STUDIA UBB. PHILOSOPHIA, Vol. 67 (2022), 2, pp. 101-112
(RECOMMENDED CITATION)
DOI:10.24193/subbphil.2022.2.06

MEANINGFUL HUMAN-MACHINE INTERACTION: SOME SUGGESTIONS FROM THE PERSPECTIVE OF AUGMENTED INTELLIGENCE

MARTINA PROPERZI*

ABSTRACT. In this article I will address the issue of the meaning of human-machine interaction as it is configured today in the light of substantial results achieved in the design and the manufacture of Artificial Intelligence (AI) systems. My starting point is a refined solution for meaningful AI recently suggested by Froese and Taguchi from the perspective of so-called augmented intelligence. Interpreted as a kind of human-machine interaction, augmented intelligence distinguishes itself by the fact that it merges the interacting poles into a new hybrid entity. After having clarified the technical and the methodological background of my proposal, I will discuss a case of study of so-called bio-synthetic augmentation, where hybridisation overlaps with the cyborgisation of the human body.

Keywords: Human-Machine Interaction; Augmented Intelligence; Meaning; Cyborg Body; Bio-integrated Interfaces.

1. A very brief overview of contemporary research and innovation in the field of Human-Machine Interaction

Human-Machine Interaction (HMI) is a well-established field of Contemporary Research and Innovation studies. It is attracting more and more the attention of academic scholars, developers, manufacturers and the general public as well due to the strong impact that the new generation of intelligent or smart machines is having on nearly all aspects of everyday human life, at both the individual and the

* Pontifical Lateran University of Rome; email: martinaproperzi@alice.it; ORCID: 0000-0001-6198-3977.

societal level. During the last two decades, interaction theorists have deeply inquired the principles of HMI. According to Müller, for example, psychological principles play a pivotal role in the interactions human beings have with machines, above all with intelligent machines.[1] Here, interaction seems to crucially rely on a process of goal-attribution performed by the human designer and/or user. A process of goal-attribution performed by the human designer and/or user, who ascribes purposive behaviour to intelligent machines. These letters, accordingly, appear as embodying an autonomous kink of agency. Goal-attribution is a psychic process that runs in most cases unconsciously. A psychic process that runs in most cases unconsciously – it pertains to both the individual and the social mind. It pertains to both the individual and the social mind. Its phenomenology grounds on a lived experience of resistance that intelligent machines (are intended to) oppose to the realisation of individual and collective human actions. Following this view, HMI would imply a plurality of and a contrast among different behavioural goals – the goals of the human designer and/or user and those attributed to intelligent machines.

However, as stated by Müller himself, psychological principles, such as the principle of goal-attribution, are not able to explain all the aspects of human-machine interaction, at least where machines are intelligent or smart devices.[2] Here, advanced engineering principles too are required. In this direction, during the last two decades significant progress has been made in both the design and the manufacture of Artificial Intelligence (AI) systems that emulate some aspects of intelligent behaviour. Autonomy is maybe the core property of today AI systems. In this context, autonomy is usually presented as a human-independent ability of resource acquisition, remarkably data acquisition.[3] Well-known examples of autonomous AI systems are self-driven cars, virtual assistants, collaborative robots and intelligent drones – these letters represent an all-pervasive presence in the current debate on potentially injurious autonomous technology.[4] Since the end of the '90s more nature-inspired AI systems have been designed by scholars working in unconventional areas and/or

1 V.C. Müller, "Interaction and Resistance: The Recognition of Intentions in New Human-Computer Interaction", in A. Esposito et al. (Eds.), *Towards Autonomous, Adaptive, and Context-Aware Multimodal Interfaces: Theoretical and Practical Issues*, Springer, Berlin, 2011, pp. 1-7.

2 V.C. Müller, "Autonomous Cognitive Systems in Real-World Environments: Less Control, More Flexibility and Better Interaction", in *Cognitive Computation*, vol. 4/2012, pp. 212-215.

3 Royal Academy of Engineering, "Innovation in Autonomous Systems", in https://www.raeng.org.uk/publications/reports/innovation-in-autonomous-systems, access 17 April 2020. Here, data overlap with discrete pieces of information that represent (discrete) states of the world by means of the association with numerical values.

4 S. Omohundro, "Autonomous Technology and the Greater Human Good", in *Journal of Experimental & Theoretical Artificial Intelligence,* vol. 26, n. 3/2014, pp. 303-315.

fields of AI, such as Artificial Life and Cognitive Computing.[5] This line of research is producing innovation, especially in the applied sectors of Big Data, Collaborative and Soft Robotics, Incorporable Interfaces and Intelligent Sensor Networks.[6]

Considering both conventional and unconventional AI, the point to highlight for the purpose of the present article is the limited control exercised by the human designer and user, who cannot influence and predict the behaviour of the AI system, at least not completely. Think for instance at data-driven autonomous AI systems based on techniques of Machine Learning, e.g., on Deep Neural Networks: they can generate and improve automatically – that is to say, by the use of data – the algorithms they compute. The restriction of the space for human control is crucial for the occurrence of interaction, in a sense relevant for HMI. I suggest connoting this sense as "participatory". It implies, indeed, (the conceptual elaboration of) a behavioural coupling, where the human designer and/or user and the machine participate in a shared conduct characterised by multiple and potentially conflicting goals.

2. Structure of the article

In this article I will address the issue of the meaning of human-machine interaction as it is configured today in the light of substantial results achieved in the design and the manufacture of AI systems. My starting point is a refined solution for meaningful AI recently suggested by Froese and Taguchi from the perspective of so-called augmented intelligence.[7] Interpreted as a kind of human-machine interaction, augmented intelligence distinguishes itself by the fact that it merges the interacting poles into a new hybrid entity. After having clarified the technical and the methodological background of my proposal (§§ 3-4), I will present and discuss according to an open-problem modality a case of study of so-called bio-synthetic augmentation, where hybridisation overlaps with the cyborgisation of the human body (§§ 5-6). § 7 will be devoted to conclusions.

[5] A. Adamatzky, "East-West Paths to Unconventional Computing", in *Progress in Biophysics and Molecular Biology*, vol. 131/2017, pp. 469-493.

[6] K. Rozenberg, T. Bäck and J.N. Kok (Eds.), *Handbook of Natural Computing*, Springer, Berlin-Heidelberg, 2012.

[7] T. Froese and S. Taguchi, "The Problem of Meaning in AI and Robotics: Still with us after All These Year", in *Philosophies*, vol. 4/2019, pp. 539-560.

3. Augmentation: towards a new paradigm for HMI

In a co-authored paper dating back to 2019 Froese and Taguchi reconstructed in some details the history of foundational studies on AI. This historiographical effort is intended as finalised to focus the attention of the scientific community on the lack of suitable solutions for (issues related to) the so-called meaningful AI. Meaningful AI consists in very specific theories, usually collected with the prospect of providing answers to a foundational problem known as the grounding problem.[8] In its most general version, the grounding problem concerns the topic of reference of symbolic and sub-symbolic languages. For example, machine languages are composed by number series that, it is usually maintained, refer to (discrete) states of the world.[9] The alleged referential character of machine languages may be taken as a challenging example of what one more abstractly would connote as the semantic function of language, the function of meaning something. However, how do languages like machine languages get their meaning?

Since the ‘90s the importance of embodiment and enaction as unavoidable pre-conditions for as unavoidable pre-conditions for the generation of meaning has been stressed by a group of philosophers of AI and of AI scholars.[10] They attempted to contrast the disembodied and mentalistic approach pursued by the first generation of theorists and developers of AI. From a technical point of view, the alternative approach pursued focuses on building robots that are able to mimic the natural ability of organisms to enact patterns of information through body-related motor skills.[11] More recent studies have investigated the conceptual grounding of these technical works aiming at reproducing embodiment and enaction in artificial systems.[12]

However, as Froese and Taguchi observed,

---

8 M. Taddeo and L. Floridi, “Solving the Symbol Grounding Problem: A Critical Review of Fifteen Years of Research”, in *Journal of Experimental & Theoretical Artificial Intelligence*, vol. 17, n. 4/2005, pp. 419-445.

9 S. Harnad, “The Symbol Grounding Problem”, in *Physica D*, vol. 42/1990, pp. 335-346.

10 H.L. Dreyfus, *What Computers Can't Do. New York*, MIT Press, New York (NY), 1972; R. Brooks, “Intelligence Without Reason”, in J.P Mylopoulos and R. Reiter (Eds.), *IJCAI' 91: Proceedings of the 12th International Joint Conference on Artificial intelligence*, Kaufmann, San Francisco (CA) 1991, pp. 569-595.

11 To this purpose, a particular class of architectures named subsumption architectures was designed and fed by behaviour language groups. See: R. Brook, “Elephants Don't Play Chess”, in *Robotics and Autonomous Systems*, vol. 6/1990, pp. 3-15.

12 R. Pfeifer and J. Bongard, *How the Body Shapes the Way We Think. A New View of Intelligence*, MIT Press, Cambridge (MA), 2007; T. Froese and T. Ziemke, “Enactive Artificial Intelligence: Investigating the Systemic Organization of Life and Mind”, in *Artificial Intelligence*, vol. 173/2009, pp. 466-500.

> even the enactive approach, which has made a substantial effort to account for value and meaning in a non-representational manner, ultimately leaves it equally mysterious how the subjective, i.e. value, meaning, intention, purpose, etc., as such, on its own terms, could make a difference for the movements of an agent, if it is assumed that its internal and external activity is already completely governed by purely dynamical laws.[13]

The researchers highlight a naturalistic bias in the conceptual grounding of the research programme of embodied and enactive AI. The naturalistic bias would consist in the attempt of explaining meaning, with its unavoidable subjective dimension, as an entirely natural phenomenon. This happens by assuming that the behaviour of an embodied agent is «completely governed by purely dynamical laws» − namely by the set of natural laws that rule how a system develops or alters over time. Starting from this evidence, Froese and Taguchi stressed the need to draw up a new agenda for embodied and enactive AI. They have specifically suggested a shift in perspective from duplicating human and more in general biological abilities to augmenting them by means of pushing the participatory interaction between human beings and intelligent machines at a closer level, namely the level of hybridisation. To quote the researchers:

> One failsafe way of practically solving the problem of meaning in AI and robotics is to make sure that there is always a human somewhere in the behavioral loop. At least in the near future, if the nature– strategy is on the right track, researchers interested in using a synthetic approach to generate technological advances based on meaning would be better served shifting their focus from duplicating human understanding in artificial systems, to directly empowering humans by extending their existing subjective capacities by designing better interfaces.[14]

The hybridisation described by Froese and Taguchi captures the state-of-the-art in the research and innovation practices related to the topic of augmentation.[15] "Augmentation" is a term coined by Douglas Engelbart during the '60s. Engelbart envisioned a new theoretical framework for AI, where centrality is given to human subjectivity improved by AI systems.[16] Augmentation brings into question the polarisation of the interacting poles distinctive of contemporary HMI. This happens

---

[13] T. Froese and S. Taguchi, "The Problem of Meaning", *cit*., p. 541.

[14] *Ivi*, p. 549.

[15] H. Hassani et al., "Artificial Intelligence (AI) or Intelligence Augmentation (IA): What is the Future?", in *AI*, vol. 1/2020, pp. 143-155.

[16] D. Engelbart, "Augmenting Human Intellect: A Conceptual Framework", in *Summary Report – Stanford Research Institute*, 1962, 1024.

in two complementary directions: the first one, known as human-in-the-loop augmentation, is characterised by the insertion of human cognitive and/or behavioural skills into AI systems. Human-in-the-loop augmentation is producing innovation above all in the world of smart services.[17] The second direction is the so-called bio-synthetic augmentation. In bio-synthetic augmentation human bodily skills are improved, enhanced by AI systems. Bio-synthetic augmentation requires the design and manufacture of advanced interfaces, for example bio-integrated interfaces that proved high degrees of compatibility with the organic body.[18] Froese and Taguchi's proposal may be interpreted as an attempt of conceptualising augmentation as a kind of meaningful AI, looking at human subjectivity as a plastic horizon of meaningfulness that contains the autonomous information processing of intelligent machines or, alternatively, it is contained in it.

4. An integrative methodology for studying augmented intelligence

As seen, Froese and Taguchi's proposal aims at overcoming some limitations of the research programme of embodied and enactive AI. Following the researchers, a new conception of artificial systems and their interaction with the human designer and/or user is needed, a conception that goes in the direction of thematising hybrid systems able to augment human natural skills. From a methodological point of view, Froese and Taguchi suggest a trans-sectorial framework for studying augmented intelligence as a kind of meaningful AI. They envision a methodology where differential methods, i.e., methods typically used to describe dynamical phenomena like behavioural dynamics from an impersonal ("third-person") perspective, are combined with phenomenological methods that investigate experience from a first-person point of view focusing on the aspect of meaning, namely on meaningful experience. In the previous paragraph we saw how foundational studies on embodied and enactive AI usually opt for a conceptual approach that avoids reference to extra- or super-natural realms. Drawing the attention on subjectivity as a nature-independent realm, Froese and Taguchi contrast this view as biased by naturalistic assumptions. The methodology they promote stands out for integrating the first-person perspective into the impersonal account pursued by embodied and enactive AI theorists.

---

[17] N. Zheng et al., "Hybrid-Augmented Intelligence: Collaboration and Cognition", in *Frontiers of Information Technology & Electronic Engineering*, vol. 18, n. 2/2017, pp. 153-179.

[18] T. Froese, "Bio-Machine Hybrid Technology: A Theoretical Assessment and Some Suggestions for Improved Design", in *Philosophy of Technology*, vol. 27/2014, pp. 539-560.

A particularly relevant point made by Froese and Taguchi concerns the concept of nature that they attempt to formulate anew. As put by the researchers,

> the assumption of state-determinism sits in tension with other commitments of the enactive approach that have received less attention in the literature, namely its insistence on the groundlessness and the interdependence of the subjective and the objective, which makes it possible to metaphorically conceive of action as "laying down a path in walking". We therefore propose that it is time to step back for a moment and ask ourselves whether the problem of this failure of naturalizing meaning perhaps not only derives from a faulty concept of mind, but rather from an inadequate concept of nature […] We then sketch an alternative concept of nature, one that places limits on its scope, and which we therefore believe has a chance of accounting for the possibility that meaning makes a difference in a material world.

According to Froese and Taguchi, reconceptualising nature is a useful strategy for eluding the naturalistic bias that underpins the research programme of embodied and enactive AI. In the remaining part of this article, i will attempt to problematise the subjective dimension of meaning disticntive of bio-synthetic augmentation by virtue of a phenomenological toolkit. To this purpose, I will introduce and discuss according to an open-problem modality a case study that I consider of particular interest as it is one of the few examples of advanced clinical translation of a bio-integrated interface accompanied by a systematic tracking of the user experience. The case at stake is that of the implantation of artificial corneal extracellular matrices (ECMs) capable of regenerating the damaged organ in patients suffering from blindness induced by the irreversible loss of optical quality of the cornea.

5. A case study: bio-integrated artificial corneal ECMs

The cornea is the protective frontal part of the human eye responsible for transmitting and refracting incident light rays that are focused on the retina by the lens, i.e., the natural lens of the eye. The irreversible loss of optical quality of the cornea, namely the loss of its transparency due to disease or damage, is the second cause of blindness in humans and is typically addressed either with corneal transplantation or with the use of synthetic prostheses. However, the gap between the availability and demand of the transplantable organ, on the one hand, and the complex implantation procedures as well as the frequent post-operative complications, on the other hand, have highlighted the need to pursue new therapeutic approaches, attempted, above all, in the field of regenerative medicine.

Towards this end, a research group active for over a decade in Sweden, Canada and the United States first developed in the laboratory and then tested on animals and humans a corneal metaplasm, consisting of bio-integrated artificial ECMs.[19] Once implanted in the eye, the artificial ECMs have the ability to regenerate the damaged organ, emulating the functions of the natural ECMs, which constitute the part of the tissues not composed of cells. Like the natural ones, artificial ECMs are made of a biopolymer (recombinant collagen of human origin). Unlike natural ECMs, however, they are devoid of cellular filling to ensure the repopulation by the cells of the natural organ and thus prevent reactions of rejection. As the results of the aforementioned study suggest, the bio-integrated artificial ECMs, which were first tested on animal subjects and then implanted in a group of ten human subjects, were shown to be stably incorporated by the patients in the long term (two years of follow-up), leading to an improvement in the pre-anormal visual capacity in six out of ten patients tested as well as to the regeneration of the epithelium, nerves, stroma and tear film in all the subjects involved in the study.

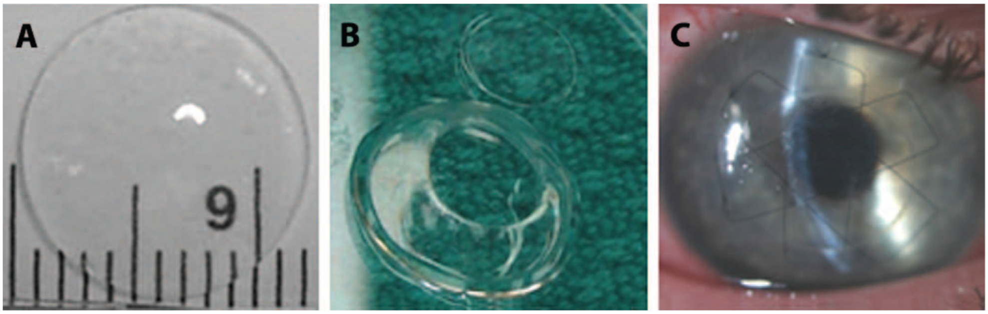

Fig. 1 (A-C): Fabricated and implanted corneal ECMs.
See: M. Fagerhol et al., *A Biosynthetic Alternative*, cit. p. 2.

In 2018 another research group based at the Institute of Genetic Medicine of Newcastle University succeeded for the first time in producing perfectly functional artificial human corneas by using an advanced 3D bio-printing technique.[20] The step forwards compared to the production of corneal metaplasm concerns the fabrication of entire bio-integrated corneal structures. To this end, the research team first constructed a model of an adult human cornea using a rotating Scheimpflug

[19] M. Fagerholm et al., "A Biosynthetic Alternative to Human Donor Tissue for Inducing Corneal Regeneration: 24-Month Follow-Up of a Phase 1 Clinical Study", in *Science Translational Medicine*, vol. 2, n. 46/2010, pp. 1-8.

[20] A. Isaacson, S. Swioklo, C.J. Connon, "3D Bioprinting of a Corneal Stroma Equivalent", in *Experimental Eye Research*, vol. 173/2018, pp. 188-193.

camera equipped with a keratoscope (Placido's disc). The model obtained was utilised by the researchers as a basis to reproduce the microarchitecture of the natural organ through a 3D printing process that uses a bio-ink composed of the combination of two biopolymers (collagen and alginate) and of corneal stroma cells from a healthy donor. After the 3D printing of the corneal microstructures, the research group induced a self-assembly process of the tissue by exploiting the natural ability proper of specialised fibroblasts residing in the corneal stroma to produce components of the ECM. The clinical translation phase of the device is still in progress.[21] Further contributions to the development of bio-printing techniques have stemmed from numerous research groups and companies specialised in bio-ophthalmology.[22]

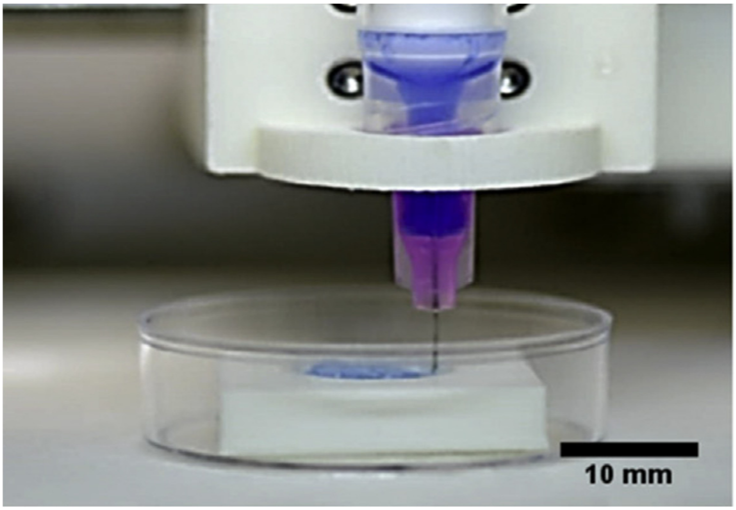

Fig. 2: View of the 3D bioprinting process of artificial human corneas.
See: A. Isaacson, S. Swioklo, C.J. Connon, *3D Bioprinting*, cit., p. 192.

6. An open-problem oriented discussion of the case study

As a case study of bio-synthetic augmentation, bio-integrated artificial corneal ECMs and their most recent evolutions may be inquired under the lens of the interaction-based approach to meaningful AI stressed by Froese and Taguchi.

---

21 Newcastle University, "First 3D-printed Human Corneas", in *Science Daily*, http://www.sciencedaily.com/releases/2018/05/180529223312, access 9 May 2019.

22 B. Zhang et al., "3D Bioprinting for Artificial Cornea: Challenges and Perspectives", in *Medical Engineering & Physics*, vol. 71/2019, pp. 68-78.

In this direction, there are at least two couples of concepts that offer suitable interpretative lines, if approached in accordance with the methodology exposed in § 4. The first couple (Couple 1) consists of the concepts of dynamics and statics, whereas the second couple (Couple 2) embraces the concepts of passivity and activity. An extensive analysis of these four concepts cannot be provided here. Accordingly, with no claim of being exhaustive, I limit myself to outline a discussion of the case study of bio-integrated artificial corneal ECMs that centralises open problems associated with the interpretative lines furnished by Couple 1 and Couple 2.

- Couple 1 (dynamics and statics). The application of this conceptual couple crosscuts the contemporary scenario of applied natural and human sciences. On the other hand, the concepts of dynamics and statics have been widely discussed within the phenomenological movement since its very beginning due to the work of the founder of classical phenomenology, Edmund Husserl. Husserl showed how, interpreted as a subjective process, the constitution of meaning has both dynamical and statical aspects.[23] The distinction between dynamical and statical constitution is not a fixed one. It can be traced in relation to a criterium of time-(in)dependency: dynamical constitution is a time-dependent process, differently from statical constitution, where time has no corresponding values. Patients who received the implantation of bio-integrated artificial ECMs experience up to three functional states regarding their (potential or actual) visual behaviour, namely the anormal state, the restored normal state and the augmented state. In this case, therefore, the subjective constitution of meaning associated with vision is a multi-, inter- and trans-conditional process: constitution might reveal peculiarities in each functional state, as well as in the passage among different states and in the unity emerging from these passages.[24] Accordingly, here, either dynamical constitution or statical constitution are involved. The following questions exemplify a group of problems that concern the concepts of dynamics and statics as they are used to interpret the visual behaviour performed by implanted patients.

    - How does the technologically augmented body work as a dynamical generator of meaning? How does it work as a static generator?

[23] E. Husserl, *Analyses Concerning Passive and Active Synthesis: Lectures on Transcendental Logic*, translated by A.J. Steinbock, Kluwer, Dordrecht, 2001.

[24] M. Properzi, "Il modello corporeo: un'indagine sulla normatività dell'incorporamento di dispositivi biosintetici", in *Filosofia Morale/Moral Philosophy,* vol. 1/2022, pp. 105-126.

- Is there a relevant sense according to which subjective constitutive processes underlying augmented vision differentiate from processes of (a)normal visual behaviour?
- What is the relationship between functional augmentation and semantical augmentation with regard to their corresponding dynamical and statical aspects?

- Couple 2 (passivity and activity). The general remarks made about Couple 1 apply to this couple of concepts too. Also in this case, there is no fixed distinction between passive constitution and active constitution. Here, the criterium of distinction refers to the constitutive modality, which may be receptive or spontaneous with regard to the way meanings are captured and mutually organised. Patients subjected to bio-synthetic augmentation perform passive constitution as a hyper-structured process. Hyper-structuration is due to the interweaving of visual and proprioceptive data derived from the restored oculomotion with mnemonic and imaginative data produced by a kind of vision-related fading memory and by mental imagery, respectively.[25] Mnemonic data concern a sense of lacking-of that is felt by patients in the anormal state of blindness, a sense that contrasts with the overflow of visual images elicited by the restored and over all the augmented functional state. On the other hand, active constitution, such as that performed in active visual attention, is a hypo-structured process. Hypo-structuration affects the subject-relatedness of lived experience, i.e., its quality of being related to the constitutive activity of the human subject. In augmented vision, indeed, meanings (as actively constituted) generate from the hybridisation of two interacting active poles, namely the implanted patients and the artificial ECMs integrated in the diseased or damaged eye. Analogously to Couple 1, Couple 2 has associated a group of problems that may be approached by means of sample questions. Here, the focus is on the role played by the concepts of passivity and activity in meaningful experience associated with bio-synthetically augmented intelligence.

  - How does the technologically augmented body work as a passive generator of meaning? How does it work as an active generator?
  - Is there a relevant sense according to which hyper- and hypo-structured subjective constitutive processes underlying augmented vision differentiate from processes of (a)normal visual behaviour?

[25] M. Properzi, "Body Model and Biosynthetic Devices: Interpretating Technological Incorporation with the Help of Edmund Husserl's Genetic Phenomenology", in *Agathos,* vol. 13, n. 1/2022, pp. 41-60.

- What is the relationship between functional augmentation and semantical augmentation with regard to their corresponding passive and active aspects?

7. Conclusion

In this article I attempted to problematise augmented intelligence as a kind of meaningful HMI. The starting point of my investigation was the recent anti-naturalistic proposal developed by Froese and Taguchi. The researchers stressed the role of human subjectivity as a plastic horizon of meaningfulness that may augment the performance of intelligent machines or be augmented by it. The methodology introduced by Froese and Taguchi combines third-person differential methods with first-person phenomenological methods. The prospect, here, is improving the understanding of meaning in the context of the interaction human beings have with intelligent machines. On this methodological basis, I discussed a case of study of so-called bio-synthetic augmentation, where hybridisation overlaps with the enhancement of human bodily skills. In so doing, centrality was given to a modality of discussion focused on open problems, with the prospect of paving the way to further investigations on the subject matter.