Mem. S.A.It. Vol. 94, 97

Memorie della

VITE I Conference: Contributes in the frame of a Human Augmentation Space

Agnese Augello[1], Giuseppe Caggianese[1], and Luigi Gallo[1]

Institute for High Performance Computing and Networking, National Research Council of Italy
e-mail: agnese.augello@icar.cnr.it

Received: 16/01/2023; Accepted: 27/01/2023

Abstract. Our contribution is to examine some of the works presented during the VITE I conference from a perspective of Human Augmentation (HA). In the paper, we provide a definition of HA framed by Enactivism theory, also schematizing our viewpoint in a three-dimensional space and into an architecture for designing and implementing HA systems.

Key words. Human Augmentation, Enactivism, Augmented Reality, Virtual Reality, Artificial Intelligence

1. Introduction

Nowadays, human beings are more and more entwined with smart devices, and AI systems to the extent that has recently emerged a research field known as Human Augmentation (HA) or Augmented Humanity (AH) (Schmidt (2017); Guerrero et al. (2022); Raisamo et al. (2019)). HA addresses methods, technologies and their applications for enhancing sensing, action and/or cognitive abilities of a human (Raisamo et al. (2019)). It is aimed at improving human capabilities, and productivity by augmenting the normal ranges of human functions through restoring or extending their capabilities (Guerrero et al. (2022)). In Augello et al. (2022) we framed HA systems according to Enactivism cognitive theory, discussing some aspects to be addressed in the design, implementation and evaluation of these kinds of systems to augment users' abilities and in particular cognitive processes effectively.

We examined the scope of HA within the umbrella of Enactivism because this cognitive theory emphasizes the embodied nature of perception, cognition, and understanding. This theory posits that cognitive processes are shaped by the relationship between the living body and its environment, where perception is not just a passive acquisition of information from the environment, but is considered an active process involving the user's actions (Varela et al. (2017)). From this viewpoint, it can be inferred that a system that alters the interaction between individuals and the environment, by enhancing their sensorimotor abilities through the integration of sensors and actuators, will also impact their cognitive processes. In this paper, starting from these considerations, we examine some of the works presented during the VITE I congress according to this enactive interpretation of HA. We provide a definition of a HA system framed by Enactivism theory, schematizing our perspective in a three-dimensional HA space, where the examined works are therefore mapped.

2. Enactive perspective of Human Augmentation

We consider a HA system as the set of technologies and programs that introduce a change in an individual sensorimotor, memory and processing capabilities, thereby influencing their cognitive processes.

In these kinds of systems, the knowledge, experience and needs of the users must be at the centre of system design. From an architectural point of view, we conceive a HA system (see Fig. 1) as a coupling of human abilities with technologies and methodologies introduced by the system. In particular, the introduction of sensors and actuators enables new sensorimotor modalities and allows a user to interact with a mixed physical and virtual environment taking also advantage of storage, computation, and reasoning modules introduced by the system too.

We outlined a space of three dimensions: a sense dimension, a motor dimension, and a dimension related to knowledge and reasoning.

We then hypothesized that the HA system introduces an augmentation along the space dimensions, enabling the individual to interact and reason in augmented ways with elements embedded in a hybrid real-virtual environment (see Fig. 2).

Specifically, the sensory dimension can be expanded by introducing devices equipped with sensors, such as visors, glasses, and haptic sensors. The motor dimension and therefore the physical capabilities of the human can be augmented with artificial limbs but also with devices capturing user actions such as controllers, gloves, and tracking sensors. Human memory and processing capabilities can be supported and extended by exploiting knowledge resources, simple processing systems or advanced AI modules, based on symbolic (ontologies and reasoners) and/or sub-symbolic deep approaches.

3. Example of Human Augmentation systems

VITE I conference was finalised at an exchange of experiences on research, best practices and projects in science dissemination. Several interesting works were discussed, many of them based on innovative technologies such as Virtual Reality (VR), Augmented Reality (AR) and Robotics. In this section, we provide an overview of what was discussed during the conference using the concept of human augmentation as a common thread. We start from the observation that VR and AR technologies, together with artificial intelligence methodologies can not only augment the reality we observe and interact with, but also extend, and increase in a sense the possibilities and experiences of users. We therefore can map some of the systems on the HA space, according to the dimensions on which they mostly insist and in a certain sense augment.

Most of the talks were inherent to systems introducing an augmentation of senses and memory and processing dimensions. Systems on this plan of the HA space, lead to an increase in perceptual capabilities, supported by methods for analyzing, representing, and understanding what is observed, heard, or touched through added sensors. Users can obtain additional information by introducing virtual elements and scenarios for didactic and divulgation purposes, as discussed by Arrigo and Chiazzese from ITD-CNR (an example is the H2020 project ARETE, Masneri et al. (2020)), by Budano (INFN) and Lombardo (INGV) who discussed respectively virtual experiences of a particle physics experiment and the visit of a 3D Vulcano. INAF researchers among which Daricello, Leonardi, Di Giacomo, discussed their experiences with MX, illustrating for example a virtual exhibit of celestial atlases and Starblast, a VR tour of the outcome of stellar explosions. Some of the presented systems allow for gaining knowledge about Astrophysical Phenomena, as in the case of the project named 3DMAP-VR, discussed by Orlando (INAF), or about the accomplishment of peculiar activities, such as the exploration tool AR-IoT, presented by Rometsch (ESA)

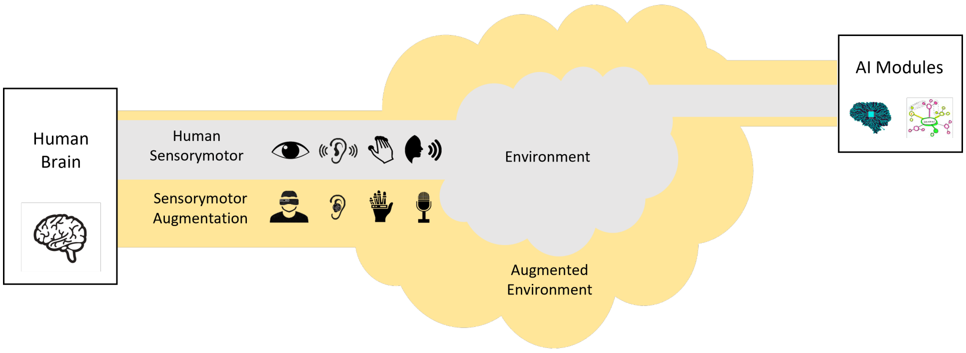

Fig. 1. Architectural schema of a HA system in our perspective

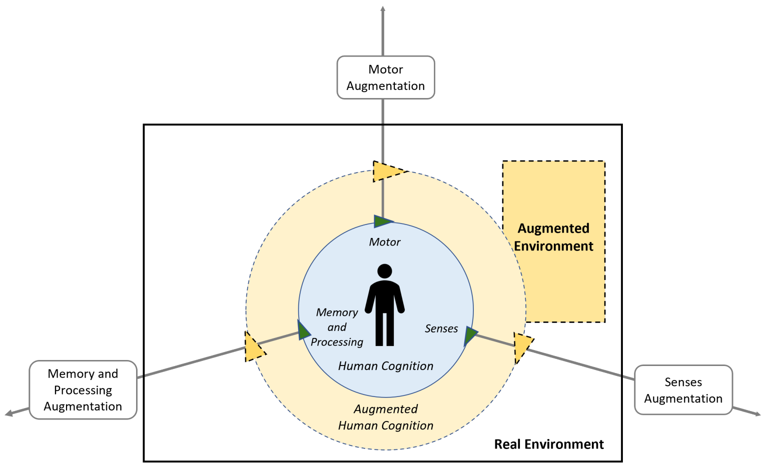

Fig. 2. The HA space.

developed to train future astronauts in extravehicular activities. Other systems were more focused on providing a multisensory artistic experience, as in the Into the (un)known approach for the exploration of the Cosmos, discussed by Inchingolo (INAF), where the most recent astrophysical data are heightened into real works of art.

Systems augmenting perception often are introduced to provide greater accessibility, by compensating for a sensory gap, offering alternative sensory stimuli as highlighted for example by Varano (INAF) and enabling the inspections of sites that are not easily or no more accessible. As an example the system developed by ICAR-CNR in the context of the PAUN project allowed for a gamified exploration of an archaeological site by means of wearable see-through devices. Other uses of AR and VR were widely discussed, for example by Gaglio (UNIPA), La Guardia and Scianna (ICAR, CNR), Corrao, Di Paola, Vinci, Ferla (UNIPA), Guidazzoli (Cineca) Liguori (Cineca). In particular, the project BrancacciPOV presented by Pescarin, introduces a collaborative exploration of a cultural heritage site, the Brancacci Chapel, where visitors can exchange their opinions during the virtual tour.

By introducing an augmentation mainly on motor and memory and processing dimensions, new possibilities for action beyond physical limitations and physical reality can be enabled. Devices such as controllers, gloves, and tracking sensors, but also sensors for sensing physiological parameters can be exploited to change the status of the mixed environment. ICAR CNR developed SmartCare, a system that supports neuro-motor and neuro-cognitive rehabilitation, based on tracking of user's movements and exploiting "biofeedback" mechanisms to adapt the exercises. Gentile and Citta' from ITD CNR, exploited wearable motion capture sensors in a serious game aimed at training visual spatial abilities (Città et al. (2019)). Motor augmentation can also be obtained through actuators in teleoperation or remote presence. For example, Mineo (ICAR, CNR) discussed some important issues related to the realization of human-inspired fully-autonomous robotic inspection systems.

By augmenting mainly senses and motor dimensions, it is possible to offer multimodal experiences for entertaining purposes. As an example Sirena Digitale[1] is a hologram impersonating a mermaid, performing the repertoire of traditional Neapolitan songs and accessible at the MAV Virtual Archaeological Museum in Herculaneum. Through a haptic interaction, it provides visitors with sensations consistent with what they are observing. Within the context of multimodal augmentation fall also the discussions made by Buonocore (UNINA) regarding digital twins for industries.

An augmentation along the different dimensions can reduce task-related cognitive load, as in the case of the industrial plants management system developed in the E-Brewery project[2], discussed by ICAR CNR. This in line with the enactive interpretation of HA. In this direction, ICAR CNR discussed the potential offered by HA systems in surgery to gain, through an augmented interaction with anatomical 3D models, a greater understanding of patients' situations before or during surgery.

4. Conclusion

In this paper, we provided an enactive perspective of HA and examined some of the works presented during the VITE I according to this viewpoint. To pursue our HA vision, it is essential to consider some requirements. While some devices can enhance human capabilities through new sensory and actuation abilities, they can also lead to an increase in the amount of information that needs to be processed which can have a negative impact on the memory and processing dimension. Additionally, some technologies can lead to an excessive movement that negatively affects the motor dimension. Devices with inadequate FOV can also have a negative effect on the senses dimension. Therefore, it is important to monitor the changes introduced by the system to obtain an effective HA.

We consider Enactivism as a theoretical framework to interpret human augmentation introduced by technology. It is important to underline that of course, it is not a requirement for the formalization of AI systems that could enable augmentation of the knowledge and reasoning dimension. Indeed, even if Enactivism represents an important theory in the context of theoretical and applied cognitive science, its "emergentist" view has proven to be less effective when addressing in computational terms high-level reasoning capabilities (Lieto (2021), Vernon (2014)). The computational augmentation of such a dimension can be obtained by considering the most suitable approach.

[1] Sirena Digitale project `https://databenc.it/sirenadigitale/`

[2] E-brewery project `http://www.cerict.it/it/progetti-nazionali-in-corso/532-e-brewery.html`

References

Augello, A., Caggianese, G. & Gallo, L., Human Augmentation: An Enactive Perspective, International Conference on Extended Reality, 219, Springer, 2022

Città, G., Gentile, M., Allegra, M., Arrigo, M., Conti, D., Ottaviano, S., Reale, F. & Sciortino, M., The effects of mental rotation on computational thinking, Computers & Education 141, 103613, Elsevier, 2019

Guerrero, G., da Silva, F. J. M., Fernández-Caballero, A. & Pereira, A., Augmented Humanity: A Systematic Mapping Review, Sensors 22, nr. 2, 514, Multidisciplinary Digital Publishing Institute, 2022

Lieto, A., Cognitive Design for Artificial Minds, 2021

Masneri, S., Dominguez, A., Wild, F., Pronk, J., Heintz, M., Tiede, J., and Nistor, A., Chiazzese, G. & Mangina, E., Work-in-progress—ARETE-An Interactive Educational System using Augmented Reality, 2020 6th International Conference of the Immersive Learning Research Network (iLRN), 283, IEEE, 2020

Raisamo, R., Rakkolainen, I., Majaranta, P., Salminen, K., Rantala, J. & Farooq, A, Human augmentation: Past, present and future, International Journal of Human-Computer Studies 131, 131, Elsevier, 2019

Schmidt, A., Augmenting human intellect and amplifying perception and cognition, IEEE Pervasive Computing 16, 6, 2017

Varela, F. J., Thompson, E. & Rosch, E., The embodied mind, revised edition: Cognitive science and human experience, MIT press, 2017

Vernon, D., Artificial cognitive systems: A primer, MIT Press, 2014