Going beyond the System in Systems Thinking: the cybork

Federico Cabitza[1] and Francesco Varanini[2]

[1] Università degli Studi di Milano-Bicocca, Milano 20126, Italy,
cabitza@disco.unimib.it
[2] Università degli Studi di Udine, Via Palladio, 8, Udine, Italy
fvaranini@gmail.com

Abstract. In this paper we make the point of the need to introduce a new concept, and the related term, to account for the dynamic nature of socio-technical systems and make this nature a primary concern of systems thinking to understand and intervene on this kind of systems: the cybork.

Keywords: Systems Thinking, Socio-technical Systems, Gestell, Bildung, Cyborg, Cybork

1 Motivations and Background

The cybork is a concept that we do not draw from the void, nor we have coined just as a result of a free association of ideas and words. All the opposite, we propose it as a term that condenses different flows of thinking in itself and yet adds something to all of them, right in virtue of its synthetic nature. These converging traditions are: cybernetics, socio-technical system theory, and systems thinking. Far from having the ambition to summarize the main tenets of these disciplines and schools of thought, or better mindsets, in what follows we will outline the elements that justify our proposal, or at least motivated us in introducing it.

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 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.

Although American for the name and the endeavour to be systematized, the cybernetic thinking can be traced back to the natively multi-disciplinary thinking of the German and Austro-Hungarian intellectuals, who were forced to emigrate to the United States for the Nazism [31]. The basic idea is feedback, i.e., the fact that "some of the output energy of an apparatus or machine is returned as input" and also the intuition that "a uniform behavioristic analysis is applicable to both

machines and living organisms, regardless of the complexity of the behavior" (ibid.) These two ideas were applied to the idea of the *Cybersin*, the "cybernetic synthesis" of the actions of the individual workers and the productive capacity of factories and plants to be applied on the nationalized sector of Chile's economy during the Unidad Popular Government (1971-1973) in order to integrate data into a global network, economic data and decisions [28]. This projects envisions, for the first time, the idea of a nation as a living organism, where animals (including humans) and machines coexist, as components of the same system and as systems themselves, so tightly interconnected (structurally coupled) to be recognized as elements of the same network.

Systems Thinking emerged in the 1940s in reaction to scientific reductionism and to solve problems effectively through the ad-hoc combination of heuristics and multiple approaches. Probably just for this *pluralistic* attitude, in "systems thinking the use of words is not a straightforward exercise even though it influences our engagement with context" [5]. Among the most important expressions in system thinking one could rightly consider *socio-techical system* [14].

This expression was coined at the Tavistock Institute in London in the 1950s to denote a new way to look at organizational change, an approach that can be traced back to the Kleinian interpretation of the Freud's psychoanalysis and that considers both humans and machines essential for the emergence of specific forms of work, indeed socio-technical systems. These systems do not preexist their animate and inanimate components (cf. Aristotle) mentioned above, but rather emerge and unfold in the continuous inter-relation between those components and mutual fit, and in their turn affect their components, their mutual arrangement and behaviors. The first socio-technical researchers (including Eric Trist, Ken Bamforth, Joan Woodward and Fred Emery) observed this phenomenon in all those forms of work where the division of labor, for the sake of efficiency, creates distinctions and hierarchies, and in those where the same quest for efficiency imposes the clear distinction between theory (and hence planning) and practice (that is execution of plans) – a distinction affirmed by Taylor through his Scientific Management but already *in nuce* in the *theorein* of Aristotle and *idea* of Plato – and hence the quantification and measurement of performance and the consequent alienation of the workers involved. "Different technologies impose different kinds of demands on individuals and organizations,and those demands had to be met through an appropriate structure" [38].

Thus, from these seminal studies on, in systems thinking and in many similar and related approaches, socio-technical system has become one of the most common expressions to account for when humans and technologies "go together". Notwithstanding its popularity, or maybe right because of it, this expression also presents some shortcomings. Although systems thinking advocates a holistic approach to the study of systems by focusing on the features of the whole that emerge from the interaction of its parts, speaking of socio-technical system still emphasizes the existence and ontological (not necessarily functional) independence of the parts of a system, at least of the social and technical parts. Moreover, although systems thinking acknowledges the complex ways in which

the parts of a system can interact with each other, and can exhibit unexpected behaviors as a whole that no part alone could produce by itself, it also assumes that systems are *structured, ordered functional* units.

In light of this, the expression socio-technical system, which looks reasonable for many practical and theoretical aims, also facilitates the neglect of two related, perhaps counter-intuitive, ideas. Shortly put these are: first, the social and the technical, in their dynamic and situated partaking in a single unitary system, actually cannot never be taken as distinct parts of this system and extracted as individual objects of study (or design). Second, looking at real socio-technical settings in terms of systems is conceptually tempting but paradoxically way too abstract and reductionist to allow for the faithful and effective account of their behavior and continuous change, especially when such an account is aimed at building programs to positively affect their construction and evolution over time.

To overcome these two shortcomings, in this position paper we will argue for a different phrase (and related analytical attitude), which could better denote autopoietic socio-technical settings and inspire different ways to design *for* them: the *cybork*. We introduce this new concept in the socio-technical theory discourse to emphasize the need to move from a model-driven, component-oriented and intrinsically static view of this kind of systems to a more organic one, where the complex entanglement between the social and the technical, as well as between the human and the artificial, is not only claimed but also acknowledged in the very representations by which we try to capture it. This leads to considering *community morphogenesis* as a new topic in the socio-technical discourse and taking the challenge to develop concepts and tools to both study and foster it[3]. To argue in favor of this stance, we will first address the shortcomings that a structural and ontological view of socio-technical settings can hide, and then argue more positively towards alternative metaphors and new proposal.

2 What socio-technicality can hide

Multiplicitism. William of Ockham once said that "entia non sunt multiplicanda praeter necessitatem". Distinguishing between humans and technologies seem totally reasonable for many practical or theoretical aims, but it is actually harmful to design technologies for the humans. Philippa Goodall in 1983 rightly stated that "design *for* use is design *of* use" [15]. Rightly so, any design is the *design of work*, and *for its change*. The point is that technologies are one with the techniques by which they are put to use; and humans are at one with their extended body of tools and devices [35, ch.1]. This is so much the case that even the human body itself could be considered the first technology (ibidem): it is essentially human the cultural use of the body as expression of the self and as first communication medium. Human sociality then, which is a cultural phenomenon,

[3] Morphogenesis seems to be the "pillars of Hercules" of computational thinking, as also prominent figures like Alan Turing have considered it as a matter of study, with limited success [2].

is enabled by technology and cannot be given without it. This is because technology should not be narrowly intended: rather, also language should be considered a human technology [6] and indeed one of the most important and characteristic of our species ("language is the first technology", *ibid.*)., which involves the use of the body with techniques that are compatible with our physiology (of course) but also socially acquired and refined over years of social interaction requiring agreed conventions and mutual expectations.

Thus, distinguishing users from their tools is as much serious as common mistake of perspectives: a hammer lying on a table, which is not even considered by a potential user as a potential object by which to hammer something, is not a hammer. Here we are not proposing a variation of the argument of George Berkeley (1710), as we are not daring to say that the hammer does not exist as a material thing unless one perceives it. Rather, we say that that thing is not a hammer until it is used as a hammer by a "hammerer", that is until it is not involved in an intentional hammering[4].

Staticism. We likely partake in (multiple) socio-technical systems any given moment. As curious observers of these human phenomena, looking at a socio-technical system is as easy as it is to belong to one, since what we would experience – the movements, the conversations, the material production of artifacts and their inscriptions, any continuous transformation of the state of affairs – would be *the* socio-technical system before, or better yet, around us. However, when we want to see any such system with the eyes of the mind, that is with that *theoretical* attitude that from Plato on distinguishes (and separates) the direct experience of the things from their detached contemplation and study, we need linguistic metaphors [20] that are isomorphic to the phenomena experienced.

3 A new metaphor to account for change

Intelligence closely regards the capability to bring things together (cf. inter-lĕgo) and to stand in the midst of them (which is 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, Nietzsche was one the first Western thinkers to denote the tendency to see things where actually just actions are[5], or better yet a doing[6], that is to acknowledge the

[4] Not necessarily enacted, but also only imagined by an agent.

[5] 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) [4]

[6] In his words: "[...] 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).

potentially harmful tendency to *reify* dynamic processes into metaphoric, yet static, entities[7].

Thus, the very word *system* (from the Greek "ensemble of things put together) suggests to look for (and hence at) ordered arrangements of entities, where mutual relations can be variously relevant to constitute the above order, or even the nature of the related things themselves [1].

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* [30], *structures* [17], and even *infrastructures* [9].

We here make the point, partly inspired by the theses of linguistic relativism [37][8], that these metaphors, besides affecting our comprehension of sociotechnical systems (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.

Gestell and Gebild. This influence regards what the German philosopher Heidegger [19] 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 [6]. However, as also noticed by Ciborra and Hanseth [12], the words Ge-stell and sys-tem indicate just the same concept (literally), in two different (but yet often converging) linguistic traditions.

In [36, 7], an alternative metaphor is discussed in regard to how we can know and understand the systems in which we also reside and work: instead of Gestell (or Gestalt), Gebild. This latter word derives from and is closely related to Bildung (growth, formation). This distinction was first put forth by Goethe in his "The metamorphosis of plants" from 1790 [16]. In hiw 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

[7] The etimology 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.

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

> moment of time. When something has acquired a form it metamorphoses immediately to a new one[9]

Gebild is then the "shaping form" [36] 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 [36]. 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.

Organism. This term 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"[10].

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 20th 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 ergonomicallly controlled labouring, desiring, and reproducing systems [intertwined with] machines [...] as communication systems, texts, and self-acting, ergonomically designed apparatuses" [18]. After all, "nothing is more human than a machine" [11](p. 8)[11].

Similarly, Longo in [23] proposed the concept of *symbiont*, in the metaphorical mould that had been clearly drawn first by Licklider [22], who used the expression

[9] cf. Goethe's Botanical Writings, pp.215-19, cited in [33]

[10] "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.

[11] 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 decloupled 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."*

man-computer symbiosis in the 1960s. However, this phrase is as much evocative as misleading, for its indulgence in making machines anthropomorphous (as they would give to have something back in return); and, even worse yet, substantially *different from* the human, rather than recognizing them part and parcel of the culture and hence of the human.

More correctly one could speak of *structural coupling* [27] 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" [27](p. xxi). Moreover, every time there is behavioral coordination in the realm of structural coupling, also communication takes place. For Maturana and Varela [26], who were strong opponents of the Shannon model of communication in terms of message exchange through a tube [3], "there is no transmitted information in communication" (p.195), but rather this latter one is the result of the coordination of communicative behaviors which occur in *social coupling*.

From the cyborg to the cybork. 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*.

This concept 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.

The *cybork* is then a portmanteau that blends together two semantic worlds and related traditions: the *cyborg*, i.e., an organism where natural and artificial elements are inexstricably intertwined and mutually fit to each other; and the *work*, that is a set of intentional activities that are *mutually dependent* and accordingly coordinated in reaching an objective [32]. The *cybork* is then a *collective organism*, a *hybrid agency*, a *network of actants* [21], a whole configuration of active forces "that is greater than the sum of its parts", or better yet (citing Koffka) "that is *other* than the sum of the parts": a sort of *collective* (of humans and non-humans).

We make the point that these collectives need a different ontology and epistemology to be detected, observed and studied, like those under development in the recent wave of sociology that has been recently dubbed the "sociology of associations" ("associology") [21] to highlight its discontinuity from the so called "sociology of the social", i.e., the traditional sociology in the mould of Durkheim [25]; and a different design to be supported (and evolved), like the contrarian de-design approaches that we have just begun to outline in a previous contribution [10].

Therefore, The idea that is denoted by such a hybrid word itself, cybork, is that it is an idle question to understand[12] what element, between the human-social one and the artificial-technical one, is more necessary; as well as how to design the latter one to support, or substitute!, the former one. 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.

4 Conclusions

The will to a system is a lack of integrity.
Friedrich Nietzsche[13]

A quick skim on this contribution could make it appear a paper stuck in the nominalistic side of socio-technical theory, the one struggling to find the better ways to denote complex phenomena. Or worse yet, an over-ambitious proposal to discard important terms in traditional socio-technical theory, like system and structure.

As a matter of fact, we propose this contribution as a short advocacy towards considering again the actual semantic roots of these seminal terms, which some IT discourse and the general grand narrative of business management and business modelling have slowly but clearly drifted towards the idea of an artificially detached and accurate *staticness*.

As a matter of fact yet, structure comes from *structus*, originally a heap or pile, something that is piled up one layer at a time, and *structūra* is indeed a building, built on layers of bricks, one brick at a time. Both the words come from *strŭo*, that is "to make by joining together, to build, erect, form, construct": *structure* was then the result of a process of undetermined piling up of materials, we would say, not predefined by any project or previous design, which only in later times indicated an ordered arrangement (especially in Cicero, but yet regarding language and rhetorical art, not physical systems).

[12] Here again we recall that to understand means "to stand in between" as if it were always possible, by discerning the relata from the relation itself.

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

On the other hand, also system, as hinted above, is a term with a long story behind: it derives from the ancient Greek *sýstema*, that stands for 'complex' and is (obviously) connected to *sýnthesis*, i.e., the action noun of the verb syntíthenai 'to put together, combine'. Clearly, *sýnthesis* is the opposite of *análysis*, that namely stands for 'breakdown', 'resolution of anything complex into simple elements'.

Since hoping in a revival of these linguistic roots for these common terms would be utterly overambitious, we rather aim to repropose the metaphors of *Gebild* – ever-growing structure, *Organism* – organic and self-organizing structure, from which we extrapolate a new term that subsumes those latter and all the similar ones – the *cybork*. This is done just to prepare the ground for new and more convinced studies in system thinking towards the ever changing bond between the social and the technical, without getting stuck in *understanding* (or worse yet, modeling) what the components and the single elements are, but rather focusing on the processes, of transformation and *translation*, which occur "where the action is" [13].

Thus, we have proposed the vision of a multitude of local and small cyborks, i.e. *ever-evolving socio-technical systems that do some action, and do some work*. By looking from some distance, these cyborks can be recognized as just connected regions of a greater, global Cybork, which both enables and justifies them all. A global Cybork so much alike the visions of Mumford – the *megamachine* [29] – or by Lotman[14] – the *semiosphere*. In particular, this latter was defined as "the place of the continuous making of sense (semiosis)" [24] and nowadays would certainly encompass the Web, as well as any of the human utterances and expressions that are entrapped in the social media and personal apps that people use while being immersed in their activities, their social interactions and texture of practices. However, notwithstanding this multiplicity and manifest dispersion, "all semiotic space can be considered a single mechanism (*if not organism*). [In so doing] not this or that brick will appear as the foundation, but the 'great system' called semiosphere" [24] (our emphasis). The same holds for the cybork: even just two people writing a conference paper by exchanging emails and feverishly consulting the Web as well as their small personal libraries at home, to have *this* very work done. By tracking down all the other cyborks that made the Web pages possible and still available and those books concrete and still understandable, one does not see just the individual cyborks doing something, but rather the one Cybork of human beings and human objects, all mobilized by some inner and ineffable force[15].

Humankind itself can be seen as a giant Cybork, constituted by smaller cyborks, an overall living system where the boundary between the artificial and

[14] In semiotics, the stance by the Russian semiologist Jurij Michajlovič Lotman can be seen as an alternative perspective to the more traditional ones, both the Peircean and the Saussarian ones, and one strongly opposing any stance that sees the whole ontologically as sum of its parts.

[15] "to do things, like certain inanimate objects,[not necessarily] knowing what they are doing, as, for instance, fire burns" Aristotle, Metaphysics, 981a-b

and the natural, the living and the machine tends to blur and fade away. That notwithstanding, while the human beings consider themselves parts contained within complex socio-technical systems, they are also called to contain their technologies, to keep them together and prevent any of them from dismembering the human with centrifugal forces that distance it from its responsibility.

Senge [34] defined systems thinking as a framework "for seeing interrelationships rather than things, for seeing patterns of change rather than static snapshots." The Goethe's metaphor of the Gebild, to account for the astonishing complexity of Nature, as well as the new metaphor of the cybork to account for the inextricability of hands and tools – nature and culture, in any kind of work capable of changing the world, shed light on the dynamic nature of any socio-technical system; and the evolutionary nature of any thinking.

References

1. Barad, K. (2003). Posthumanist performativity: Toward an understanding of how matter comes to matter. Signs, 28(3), 801-831.
2. Bard, J., & Lauder, I. (1974). How well does Turing's theory of morphogenesis work? Journal of Theoretical Biology, 45(2), 501-531.
3. Barnett, G. A., & Thayer, L. (1997). OrganizationCommunication, emerging perspectives V: The renaissance in systems thinking. Greenwood Publishing Group
4. Becker, H. S. (2008). Tricks of the trade: How to think about your research while you're doing it. University of Chicago Press.
5. Bednar, P. (2016). Complex methods of inquiry: structuring uncertainty (Doctoral dissertation, Lund University).
6. Bernstein, C.. (1986). Living Tissue/Dead Ideas. Social Text, (16), 124–135.
7. Bocchi Gianluca & Varanini Francesco. (2013) Le vie della formazione. Guerini e Associati. Milano, Italy
8. Boyer, P. (2001). Religion explained: The evolutionary origins of religious thought (No. 170). Basic Books.
9. Bowker, G. C., Baker, K., Millerand, F., & Ribes, D. (2009). Toward information infrastructure studies: Ways of knowing in a networked environment. In International handbook of internet research (pp. 97–117). Springer Netherlands.
10. Cabitza, F. (2014). De-designing the IT artifact. drafting small narratives for the coming of the socio-technical artifact. In ItAIS 2014, Proceedings of the 11th Conference of the Italian Chapter of AIS, Genova, Italy.
11. Canguilhem, G., Marrati, P., & Meyers, T. (2008). Knowledge of life. Fordham Univ Press.
12. Ciborra, C. U., & Hanseth, O. (1998). From tool to Gestell: Agendas for managing the information infrastructure. Information Technology & People, 11(4), 305-327.
13. Dourish, P. (2004). Where the action is: the foundations of embodied interaction. MIT press.
14. Emery, F. E., Trist, E. L. (1960) Socio-technical Systems, Management Sciences Models and Techniques; vol. 2; London, UK.
15. Fallan, K. (2008). De-scribing design: Appropriating script analysis to design history. Design Issues, 24(4), 61-75.
16. Goethe, J. W., & Miller, G. L. (2009). The metamorphosis of plants. Boston, MA: MIT Press.

17. Greenhalgh, T., & Stones, R. (2010). Theorising big IT programmes in healthcare: strong structuration theory meets actor-network theory. Social science & medicine, 70(9), 1285-1294.
18. Haraway, D. (1991). Simians, cyborgs, and women: the reinvention of nature Routledge. New York.
19. Heidegger, M. (1954). The question concerning technology. Technology and values: Essential readings, 99-113.
20. Lakoff, G., & Johnson, M. (2008). Metaphors we live by. University of Chicago press.
21. Latour, B. (2005). Reassembling the social. Hampshire: Oxford University Press.
22. Licklider, J. C. (1960). Man-computer symbiosis. Human Factors in Electronics, IRE Transactions on, (1), 4-11.
23. Longo, G. O. (2005). Uomo e tecnologia: una simbiosi problematica. Mondo Digitale 2, 5-18.
24. Lotman, J., & Clark, W. (2005). On the semiosphere. Sign Systems Studies, 33(1), 205-226.
25. Krarup, T. M., & Blok, A. (2011). Unfolding the social: quasiactants, virtual theory, and the new empiricism of Bruno Latour. The Sociological Review, 59(1), 42-63.
26. Maturana, H. R., & Varela, F. J. (1987). The tree of knowledge: The biological roots of human understanding. New Science Library/Shambhala Publications.
27. Maturana, H. (2002). Autopoiesis, structural coupling and cognition: a history of these and other notions in the biology of cognition. Cybernetics & Human Knowing, 9(3-4), 5-34.
28. Medina, E. (2006). Designing freedom, regulating a nation: Socialist cybernetics in Allende's Chile. Journal of Latin American Studies, 38(03), 571-606.
29. Mumford, L. (1971). Technics and Human Development: The Myth of the Machine, Vol. I. Harvest Boo
30. Orlikowski, W. J., & Gash, D. C. (1994). Technological frames: making sense of information technology in organizations. ACM Transactions on Information Systems (TOIS), 12(2), 174-207.
31. Rosenblueth, A., Wiener, N., & Bigelow, J. (1943). Behavior, purpose and teleology. Philosophy of science, 10(1), 18-24.
32. Schmidt, K., & Bannon, L. (1992). Taking CSCW seriously. Computer Supported Cooperative Work (CSCW), 1(1-2), 7-40.
33. Seamon, D. (1998). Goethe's way of science: A phenomenology of nature. SUNY Press.
34. Senge P. M. (1990). The Fifth Discipline, The Art & Practice of The Learning Organization. reprint 1999. London: Random House.
35. Tenner, E. (2009). Our own devices: How technology remakes humanity. Vintage.
36. Varanini, F. (2009). Goethe: la conoscenza come morfogenesi. https://goo.gl/VXvWZe
37. Whorf, B. L. (1956) Language, Thought, and Reality. Selected Writings of Benjamin Lee Whorf. Cambridge: MIT Press
38. Woodward, J. (1965) Industrial Organization: Theory and Practice, Oxford University Press, London, 1965, p. VI