HUMAN MACHINE COOPERATION FOR A RESILIENT INDUSTRY

The future of Human-robot cooperation requires deeper cognitive interaction, where Humans and machines adjust themselves and help each other to compose an efficient and resilient production system.

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The human ability to cooperate flexibly and on a large scale to reach inaccessible goals is commonly pointed out as the single most important factor in Human dominance over other species. As magnificently described by Harari (2014)[1], other animals can cooperate on a large scale, such as ants, or with great flexibility, such as dolphins or chimpanzees in their intimate circles, but none can do it with flexibility and on a scale such as humans.

Different levels of cooperation complexity have been defined, that evolve from sharing a common goal to include the coordination of time and space. In his seminal work, Boesch (1985)[2] defined cooperation hunting as the highest level of cooperation complexity in chimpanzee hunting, in which chimpanzees share a goal (the prey), synchronize the time and define a spatial approach to the attack. To achieve this future-oriented cooperative behaviour, there is the need to share models and representations, that allow each agent of the cooperation to anticipate future states of themselves, the other agents and from the environment.

The context of vacuum cleaning can be used to explain different levels of interaction tightly correlated with the autonomy of the machines: from the handheld vacuum cleaner, which presents no autonomy and therefore is a tool; to the simple robotic vacuum cleaner, that performs dumb autonomous cleaning without any intervention from the user described as an adaptive tool; to the advanced robot vacuum cleaner, that allows the coordination of the task with the human in terms of space and time through the shared representation of the house with the human (map) and an advanced human-machine interface, described as a cooperative assistant (Krüger, 2017)[3].

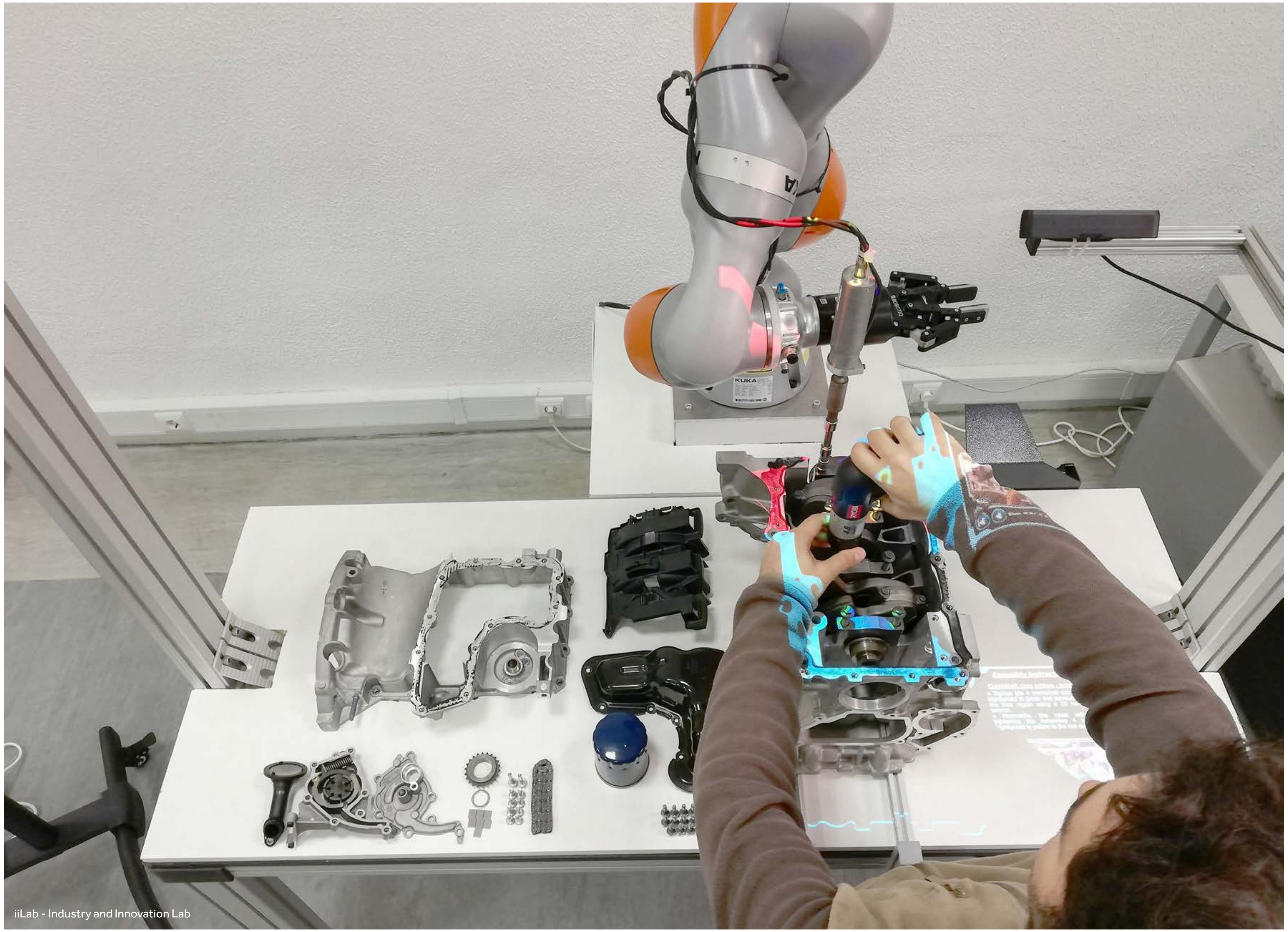
In industry, most of the cooperation is nowadays at the adaptive tool level. Consider for example an industrial robotic cell: the robot performs a pre-programmed task autonomously in parallel with a task performed by the human operator, but minimal or no adjustments are allowed in the cooperation strategy and there is no shared representation of the task in hand.

In the context of the Industry 4.0 paradigm, collaborative robotics is described as the key technology for seamless interaction between humans and machines. This assumption is one of the major pitfalls of most of the industry 4.0 approaches, as shown by the contrast between the hype around collaborative robots and the actual sales numbers (less than 5% of total robot sales in 2019 according to the International Federation of Robotics). A key element in this analysis is the definition of a collaborative robot like the one that allows safe operation in shared spaces with humans.

In perspective and considering the levels of cooperation defined above collaborative robots, per se, are close to a chimpanzee that does not harm the other chimpanzee, but there is still a long way to go to achieve productive cooperation.

Human-robot cooperation, sometimes referred to as cognitive cooperation, will require not only collaborative robots (safe) but also significant developments in the three main pillars of the human-machine interaction: the robot, the interaction, and the human. The robot must evolve to become more autonomous, namely through the deeper integration of perception and artificial intelligence. The interaction must evolve from human to machine interaction via graphical interfaces, to bidirectional and intuitive processes, using, amongst others, augmented reality, speech recognition, that allow humans and the machine to share world and task representations. Finally, the human, whose role must be central in the development of cooperative systems, requires relevant technical education to develop deeper

cooperation with complex machines, in the context of learning factories for example.
An interesting example that shows the work needed on the pillars mentioned above came up during the development of the ScalABLE4.0 project, led by INESC TEC[4]. In one of the demonstrators of the project, the team started with two collaborative robots (in the safe perspective) and evolved to a highly flexible manufacturing system, with the introduction of advanced sensing and vertically integrated artificial intelligence (robot pillar) and friendly human-machine interfaces (interaction pillar). At the end of the project, one operator and two robots were able to deal with the output of four plastic injection machines in a flexible way: complex tasks were performed by the operator and the rest performed by the robot and the system can be re-arranged very quickly. However, the flexibility of the system still relied on a support team with some technical knowledge, required to properly allocate the robots and to adjust or reprogram the robots and injection machines for different scenarios. During the final discussions with the Simoldes Plásticos team (the end-user), a glimpse of the future came up: one operator orchestrating his own cooperative production system, by allocating and reprogramming robots and machines to maximize production in high mix scenarios. To fulfil this vision, significant work must (also) be carried on the human pillar, with the empowerment of the operator the proper tools to achieve an effective cooperative production system.
Resilience in the industry has always been based upon human flexibility to overcome major challenges namely the limitations of traditional industrial automation. Nowadays the challenges have changed, with smarter and more autonomous machines in the need for deeper and more cognitive interactions with their human partner.



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[1] HARARI, Yuval Noah (2014). Sapiens: A brief history of humankind. Random House, ISBN-10 : 9780062316097

[2] Boesch, Christophe & Boesch, Hedwige. 1989. Hunting behavior of wild chimpanzees in the Tai National Park. American journal of physical anthropology 78, 4 (1989), 547–573.

[3] Krüger, Matti & Wiebel, Christiane & Wersing, Heiko. (2017). From Tools Towards Cooperative Assistants. HAI '17: Proceedings of the 5th International Conference on Human Agent Interaction.

[4] https://www.scalable40.eu/