgs" (Clynes and Kline 1960), presented at the Psychophysiological Aspects of Space Flight Symposium, introduced the concept of the cyborg as an integrated system where artificial mechanisms extend the body's innate regulatory functions.

Their assertion that adapting the human body to space was more logical than attempting to recreate terrestrial conditions in extraterrestrial environments marked a pivotal moment in the discourse on human enhancement and technology.

It reflects a broader shift towards viewing technology not as an external tool but as an intrinsic part of the human condition, capable of expanding our physical and cognitive horizons. The legacy of their work continues to shape contemporary debates on human-technology integration, ethics, and the future of human enhancement in the twenty-first century. This term is further discussed and elaborated upon through Haraway's understanding in Sects. 4 and 3, respectively through anthropological and philosophical sensibilities.

### 2.3 Intelligence

Relative to the expansion of our cognitive horizons, **Intelligence** closely regards the capability to bring things together (cf. inter-lĕgo), to discriminate and choose among them, and to stand in the midst of them (which is also the literal meaning of the term *to understand*): an intelligent gaze on things and events sees and conceives relations between them (e.g., the basic relation of cause and effect), both relations holding *in presence* (cf. the paradigmatic relation that Saussure calls metonymy) and also *in absentia* (what Saussure calls metaphors). In this regard, we have already recalled that Nietzsche was one the first Western thinkers to denote the tendency to see things where actually just actions are[3] (Nietzsche 2023), that is to acknowledge the potentially harmful tendency to *reify* dynamic processes into metaphoric, yet static, entities,[4]. More specifically, the conceptualization of the *cybork* as a collaborative space (cf. the Nonaka's *Ba*), an instance of *extended cognition* and *hybrid intelligence* is explored in Sect. 5.

### 2.4 Technology

**Technology** is a relatively modern term, popularized by Jacob Bigelow in the early nineteenth century (Bigelow 1829). Unlike "technique," which focuses on the skillful application of knowledge in various crafts and practices, "technology" denotes the systematic application of scientific knowledge towards practical objectives, particularly in industrial and economic contexts. Bigelow's introduction of "technology" signified a shift towards understanding tools, machines, and systems within the framework of industrial development and economic productivity.

This semantic differentiation reflects a broader tension in the discourse on human–machine interaction. The "*cybork*," embodying the principles of technique, maintains a commitment to human essence and creativity, emphasizing a respectful and integrative approach to technological augmentation. In contrast, the "cyborg," aligned with the domain of "technology," might be seen as representing the culmination of technological advancement where the focus is on the enhancement and extension of human capabilities through more systemic, industrial, and potentially dehumanizing means.

### 2.5 System

The concept of **System** (from the Greek "ensemble of things put together") complements this discussion by emphasizing the arrangement of interconnected entities and their mutual relations. These mutual relations can be variously relevant to constitute the above order, or even the nature of the related things themselves (Barad 2003).

Other (intended isomorphic) metaphors have spread and gained general appeal in scholarly communities, including the communities engaged in the organizational studies and the design sciences: their members like to speak of *models* (small-scale representations of a system, pruned off of unnecessary details), *frames* (Orlikowski and Gash 1994), *structures* (Greenhalgh and Stones 2010), and even *infrastructures* (Bowker et al. 2009).

The term "system" carries a historical richness that is integral to understanding its contemporary usage within

[3] If Nietzsche was among the first ones, Becker is probably among the latest ones, when he writes that "things are just people acting together" (p. 46) (Becker 2008)

[4] The etymology of *thing* i.e., a public assembly of people discussing "things of concerns" (from which it comes the metonymy by which the latter ones got the name of the former one) is a common place that we just hint at here.

socio-technical discourse. Originating from the ancient Greek *sýstema*, it denotes a 'complex' or an assemblage, closely linked to the concept of *sýnthesis*, the action noun derived from the verb syntíthenai, meaning 'to put together, combine.' This etymology underscores the intrinsic nature of systems as entities that emerge from the integration and unification of disparate components into a cohesive whole. The notion of *sýnthesis*, as the antithesis of *análysis* (which signifies the breakdown or deconstruction of complex entities into simpler elements), further enriches the conceptual landscape in which "system" is situated.

Whereas analysis aims to dissect and understand systems by examining their individual components, synthesis highlights the emergent properties and behaviors that arise from the interaction and combination of these parts. Recognizing the term 'system' as embodying the principle of synthesis encourages a move away from overly reductionist or mechanistic approaches to socio-technical systems. Instead, it fosters an appreciation of these systems as fluid, interconnected wholes, whose properties cannot be fully understood through analysis and theory alone. Notably, systems occupy a space, and we often recognize them—sometimes through an arbitrary act of recognition, demarcation, and selection (cf. again 'inter-lego')—by their capacity to produce outcomes, effects, and facts. After all, facts are constructed (from the Latin facta), and even the German Thun derives from a root meaning 'to put together' (cf. the Greek tithemi).

## 2.6 Structure

The etymology of **Structure** roots in the Latin word *structus*, signifying a heap or pile–essentially, entities aggregated layer upon layer. The term *structūra* further elaborates this concept into the notion of a building or construction, envisaging a creation brought to life brick by brick. These terms both stem from *struō*, meaning "to make by joining together, to build, erect, form, construct". In this light, the original connotation of structure encapsulates the outcome of a process characterized by the cumulative layering of materials. This process, initially, might not have been guided by any predetermined plan or design, highlighting an organic, emergent property of construction that predates the more modern interpretation of structure as an ordered arrangement.

This historical perspective reveals that "structure" once embodied a dynamic and processual essence, a far cry from the static and rigidly ordered connotation often ascribed to it in contemporary discourse, particularly within the domains of information technology, business management, and modeling. The evolution of the term to denote an ordered arrangement, especially as employed by Cicero in the context of language and rhetorical art, underscores a conceptual shift towards viewing structures as manifestations of deliberate, designed order rather than as the natural outcomes of iterative, layered processes. Recognizing this etymological journey invites a reconsideration of the term within socio-technical discourse, suggesting a return to an appreciation of structures as inherently dynamic, constructed entities that evolve over time through the interplay of various components and influences, rather than as static, unchanging constructs.

We here make the point, partly inspired by the theses of linguistic relativism (Whorf 1956),[5] that these metaphors, besides affecting our comprehension of the *cybork* (like any metaphor actually does), do also affect our comprehension and design of these systems through an overemphasis of the static, ontological and objectivistic phenomena that they exhibit.

This influence regards what the German philosopher Heidegger (1954) denoted as Gestell, literally a frame, a structure of shelves, or the enframing structure that can be imposed on people, processes, and things and any sort of system by any sort of technology, among which also language (Bernstein 1986). However, as also noticed by Ciborra and Hanseth (1998), the words Ge-stell and system indicate just the same concept (literally), in two different (but yet often converging) linguistic traditions.

Varanini (2009), Bocchi and Varanini (2013) propose an alternative metaphor for understanding systems in which we live and work. Instead of *Gestell* (or Gestalt), they introduce ***Gebild***, which can be translated as construction, formation (in the sense of arrangement), or shape—essentially, a dynamic structure. Notably, *Gebild* is derived from and closely related to *Bildung*, which connotes growth, refinement, and development. This distinction was first put forth by Goethe in his "The metamorphosis of plants" from 1790 (Goethe and Miller 2009). In his own words:

> The Germans have a word for the complex of existence presented by a physical organism: Gestalt. With this expression they exclude what is changeable and assume that an interrelated whole is identified, defined and fixed in its character. If we look at all these Gestalten, especially the organic ones, we will discover that nothing in them is permanent, nothing is at rest or defined—everything is in a flux of continual motion. This is why German frequently and fittingly makes use of the word Bildung (formation, development) to describe the end product and what is in the process of production as well. Thus [...] we should not speak of Gestalt, or if we use the term, we should at least do so only in reference to an idea, a concept, or to an empirical element that s held fast for a mere moment of time.

5 Simply put, linguistic relativism states that the language by which we describe the world affects our interpretation of it.

When something has acquired a form it metamorphoses immediately to a new one[6]

Gebild is then the "shaping form" (Varanini 2009) considered in a continuous evolution. The same object can be considered both as Gestalt, i.e., something standing firm and constant over time, and as Gebild, a sort of elusive image (or a picture of a fact, a là Wittgenstein). However, Goethe points out that looking at the continuous change of Nature, the reassuring and comforting certainty of the Gestalt is but an illusion (and perhaps even a delusion). Likewise, it is an illusion the idea that one form (one structure) can be given once and for all, and as such this is stable over time (Varanini 2009).

Thus, while Gestalt expresses the idea of something that has got a definitive and static shape (form), Gebild and Bildung express dynamic concepts, related to an ever-changing and ever-growing process, that is Bildung, as well as the thing resulting from this process, that is Gebild. This latter entity is the *organism*, which is another apt term in our argument.

### 2.7 Organism

The term **Organism** is intertwined with the ideas of action and deed: "what by means of which work is done", "that which is wrought or made", but also "what makes and does". This word comes from one the deepest linguistic roots our language shares with the others, *werg- that stands for "to do".[7]

Organisms can be natural, of course, but also artificial, when machines are complex enough to exhibit autonomous actions and behaviors. Moreover, claiming the continuity between life and technique, and between human beings and the machine is no longer eccentric, especially after the "blasphemy" purported by Haraway in the late twentieth century, which she called the *cyborg*: "a cybernetic organism, a hybrid of machine and organism [made of human beings in their] unchosen 'high-technological' guise as information systems, texts, and ergonomically controlled laboring, desiring, and reproducing systems [intertwined with] machines [...] as communication systems, texts, and self-acting, ergonomically designed apparatuses" (Haraway 1991). The concept of the "organism" serves as a convenient formal-logical framework, enabling the theoretical conflation of humans and machines. After all, "nothing is more human than a machine" (Canguilhem et al. 2008, p. 8),[8].

### 2.8 Agency

The conceptual leap from organism to **Agency** is indeed minimal, yet profoundly significant. Agency, an inherently complex and somewhat elusive term, has been adopted by digital philosophers as a surrogate for the concepts of freedom, power, and capacity (Brey and Søraker 2009). This choice reflects a reluctance to dilute its rich connotations through translation. Therefore, the term 'agency' is preferred, as it signifies a domain where humans and machines coexist, characterized by their resemblance, interchangeability, and mutual replaceability in terms of their capacity to act—meaning their ability to affect their surroundings.

While acknowledging the potential autonomy of machines, the *cybork* deliberately maintains a 'loose coupling' within the system, ensuring that the human element remains distinct yet integrally connected. In contrast, Haraway introduces the concept of 'orgs' (organisms) as entities that, freed from their flesh-and-blood complexities, can pursue cybernetic emancipation, thereby liberating themselves from patriarchal dominance. However, this abstraction of 'orgs' strips away the visceral essence of humanity, along with its historical and cultural narratives. Compared to Haraway's 'cyb-org,' the *cybork* represents a more grounded concept, anchoring the discourse in tangible human experience and societal constructs. It signifies not an abstract entity but a culturally and historically situated human individual or collective, actively engaging with technology to enrich their experiential continuum, integrating mind and body as inseparable components of a socio-technical system. This can perhaps be more accurately described as dynamic human–machine reconfigurations (Suchman 2007).

Following a similar suggestion, Longo (2005) introduced the concept of *symbiont*, i.e., a natural participant in what Licklider (1960) termed *man-computer symbiosis*, which extends the semantic scope of the concept of life (bios) perhaps a bit too far. In fact, references to symbionts and symbiosis are as evocative as they are misleading, as they indulge in anthropomorphizing machines (as if machines

[6] cf. Goethe's Botanical Writings, pp. 215–19, cited in Seamon (1998)

[7] "Cognates: Greek ergon "work," orgia "religious performances;" Armenian gorc "work;" Avestan vareza "work, activity;" Gothic waurkjan, Old English wyrcan "to work," Old English weorc "deed, action, something done;" Old Norse yrka "work, take effect". Online Etymology Dictionary, ©2001–2016 Douglas Harper.

[8] The Greek word for machine, mechané means "any artificial means or contrivance (i.e., device/arrangement/expedient) for doing a thing": the machine cannot be decoupled from either its skillful use or the goal it is aimed at. Likewise, and differently from many mainstream translations of the treatise by Aristotle about machines, we translate its beginning as follows: "Remarkable things occur [not in accordance with nature but rather] along and beyond it [parà phýsin], which are produced through techne for the advantage of humanity [...] whenever it is necessary to produce an effect [prâxai] beyond nature [parà phýsin]. [...] Therefore we call that part of techne [méros tes téchnes] solving such difficulties, a machine."

were capable of reciprocation). Even more problematic, they portray machines as substantially *different from* humans, rather than recognizing them as integral to human culture and, by extension, to humanity itself.

More correctly one could speak of *structural coupling* (Maturana 2002) between the technical element and the human element. Structural coupling between two systems, taken as "plastic composite unities", takes place whenever they "undergo recurrent interactions with structural change but without loss of organization" (Maturana 2002) (p. xxi).

### 2.9 Prosthesis

The term **Prosthesis** requires particular attention for our conceptualization of the *cybork*. It originates from the Latin "prothesis" and the Greek "próthesis," meaning 'I put in front,' encompasses actions and intentions that go beyond its modern connotation as a mere physical addition to the body. The etymological roots of the word suggest a deliberate act of positioning, presenting, or preparing something in the forefront, imbuing the concept of prosthesis with a dynamic and interactive quality. This understanding extends the notion of prosthesis from a static physical augmentation to an active engagement in the relationship between humans and machines.

In the context of human–machine interaction, a prosthesis not only compensates for physical limitations but also enables a deeper, more integrated interface with technology. It embodies the human contribution to the symbiotic human–machine system, emphasizing the active role humans play in shaping and co-evolving with technology. These tools are extensions of human intention and creativity, rather than mere physical aids, and result from a process that neuropsychologists refer to as *embodiment* (Zbinden et al. 2022), whereby the individual comes to perceive the artificial extension as part of the self, possessing a sense of ownership. The concept of prosthesis as 'putting a human being in front' underscores the centrality of the human element in the design and application of technological aids, highlighting a human-technology co-evolution in mutually enriching partnerships.

Thus, also the idea of cyborg must be overtaken. The idea that a single organism can be augmented by some artificial prosthesis is simplistic for at least two reasons: first, because it does not consider the bigger context that makes the prosthesis either possible (who built it?) or effective (i.e., what configuration of forces and competences makes it useful, e.g., the power grid supplying energy to any computational device); second (and worse yet) because it does not consider the aims by which the augmentation has been pursued, that is the intentional activities that the newly designed hybrid organism can perform better, or now accomplish. Thus, it is important to focus on what, although grounded on the human and even on single individuals, goes beyond the individual and makes a collective effort concrete: *work*.

### 2.10 Work

We began this philological journey with the term cybernetics and now arrive at the conclusion, tying together all the concepts encompassed by the term cyborg: the concept of **Work**. This term in the main Latin languages is associated with ideas of fatigue and pain (e.g., the Italian *lavoro* comes from the Latin labor, i.e., toil, effort; the Spanish *trabajo*, as well as the French *travail*, come both from *tripalium*, a particular yoke for slaves and pack animals). In fact, as said above *work* (what in German is Werk, i.e., neither Arbeit, nor Mühe) comes from the same root behind the Greek *érgon* (literally, work) and from there, after a long but yet direct semantic trajectory, our *organization*. Work then is not related to exertion, pain, atonement; but rather to energy, expression of force, accomplishment, and (what produces) wealth. In one word, to effective action.

Section 3 elaborates how this effective action dissimulates the tool with which *work* is performed, effectively embedding it in the work being performed. The Marxian understanding of *General Intellect* briefly explored in Sect. 4 further elaborates on the inextricable connection of work with collective human knowledge, transcending individual contributions.

### 2.11 What's in a name?

In light of the terminological roots discussed in the preceding sections, it becomes evident that the term *cybork* is more than just a portmanteau that combines the semantic domains and associated traditions of *cybernetics, cyborg*, and *work*; it also signifies their extension and evolution. Specifically, if the cyborg refers to an organism where natural and artificial elements are inseparably intertwined and mutually adapted; and if *work*, as previously noted, is defined as a set of intentional, *mutually dependent* activities purposefully coordinated to achieve a common goal (Schmidt and Bannon 1992); then we can clarify what we mean by *cybork* in the context of these two concepts.

The *cybork* is a *collective organism*; a *hybrid agency*; a *network of actants* (Latour 2005); a *humanchine network* formed through the activities of humans and non-humans acting collectively (though not necessarily in perfect unison) (Atkinson and Brooks 2005); a configuration of active forces greater than the sum of its parts, or more accurately "other than the sum of its parts" (Koffka 2013): a kind of *collective* composed of both humans and non-humans.

The idea that is denoted by such a hybrid word itself, *cybork*, is that it is an idle question to understand[9] what element, between the human-social one and the artificial-technical one, come first, is more relevant or necessary; as well as to understand how to design the technical side to support, or substitute!, the human side. The idea of the *cybork* is that where humans and their tools go together there is only action to be observed; ways in which action is "fed back" by other action; there is only work and reflection, and how the coupling between these two unfolds over time and transforms the world. Thus, designing for a *cybork* entails creating the preconditions and determinants necessary for the emergence of practices in which human–machine configurations evolve. We will revisit the design perspective after introducing two additional viewpoints into the discussion: the philosophical and the anthropological, which will be explored in the next sections.

## 3 The philosophical perspective: from boundary breakdowns to technology entanglement

This section critically examines the cyborg and *cybork* concepts through the lens of contemporary philosophy, particularly engaging with Donna Haraway's reinterpretation of the cyborg as a breakdown of traditional ontological distinctions (Haraway 1985), and Martin Heidegger's analysis of tool use and human-technology entanglement (Heidegger 2010). This analysis challenges the conventional views that delineate strict boundaries between human and machine, proposing instead that these categories are deeply intertwined and historically contingent. Haraway's perspective reveals the cyborg as an emblem of contested boundaries, highlighting how human identity has always been configured in relation to technology. Similarly, Heidegger's insights into the embeddedness of tools in human activities further dissolve the separation between humans and their technological extensions, suggesting a pre-existing hybrid state—what we term ' *cybork*'. This section thus positions the *cybork* not merely as a theoretical construct but as a lived reality, reshaping our understanding of human-technology interactions and challenging the individualistic premises of modern thought.

In her essay "A Cyborg Manifesto," (Haraway 1985) Donna Haraway famously does not define"cyborg" as a human being augmented with technological prostheses. That formulation of term is far too literal—harkening back to the previously-mentioned work of Clynes and Klin (1960)—and is, as Haraway argues, actually derivative. As Haraway characterizes it, "cyborg" names a crucial breakdown between the ontological distinction of human/animal and animal/machine. Although she does not say it in this exact way, cyborg deconstructs the classic set of binary oppositions by which we—human beings—have defined ourselves and secured our assumed sense of exceptionalism in relationship to those others who are our excluded other.

Haraway, it is important to point out, does not incite, institute, or invent these boundary breakdowns. She simply traces the contours and consequences of border skirmishes or untenable discontinuities that have been underway within and constitutive of the Western philosophical tradition. The cyborg, therefore, does not cause or produce this ontological erosion of the human subject; it merely provides this dissolution with a name. For this reason, "cyborg" identifies not just an enhanced human being, as is formulated in the transhumanist movement. It also describes the rather unstable ontological position in which the human subject already finds itself. We have, therefore, always and already been cyborg, insofar as the difference between human and animal and animal and machine have been and continue to be undecidable, contentious, and provisional.

Thus, when the human subject picks up and uses a technological object to do work or get something done, the separation of subject and object is not some a priori given but a theoretical and ideological contrivance that we impose on the relationship between the human organism and technological artifact. The German philosopher Martin Heidegger already identified this in Being and Time (1927) (Heidegger 2010), when he demonstrated how a tool or instrument is never existentially encountered as a thing out there in the world, but always and already is embedded in the work and therefore is an extension of the human user. Or as Michael Zimmerman succinctly explains: "In hammering away at the sole of a shoe, the cobbler does not notice the hammer. Instead, the tool is in effect transparent as an extension of his hand... For tools to work right, they must be 'invisible,' in the sense that they disappear in favor of the work being done" (Zimmerman 1990, p 139).

For Heidegger, then, the tool does not show itself as a tool separate from the human engaged in the work. They are already fused in a hybrid-being that is a *cybork*. The tool only appears as such and becomes noticeable as something separate, when it fails to function, breaks down, or is not otherwise available for use. It is at this point that the object comes into being and is objectified as such. Heidegger calls this Vorhandenheit or present-at-hand, because it expresses how what had been Zuhandenheit-ready-at-hand or "handy"-falls out of that condition and lays there before us as a mere object standing opposite a subject (the German word for this

[9] Here, we reiterate that to understand implies 'to stand in between,' that is what happens when one can discern the relata from the relation itself.

is Gegenstand or “standing against”). This mode of being, therefore, is not original; it is derivative.

Consequently, like Haraway’s “cyborg,” the *cybork* is already the condition in which we find ourselves. We are always and already tangled up in our tools and instruments and these entanglements already shape our understanding and definition of ourselves as “human.” The classic Western distinction between human subject and technological, is actually a secondary and derivative state of being that itself only comes into being when something disturbs this condition or fails to work. But this does not mean that “*cybork*” is just another name for what has been called “cyborg.” The latter is still too subjective and beholden to the individualism that is the hallmark of Cartesian metaphysics. *cybork* by contrast recognizes that the concept of the (post)human subject is also derivative, only coming into being as a product of having been subsequently differentiated from its objects, i.e. by finding itself standing opposite from and taking possession of the object as it comes to be objectified. *cybork*, therefore, acknowledges that we (understood as in terms of a primordial undifferentiated plurality) are originally tangled up in and involved with a myriad of others with whom/which we always and already share a common bond of kinship.

## 4 The anthropological perspective: from the *Body without organs* to the human (collective) body

This section develops Donna Haraway’s discussion on the cyborg as a boundary-defining entity that challenges established notions of gender and identity, to introduce the boundary blurring that occurs also between the individual and the collective.

We discuss the Marxian concept of the ‘General Intellect’ to conceptualize the *cybork* not just in terms of labor but as a fusion of work and knowledge, reflecting a collective human capacity that transcends individual contributions.

Elaborating on the transhumanist vision inherent in Haraway’s work, the author contended that machines in the mid-20th century were merely extensions of a male-centric reproductive vision, serving as “a caricature of the male-dominated reproductive dream.” However, she notes a significant shift in the late 20th century, where machines began to blur the lines between natural and artificial, mind and body, and self-generated versus externally imposed designs. These machines, described as “self-propelled, self-designed, autonomous,” embody “man’s dream” and are imbued with vitality, contrasting starkly with our own perceived lethargy. Haraway suggests this evolution marks a new frontier for reimagining oneself as part of a cyborg identity.

Yet, the advancements witnessed in the current century—spanning Artificial Intelligence and robotics–echo, and perhaps intensify, the very caricatures Haraway critiqued. Despite technological progress, the machines and systems developed continue to reflect a predominantly masculine vision, one that not only seeks to transcend human mortality through medical innovation but also aims to diminish our humanity via technological augmentation. This vision, predominantly championed by a select group of male techno-scientists and entrepreneurs in Silicon Valley, still harbors aspirations toward creating life, Artificial Intelligence, and consciousness in its own image. The persistence of this vision underscores a critical reflection on our socio-technical landscape, revealing how contemporary technological endeavors, much like their predecessors, remain deeply entangled with gendered aspirations and power dynamics.

Donna Haraway’s engagement with the philosophical landscape is both nuanced and selective: she briefly references Jacques Derrida, whose exploration of the machine introduces a post-surrealist vision that aligns with certain interpretations of the cyborg. Specifically, it connects with the vision of a cyborg as a being intent on self-reinvention through the detachment from historical and cultural foundations. Instead, she places significant emphasis on Michel Foucault’s concept of biopolitics (Foucault 1988), viewing it as a central pillar in her exploration of the interplay between technology, identity, and society. Foucault’s analysis of the ways in which power operates through the regulation of bodies and populations provides a critical backdrop for understanding the cyborg as a figure that transcends traditional boundaries and classifications.

Although Gilles Deleuze is not directly cited by Haraway, Rosi Braidotti’s preface to the Italian edition of Haraway’s work (Haraway et al. 2018) suggests a conceptual resonance with the radical ideas presented in Deleuze and Félix Guattari’s “Anti-Oedipus” (Deleuze and Guattari 2009). Braidotti interprets Haraway’s cyborg theory as aligning with Deleuze and Guattari’s rejection of rigid psychoanalytic frameworks (notably the Oedipal complex) and their advocacy for a fluid, multiplicitous understanding of desire and identity. This reading positions Haraway within a Deleuzo–Guattarian framework, emphasizing the cyborg’s potential to challenge and dismantle hierarchical structures and binary oppositions.

In this context, Haraway’s work can be seen as a call to rethink the foundations of our understanding of the self and its relation to the other, be that other human, non-human, or technological, inviting a reevaluation of power, identity, and resistance in the age of advanced biotechnology and digitalization.

In “Anti-Oedipus,” Gilles Deleuze and Félix Guattari introduce the concepts of the “Body without Organs” (BwO) and the “Desiring Machine,” offering a radical rethinking of desire, production, and the self beyond traditional psychoanalytic frameworks. The BwO represents a plane of immanence or a canvas of possibilities, devoid of hierarchical organization or pre-defined functions, while the Desiring Machine symbolizes the flows and breaks of desire that create and disrupt connections within this plane.

Drawing an analogy between these concepts and technology, where the BwO is likened to hardware and the Desiring Machine to software, provides an insightful framework for understanding the cyborg. In this analogy, hardware serves as the foundational support or the "Pre-plan" upon which software, or the operational logic and processes of the Desiring Machine, is organized. This relationship underscores the idea that every system, whether a singular device or larger societal configurations like the State, is constructed upon a BwO, which represents a fundamental level or "Grade Zero" of intensity and potential.

Therefore, within this conceptual framework, the cyborg can be viewed as a Desiring Machine grafted onto a Body without Organs. This representation illuminates the cyborg as a nexus of potentialities, where human (BwO) and technology (Desiring Machine) merge to create a being of intensified desires and capacities.

The tendency to equate technology exclusively with tangible tools or machines overlooks the profound significance of the human body as the primordial technical object. Marcel Mauss's seminal 1934 lecture, "Les Techniques du corps" (Mauss 2023), serves as a foundational text in understanding this perspective. Mauss elucidates that the body is humanity's first instrument, positing it as the original site of technicity. This framing invites a reconsideration of technology not merely as external apparatuses but as intrinsic to the embodied human experience.

Mauss's work reveals the often unconscious competence with which humans engage with bodily techniques, practices that are so ingrained in our daily lives that we perform them without explicit formal knowledge. He critically addresses the fallacy of universal technical solutions, highlighting the diversity of bodily practices across cultures and cautioning against the imposition of homogenized techniques under the guise of authority or progress. This imposition, often facilitated by a blend of disrespect for cultural particularities, threatens to erode human difference and tradition.

In light of Mauss's insights, the rush towards digital technologies and the cyborgian integration of mechanical augmentations into the human form warrants a critical pause. The transformation into cyborgs—without a concurrent understanding and appreciation of the body's intrinsic technical capacities—risks amplifying our disconnection from our own embodied techniques. If we are not proficient in the art of wielding our primary technical object—the body—how can we hope to skillfully navigate the complexities introduced by external prosthetics and augmentations?

Mauss's reflections offer a compelling critique of contemporary technological enthusiasms, urging a return to the corporeal fundamentals of technicity. In considering the future of human-technology relations, Mauss's emphasis on the body as the first technical object provides a crucial counterpoint to the narrative of relentless digital advancement.

This conceptualization of the *cybork* embodies a historical and material consciousness, despite its deep integration with technology in ways unforeseen by earlier thinkers such as Karl Marx. However, drawing upon Marx's "Fragment on Machines" from the Grundrisse (Marx 2005), where he discusses the concept of General Intellect—a collective, societal knowledge that transcends individual contributions—it's conceivable to argue that Marx was, in essence, anticipating the "*cybork*". This entity is not solely defined by its labor ("work") but also by its engagement with and contribution to collective human knowledge. Therefore, the inclusion of the letter "k" in "*cybork*" might be interpreted as signifying both "work" and "knowledge", epitomizing the dual essence of this conceptual entity.

This interpretation situates the "*cybork*" within a rich dialogue about the intersection of technology, labor, and knowledge in the construction of identity. Unlike Derrida's post-surrealist machine, which may seem to advocate for a rupture from the past, the "*cybork*" is deeply embedded within the continuum of human history and knowledge: technology does not sever ties with cultural and historical roots, but rather serves as a medium through which these connections are reinterpreted and reinvigorated.

## 5 The design science perspective: socio-technical and extended cognition

This section positions the concept of the *cybork* within socio-technical and extended cognition frameworks, both of which are vital for understanding its potential in the design and assessment of human-technology agencies. Serving as the cornerstone of our analysis, this section thus acts as a bridge between the theoretical insights discussed earlier and practical applications, ultimately resulting in a comprehensive framework for designing human-technology arrangements.

Initially we recognize that the *cybork* concept builds upon established frameworks such as systems thinking, which theorizes the integration of human and technological capabilities into unified, dynamic entities. The discussion then transitions to exploring how the *cybork* extends cognitive processes beyond the individual by incorporating tools and environments into a wider cognitive system, as highlighted by extended cognition theory (Clark and Chalmers 2016). This theoretical progression leads to what we consider the most significant contribution of this work: a new approach for understanding and designing technologies that transcends conventional socio-technical boundaries. By addressing both socio-technical and cognitive aspects, we present practical examples of what constitutes a *cybork*. In doing so, we aim to set the stage for further contributions, especially regarding the *cybork*'s potential to redefine human–machine interactions within complex systems.

The section concludes with key implications for design practice, presenting a set of design principles that serve as a roadmap and offer practical guidance for creating technologies that genuinely support and enhance human cognitive and social capabilities.

### 5.1 Systems thinking and socio-technical systems

The foundational concept underpinning the discussion on *cybork* is that of feedback—namely, the mechanism by which a portion of an apparatus's output energy is rechanneled back as input, thereby instituting a cyclical process of action and reaction. Moreover, it is posited that a uniform behavioristic analysis, irrespective of the complexity of the observed behavior, is equally applicable to both mechanistic constructs and living organisms. These core ideas were instrumental in the conceptualization and development of *Cybersin*, a term coined to denote the "cybernetic synthesis" that integrates the actions of individual workers with the productive capabilities of factories and plants within the nationalized segment of Chile's economy during the tenure of the Unidad Popular Government (1971–1973) (Loeber 2018). This project aimed to interconnect economic data and decision-making processes into a cohesive, nationwide network. This effort envisaged, for the inaugural time, the conceptualization of a nation as a living organism—a complex system where humans and machines are not merely cohabitants but integral components, structurally intertwined to such an extent that they are perceived as unified elements of a singular, expansive network (Medina 2006). This vision represents a radical reimagining of societal and economic structures, proposing an integrated alignment of human labor, technological systems, and feedback mechanisms within the broader framework of the national economy and governance. It paves the way for the idea that these structures can be designed, implemented, and evaluated based on desirable behaviors and performance.

**Systems thinking** is a paradigm that surfaced in the 1940 s, when it stood as an intellectual counterpoint to the limitations of scientific reductionism, by advocating for a comprehensive approach to problem-solving through the strategic amalgamation of heuristics and multifaceted methodologies. This inclination towards a *pluralistic* perspective underlies the nuanced and often complex employment of language within systems thinking, a domain where terminological precision and conceptual clarity are paramount, yet simultaneously contingent upon the contextual engagement of the practitioner (Bednar 2016). Within the lexicon of Systems Thinking, the notion of the *socio-technical system* emerges as a central idea, epitomizing the interdisciplinary nature of this field (Emery and Trist 1960). This term highlights the inherent interconnectedness of social and technical elements within organizational environments, advocating for an integrated analysis that moves beyond the conventional dichotomies often prevalent in the analysis of complex systems. By embracing this holistic approach, Systems Thinking facilitates a deeper understanding of the interactions that shape the relationship between human agents and technological infrastructures, thus offering a robust framework for understanding the complexities of contemporary socio-technical systems (Emery and Trist 1960).

The term **socio-technical system** was conceptualized at the Tavistock Institute in London during the 1950s, marking a new perspective on organizational change and the design and improvement of processes in which humans use technology to accomplish their work. This approach, which is deeply rooted in the Kleinian interpretation of Freudian psychoanalysis, posits humans and machines as integral to the emergence of distinctive work forms—essentially, socio-technical systems. These systems do not preexist as independent from their animate and inanimate constituents; instead, they manifest and evolve through the dynamic interplay and mutual adaptation of these elements, subsequently influencing the configuration and behavior of their components (cf. Aristotle).

Pioneers in socio-technical research, including Eric Trist, Ken Bamforth, Joan Woodward, and Fred Emery, recognized this phenomenon in work environments where the division of labor, driven by efficiency, engenders distinctions and hierarchies. Furthermore, they observed it in contexts where the pursuit of efficiency requires a clear demarcation between theory (planning) and practice (execution), a separation that Taylor's Scientific Management explicitly articulated, albeit being implicitly present in the *theorein* of Aristotle and the *idea* of Plato.

This bifurcation leads to the quantification and measurement of performance and, consequently, the alienation and deskilling of the workforce (Braverman 1998). As Joan Woodward succinctly noted, "Different technologies impose different kinds of demands on individuals and organizations, and those demands had to be met through an appropriate structure" (Woodward 1965). This observation underscores the necessity of aligning organizational structures with the specific requirements imposed by varying technologies, thereby fostering the development of socio-technical systems that harmonize the intricate relationship between human agents and technological mechanisms.

Thus, following the foundational work in the field, within systems thinking and numerous cognate and related disciplines, the term "socio-technical system" has ascended to prominence as a descriptor for the synergistic interplay between humans and technologies. Despite its widespread acceptance and utility, this terminology is not devoid of limitations, which motivated us to develop the concept of *cybork*. A core critique lies in its potential to reinforce the notion of distinct and ontologically (if not necessarily functionally) separate components within a system, particularly the social and technical aspects. This perspective, while useful, can inadvertently suggest a more fragmented view of system components than the holistic approach systems thinking aims to promote.

Furthermore, although systems thinking is laudable for its emphasis on the emergent properties arising from the interactions of system components—properties that cannot be ascribed to any single part in isolation—it concurrently presupposes that systems are *structured* and *ordered functional* entities. This assumption, while foundational to understanding systemic behaviors and outcomes, might inadvertently downplay the fluidity and dynamism inherent in socio-technical systems. These systems are often characterized by a degree of complexity and unpredictability that transcends simple structural and functional delineations, embodying a web of interactions that can lead to novel and unforeseen outcomes. Consequently, while the socio-technical system framework provides a valuable lens through which to view the interdependencies of humans and technologies, it also invites a continuous reevaluation of its conceptual boundaries to more fully embrace the intricate, emergent nature of these interactions.

The socio-technical system framework, while pragmatically and theoretically appealing, inadvertently contributes to the oversight of two, perhaps counterintuitive, notions. Firstly, it suggests that the social and technical components, despite their collaborative integration within a unified system, can be dissectively isolated for individual analysis or design. This perspective overlooks the intrinsic interdependence of these elements, where their dynamic and context-specific interactions render them inseparable in practice. Any attempt to segregate these components not only misconstrues the essence of socio-technical systems but also risks undermining the complexity and coherence of the system as a whole.

Secondly, the conceptual elegance of framing real-world socio-technical scenarios as systems, while initially attractive, paradoxically introduces a level of abstraction and reductionism that may dilute the richness and intricacy of these entities. This approach, by focusing on systemic structures and functions, can obscure the nuanced behaviors and continual evolution inherent in socio-technical environments. Especially when the objective extends to devising interventions that constructively influence their development over time, a purely systemic view might fall short in capturing the dynamic and emergent properties of socio-technical systems. This critique points to the need for a more granular and context-sensitive understanding that transcends conventional systemic frameworks, advocating for approaches that recognize the fluidity, complexity, and interconnectedness of the social and technical dimensions in shaping socio-technical realities.

To address the limitations inherent in the traditional socio-technical system framework, we advocate for a shift in terminology and analytical perspective towards the concept of the *cybork*. We propose this concept in the socio-technical theory discourse with the intention of transcending the model-driven, component-focused, and inherently static understanding of socio-technical systems.

Consider, for example, two individuals collaboratively writing a conference paper through email exchanges, consulting online resources and personal libraries. This process reveals both multiple local cyborks (starting from the team of two) and also a global *cybork*, a dynamic convergence of humans, objects, and technologies, driven by an ineffable force that propels these elements toward achieving tasks and objectives. This force, reminiscent of Aristotle's observation in the *Metaphysics* (Aristotle 1933) about entities acting without conscious intent—like fire burning—emphasizes the often subconscious motivations guiding interactions within the global *cybork*. From this perspective, the *cybork* transcends being merely another term for a socio-technical system; it represents a paradigm that embodies the combination of humans and technology, illustrating the profound interconnectedness and mutual dependency inherent in our technological engagements.

### 5.2 Extended cognition

The theory of Extended Cognition posits that aspects of cognition can be extended into the tools and environments we interact with (Clark and Chalmers 1998). The *cybork*, as a blend of human and technological systems, epitomizes this idea, whereby AI systems are integrated as part of the cognitive processes—whether for memory, computation, or decision-making—involved in human decision-making. This involves not just interaction but integration, where tools and human capabilities are so intertwined that they create a new cognitive entity—similar to how Alzheimer patient Otto's notebook, in the Clark and Chalmers (1998) scenario, becomes an integral part of his cognitive system as part of his memory.

The interactions within the *cybork* system reflect Hutchins's concept of *distributed cognition* (Hutchins 2000), where the cognitive processes are not confined to the individual but are distributed across the network of human and AI agents. This model emphasizes the collective intelligence emerging from the synergy between different cognitive agents, both biological and artificial, possibly pointing towards what Malone defined as "superminds" (Malone 2018):

> I define a supermind as a group of individuals acting together in ways that seem intelligent. [...] All superminds have a kind of collective intelligence, an ability to do things that the individuals in the groups could not have done alone. What's new is that machines can increasingly participate in the intellectual, as well as the physical, activities of these groups. That means we will be able to combine people and machines to create superminds that are smarter than any groups or individuals our planet has ever known.

More specifically, the *cybork* can be regarded as the embodiment of extended functionalism, where cognition is characterized by the process of information handling, regardless of whether it takes place internally or externally. This perspective brings us back to the question, "Where is the intelligence?" with which we initiated our argument. We contend that intelligence is not a static attribute but a dynamic and emergent quality that materializes from human-human and human-technology interactions occurring within a "Ba", a Japanese concept that loosely translates to "place," but is more accurately described as "a shared space for emerging relationships [or] a shared space that serves as a foundation for knowledge creation" (Nonaka and Konno 1998): any place where humans and technologies meet and interact. In this context, Harrison and Dourish (1996) highlight that a 'place' is shaped through the social interactions and cultural practices that take place within it.

The relevance of space, or place, that allows for the emergence of intelligence also characterizes Suchman's description of all human actions as situated, heavily depending on the specific context of occurrence: *"the mutual intelligibility that we achieve in our everyday interactions ...is always the product of in situ, collaborative work."* (Suchman 1987).

Similarly, Nonaka's "Ba" is a shared, collaborative space enriched by knowledge and experiences where individuals interact and learn from each other. The integration of AI into a "Ba" not only changes the physical and digital infrastructure but also the very essence of social interactions and cultural practices within these places. The interaction within this shared place interactions between humans and AI systems contribute to a shared "place" where hybrid intelligence (Dellermann et al. 2019) emerges: the interaction within a "Ba" (Nonaka and Konno 1998) leads to emergent properties that could not be predicted by examining the separate components alone. It provides "a platform for advancing individual and/or collective knowledge", from which "a transcendental perspective integrates all information needed" (Nonaka and Konno 1998). Similarly, in a *cybork* system, the emergent cognitive capabilities arise from the complex interactions between human and Artificial Intelligence, leading to novel insights and solutions that are beyond the capacity of either partner alone.

This concept echoes the philosophy of Kitarō Nishida (1987), who posited that knowledge and its subject are inseparable, unified entities (cf. Nonaka, "*Ba* may also he thought of as the recognition of the self in all" Nonaka and Konno 1998). For Nishida, human cognition is characterized as 'pure experience'—an ongoing, emergent phenomenon that continually renews itself within the flow of life. Such an approach to understanding places a premium on the immediacy and authenticity of personal experience over the static, accumulated data that AI systems typically leverage.

The implication here is significant: while current AI systems, which rely on training data, function based on the accumulation of past experiences (essentially, the residue of human activity), the *cybork* interacts with the world in an immediate and deeply personal way. The *cybork* represents a conscious commitment to affirm and maintain human identity amid technological progress. This commitment is not a singular declaration but an ongoing reaffirmation of humanity's unique value and potential.

An AI-assisted medical équipe can be seen as a practical instance of *cybork*, in continuity to Nonaka's "Ba". In this scenario, human clinicians and AI systems collaborate within a shared space (both physical and digital) where their collective intelligence, what Dellermann et al. (2019) call *hybrid intelligence* to emphasize the role of computational artifacts, exceeds the capabilities of each individual component. The AI system assists in analyzing extensive and complex data to uncover hidden patterns, while human professionals bring their clinical expertise, ethical judgment, and empathy into the decision-making process. This interaction impacts ad shapes established professional practices: the AI-assisted medical team forms a new shared space of knowledge and capabilities, enabling insights and solutions that neither the AI nor the clinicians could achieve independently. The *cybork* concept describes this collaborative process, highlighting how technology and human expertise merge to produce outcomes that are both practical and transformative.

### 5.3 Implications for socio-technical design

The convergence of systems thinking, extended cognition theory, and the *cybork* concept holds significant implications for designing contemporary socio-technical systems. Instead of approaching design through the conventional, dualistic lens that separates social and technical components, the *cybork* framework necessitates a more integrated and nuanced approach that acknowledges the intrinsic interweaving of human and technological agencies within shared interactive spaces.

First, the design process must recognize that the emergence of *hybrid collective intelligence* within *cybork* systems cannot be reduced to isolated technical specifications, functions or social protocols. Designers need to adopt strategies that purposefully cultivate and sustain shared spaces, i.e., "Bas" where *cybork* thrives. This aligns with Nishida's focus on pure experience, indicating that effective socio-technical design should prioritize enabling authentic, direct interactions rather than merely optimizing information flow or interface mechanics.

Second, the extended cognition perspective mandates a fundamental rethinking of how we delineate the boundaries of designed systems. Instead of designing tools that solely augment human capabilities, designers must consider how technological components become integral to expanded cognitive systems. This shift requires attention to the "trust and glue" conditions outlined by Clark and Chalmers (Gallagher and Petracca 2024), ensuring that technological elements are reliably present, easily accessible, and automatically endorsed by human participants within the *cybork* system.

Third, the dynamic and emergent nature of *cybork* systems challenges traditional design methodologies that rely on predetermined specifications and fixed outcomes. Designers must instead embrace *adaptive design* frameworks that can evolve and respond to the ongoing development of human-technology relationships within the *cybork*. This approach recognizes that the intelligence and capabilities of *cybork* systems arise through use rather than being fully specified beforehand (Cabitza et al. 2020).

The practical implications of these insights are exemplified in the previously discussed medical équipe. Designing such systems goes beyond crafting efficient interfaces for accessing medical data or implementing precise diagnostic algorithms. It involves creating environments that foster hybrid intelligence through dynamic interactions between human expertise and artificial intelligence within a shared professional space (Anichini et al. 2024). This might entail designing adaptable systems that can respond to varying clinical scenarios, support different forms of human-AI collaboration, and uphold human agency while harnessing technological capabilities.

These design principles suggest a shift from "component-centric design" (Carayannis and Coleman 2005) to what can be termed "emergence-oriented design": an approach focused on creating conditions that enable the development of effective *cybork* systems rather than detailing their exact configuration (Cabitza et al. 2020). This shift marks a significant departure from traditional socio-technical design practices and introduces new avenues for research and practical application across fields such as healthcare, education, and beyond.

## 6 Conclusions

> *The will to a system is a lack of integrity.* Friedrich Nietzsche[10]

This work has presented a critical exploration of the concept of the *cybork*, aiming to expand the conceptual toolkit available to scholars and practitioners from different perspectives around the concept of socio-technical theory. Our contribution is not aimed at resolving the issue of "intelligence" but, more modestly, to introduce the term "*cybork*" as a tool for orienting inquiry and deepening our understanding of the evolving dynamics within socio-technical systems, and for designing (for) them.

We have observed how, over time, key terms in the socio-technical discourse have been gradually but distinctly shifted towards connotations of an artificially detached and exact *staticness* by prevailing IT narratives and the overarching paradigms of business management and modeling. This paper advocates for a re-engagement with the original, more fluid meanings of these terms, challenging the oversimplification of dynamic systems into rigid, unchanging entities.

By focusing on the processes of transformation and translation that occur within socio-technical systems, the *cybork* concept aligns with Paul Dourish's call to situate our understanding "where the action is", in the evolving processes that define these systems (Dourish 2004).

The *cybork* could be understood as a network of hybrid actants or cyborgs. However, this distinction is not merely a matter of scale, but of focus. In the *cybork* concept, relationships, processes, fluid configurations, and behaviors take precedence, rather than entities, properties, functions, information, or intentions.

The term *cybork* thus signals a departure from traditional ontological categories and emphasizing the interstitial spaces where conventional boundaries blur or cease to exist, pointing in particular to three boundary breakdowns. These occur between humans and their tools, extending the concept of the cyborg to highlight the inextricable link between users and the technologies they utilize; Between individuals and collectives, challenging the dichotomy between singular actors and the broader socio-technical networks they are part of; Between static entities and their dynamic, intentional activities (work), thus transcending the opposition between being and doing, or existence and action.

The *cybork* metaphor, in the three arenas and discourses where we have introduced it, facilitates a poststructuralist deconstruction of the conceptual opposition between individual actors or users and the outcomes of their engagement

[10] Orig.: Der Wille zum System ist ein Mangel an Rechtschaffenheit. Götzen-Dämmerung, §26,

within socio-technical ensembles. We propose this metaphor to encourage a reevaluation of how socio-technical systems are conceptualized, moving beyond simplistic binaries such as human/machine dualism, as well as the more fundamental entity/process distinction. Instead, it offers a 'condividual' alternative to the individual/collective dichotomy, suggesting that the human–machine amalgam constitutes a social body in its own right. If we accept that 'we are cyborgs' (cf. Haraway), we should also acknowledge that 'we do *cybork*'.

**Funding** Open access funding provided by Università degli Studi di Milano - Bicocca within the CRUI-CARE Agreement. F. Cabitza acknowledges funding support provided by the Italian project PRIN PNRR 2022 InXAID—Interaction with eXplainable Artificial Intelligence in (medical) Decision making. CUP: H53D23008090001 funded by the European Union—Next Generation EU. C. Natali gratefully acknowledges the PhD grant awarded by the Fondazione Fratelli Confalonieri, which has been instrumental in facilitating her research pursuits. Chiara Natali gratefully acknowledges the financial support provided by the Federal Commission for Scholarships for Foreign Students in the form of the Swiss Government Excellence Scholarship (ESKAS No. 2024.0002) for the academic year 2024–2025.

**Data availability** Not applicable: our research did not stem from the analysis (nor imply the generation) of any datasets.

## Declarations

**Conflict of interest** On behalf of all authors, the corresponding author states that there is no conflict of interest.



## References

Anichini G, Natali C, Cabitza F (2024) Invisible to machines: designing AI that supports vision work in radiology. In: Computer Supported Cooperative Work (CSCW), pp 1–44
Aristotle (1933) Metaphysics, vol 1. Harvard University Press, Cambridge
Atkinson C, Brooks L (2005) In the age of the humanchine. In: ICIS 2005 proceedings, vol 11. pp 123–135
Barad K (2003) Posthumanist performativity: toward an understanding of how matter comes to matter. Signs 28(3):801–831
Barad K (2007) Meeting the universe halfway: quantum physics and the entanglement of matter and meaning. Duke University Press, Durham
Becker HS (2008) Tricks of the trade: how to think about your research while you're doing it. University of Chicago Press, Chicago
Bednar P (2016) Complex methods of inquiry: structuring uncertainty. PhD thesis, Lund University
Bernstein C (1986) Living tissue/dead ideas. Soc Text 16:124–135
Bigelow J (1829) Elements of technology: taken chiefly from a course of lectures delivered at Cambridge, on the application of the sciences to the useful arts: now published for the use of seminaries and students. Hilliard, Gray, Little and Wilkins, Boston
Bocchi G, Varanini F (2013) Le Vie della Formazione. Guerini e Associati, Milano
Bowker GC, Baker K, Millerand F, Ribes D (2009) Toward Information Infrastructure Studies: Ways of Knowing in a Networked Environment. In: Hunsinger J, Klastrup L, Allen M (eds) International Handbook of Internet Research. Springer, Dordrecht. https://doi.org/10.1007/978-1-4020-9789-8_5
Braverman H (1998) Labor and monopoly capital: the degradation of work in the twentieth century. NYU Press, New York
Brey P, Søraker J (2009) 'Philosophy of Computing and Information Technology' Philosophy of Technology and Engineering Sciences. In: Meijers A, Gabbay D, Thagard P, Wood J (eds) Handbook for Philosophy of Science, vol 14. Elsevier
Cabitza F, Locoro A, Ravarini A (2020) Trading off between control and autonomy: a narrative review around de-design. Behav Inf Technol 39(1):5–26
Canguilhem G, Marrati P, Meyers T (2008) Knowledge of life. Fordham University Press, New York
Carayannis E, Coleman J (2005) Creative system design methodologies: the case of complex technical systems. Technovation 25(8):831–840
Ciborra CU, Hanseth O (1998) From tool to Gestell: Agendas for managing the information infrastructure. Inf Technol People 11(4):305–327
Clark A, Chalmers D (1998) The extended mind. Analysis 58(1):7–19
Clark A, Chalmers D (2016) The extended mind. InterAction 8(1):48
Clynes ME, Kline NS (1960) Cyborgs and space. Astronautics 14(9):26–27
Deleuze G, Guattari F (2009) Anti-Oedipus: Capitalism and Schizophrenia. Penguin, London
Dellermann D, Ebel P, Söllner M, Leimeister JM (2019) Hybrid intelligence. Bus Inf Syst Eng 61(5):637–643
Dourish P (2004) Where the action is: the foundations of embodied interaction. MIT Press, Cambridge
Emery FE, Trist EL (1960) Socio-technical systems. In: Management sciences models and techniques, vol 2, pp 83–97
Foucault M (1988) The political technology of individuals. In: Martin LH, Gutman H, Hutton PH (eds) Technologies of the self: a seminar with Michel Foucault. University of Massachusetts Press, Amherst, pp 145–162
Gallagher S, Petracca E (2024) Trust as the glue of cognitive institutions. Philos Psychol 37(1):216–239
Gherardi S et al (2009) Community of practice or practices of a community. In: Armstrong SJ, Fukami CV (eds) The SAGE handbook of management learning, education and development. SAGE, pp 514–530. https://doi.org/10.4135/9780857021038.n27
Goethe JW, Miller GL (2009) The metamorphosis of plants. MIT Press, Boston
Greenhalgh T, Stones R (2010) Theorising big it programmes in healthcare: strong structuration theory meets actor-network theory. Soc Sci Med 70(9):1285–1294
Haraway DJ, Borghi L, Braidotti R (2018) Manifesto Cyborg : Donne, Tecnologie e Biopolitiche del Corpo / Donna J. Haraway; a Cura di Liana Borghi, Prefazione di Rosi Braidotti. Universale Economica Feltrinelli. Saggi. Feltrinelli, Milano
Haraway D (1985) A manifesto for cyborgs: science, technology, and socialist feminism in the 1980s. Soc Rev 80:65–108

Haraway D (1991) Simians, cyborgs, and women: the reinvention of nature. Routledge, NYC
Harrison S, Dourish P (1996) Re-place-ing space: the roles of place and space in collaborative systems. In: Proceedings of the 1996 ACM conference on computer supported cooperative work, pp 67–76
Heidegger M (1954) The question concerning technology, pp 99–113
Heidegger M (2010) Being and time. SUNY Press, Albany
Hutchins E (2000) Distributed cognition. In Smelser NJ, Baltes PB (eds) International encyclopedia of the social and behavioral sciences, vol 138. Elsevier Science, pp. 1–10
Kent T (1993) Paralogic rhetoric: A theory of communicative interaction. Bucknell University Press
Koffka K (2013) Principles of gestalt psychology. Routledge, London
Kuutti K, Bannon LJ (2014) The turn to practice in HCI: towards a research agenda. In: Proceedings of the SIGCHI conference on human factors in computing systems, pp 3543–3552
Latour B (2005) Reassembling the social. Oxford University Press, Hampshire
Licklider JC (1960) Man-computer symbiosis. IRE Trans Hum Factors Electron 1:4–11
Loeber K (2018) Big data, algorithmic regulation, and the history of the Cybersyn project in Chile, 1971–1973. MDPI, Basel
Longo GO (2005) Uomo e Tecnologia: Una Simbiosi Problematica, vol 2. pp 5–18
Malone TW (2018) How human-computer 'superminds' are redefining the future of work. MIT Sloan Manag Rev 59(4):34–41
Marx K (2005) Grundrisse: foundations of the critique of political economy. Penguin UK, London
Maturana H (2002) Autopoiesis, structural coupling and cognition: a history of these and other notions in the biology of cognition. Cybern Hum Knowing 9(3–4):5–34
Mauss M (2023) Les Techniques du Corps. Flammarion, Paris
Medina E (2006) Designing freedom, regulating a nation: socialist cybernetics in Allende's Chile. J Lat Am Stud 38(03):571–606
Mitcham C, Schatzberg E (2009) Defining technology and the engineering sciences. In: Meijers A (ed) Handbook of the philosophy of science: Philosophy of technology and engineering sciences. North-Holland, pp 27–63. https://doi.org/10.1016/B978-0-444-51667-1.50006-9
Nietzsche F (2023) On the genealogy of morality. Broadview Press, Peterborough
Nishida K (1987) Intuition and reflection in self-consciousness. State University of New York Press, New York
Nonaka I, Konno N (1998) The concept of "Ba'': building a foundation for knowledge creation. Calif Manag Rev 40(3):40–54
Orlikowski WJ (1995) Action and artifact: the structuring of technologies-in-use. Sloan School of Management, Cambridge
Orlikowski WJ, Gash DC (1994) Technological frames: making sense of information technology in organizations. ACM Trans Inf Syst (TOIS) 12(2):174–207
Rosenblueth A, Wiener N, Bigelow J (1943) Behavior, purpose and teleology. Philos Sci 10(1):18–24
Schmidt K (2011) The concept of 'work'in CSCW. Computer Supported Cooperative Work (CSCW), vol 20. pp 341–401
Schmidt K, Bannon L (1992) Taking CSCW seriously. Computer Supported Cooperative Work (CSCW), vol 1(1–2). pp 7–40
Seamon D (1998) Goethe's way of science: a phenomenology of nature. SUNY Press, Albany
Simon HA (1988) The science of design: creating the artificial. Design Issues 4:67–82
Suchman LA (1987) Plans and situated actions: the problem of human-machine communication. Cambridge University Press, Cambridge
Suchman LA (2007) Human-machine reconfigurations: plans and situated actions. Cambridge University Press, Cambridge
Varanini F (2009) Goethe: la conoscenza come morfogenesi. https://goo.gl/VXvWZe
Whorf BL (1956) Language, thought, and reality. Selected writings of Benjamin Lee Whorf. MIT Press, Cambridge
Wiener N (1961) Cybernetics: or control and communication in the animal and the machine, 2nd edn. Hermann & Cie and MIT Press, Paris and Cambridge
Woodward J (1965) Industrial organization: theory and practice, vol VI. Oxford University Press, London
Zbinden J, Lendaro E, Ortiz-Catalan M (2022) Prosthetic embodiment: systematic review on definitions, measures, and experimental paradigms. J Neuroeng Rehabil 19(1):37
Zimmerman ME (1990) Heidegger's confrontation with modernity: technology, politics, and art. Indiana University Press, Bloomington