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THE POTENTIAL OF ROBOT-SUPPORTED COLLABORATIVE WORK

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ABSTRACT

Human-Robot Collaboration constitutes a branch of Human-Robot Interaction, seeking to implement collaborative robotic systems in organizations with the purpose of empowering the workforce via the semi-automation of their work routines. To date, scientifically rigorous research on robot-supported collaborative work is still scarce and limited by domain-specificity. This paper reflects on the potential of collaborative robots and presents a rationale for more systematic and ecologically valid empirical studies on the representation of intention to foster mutual awareness in human-robot collaboration across different sectors.

CCS CONCEPTS • Human-robot collaboration (HRC) • Computer-Supported Cooperative Work (CSCW) • Situational Awareness

Additional Keywords and Phrases: Human-Robot Collaboration (HRC), Participatory Design (PD)

INTRODUCTION

In line with the Industry 5.0 paradigm (Nahavandi, 2019), the recent concept of Corporate Social Responsibility (CSR) (Carrol, 2008) invites enterprises to redesign their business model to generate a better social impact on their surrounding environment. Contemporary phenomena such as ageing population, back-shoring of industrial plants and labor shortage are impacting many developed countries and call for a major adoption of autonomous technologies in critical industries and public institutions (Guertler et al., 2023). As past industrial revolutions testify, the introduction of a modern technology in the workplace represents a double-edged sword: it could either empower the workforce by upskilling it and increasing its productivity or obstruct original practices and thus deteriorate working conditions, with the risk of triggering technophobic reactions (Sabie et al., 2023). The emerging research field of Human-Robot Collaboration (HRC) addresses such challenges, conceiving robots as complementary technologies, designed to augment human operators: collaborative robots (*cobots*) will not substitute workers, but rather operate in coordination with them to achieve common goals in a customized and flexible way (Nahvandi, 2019). In the present short paper, I argue that a human-centered, systematic, and rigorous exploration of HRC solutions holds countless benefits for robotic companies and for the customers they serve. To ensure a frictionless and successful adoption of robots in multiple industries, HRC practitioners should reach out to the workers who will be ultimately impacted by this digital transformation to better frame their role as active co-shapers of constantly evolving socio-technical systems (Weiss, 2021).

1. THE DESTINY OF COBOTS

Cobots are flexible, safe and easy-to-program robots designed to operate in close proximity to humans (Peshkin, 1999). Such a technology offers multiple potential positive outcomes for stakeholders at distinct levels and operating in different sectors (Kim, 2022). Its adoption would generate immediate benefits for early adopters, such as:

- Diminish the cognitive and physical workload of workers.
- Free workers from monotonous and/or risky tasks.
- Enhance the preexisting expertise of workers and increase their productivity.
- Upskill the workforce with new capabilities and enrich their work routine.

On the long term, such robotic platforms would be useful to secondary adopters as well as they lower the learning curve for the mastery of complicated procedures by non-expert professionals (Catchpole et al., 2016; Zhang et al., 2022). The computation of procedures could also form a digital archive of best practices to train novice workers and inform secondary stakeholders.

Overall, these foreseen outcomes would advantage the whole organization by:

- Streamlining workflows and increasing their agility.
- Reducing the error rate, safety hazards and operating time.
- Improving the ergonomic quality of working conditions and thus the job satisfaction of employees.
- Creating safe platforms for the experimentation of innovative professional practices.

To the manufacturers of robotic technologies, HRC offers multiple opportunities:

- Research and develop innovative technological solutions to solve problems with a context-aware approach that prioritizes human factors.
- Compensate for the deficiencies of robots by designing semi-autonomous systems that require the initiative and oversight of human experts to operate.
- Prevent and manage usability issues by delivering technology designed with a human-centered approach.

In the end, all the members of the organization would benefit from the adoption of robots as a mean to sustain the collaborative practices that lead to the delivery of a product or a service in different sectors. I believe that such an innovation should be introduced in a bottom-up and gradual fashion, engaging with frontline workers from the initial phases of the research process to capture eventual friction at the root. In my view, HRC will truly empower people only if academics and decision makers adopt a participatory design approach (see Schuler & Namioka, 1993) and conduct field work to investigate the experience of end-users in their original context. Collected data about human aspects and situational factors would be translated into design requirements for the development of human-centered robotic platforms as complex socio-technical systems.

2.CONCEIVING COBOTIC PLATFORMS AS COMPLEX SOCIO-TECHNICAL SYSTEMS

When users rely on technology to complete a shared activity, they form a so-called Human-In-The-Loop (HIL) system (Sreeram & Noof, 2021). In a HIL, the correct execution of a given task depends on the harmonious coordination between one or more human agents (HA) and one or more robotic agents (RA). The successful organization of an HIL system involves more than sequentially allocating operative tasks to each of the involved parties, considered as isolated entities. HRC practitioners should address HIL as complex systems, analyzing the dynamic ways in which its parties are entangled and mutually interact and considering the influence of contingent circumstances on their performance.

This involves going beyond a dyadic human-robot interaction and addressing HIL as socio-technical systems in which the productive activity of group of social subjectivities is mediated by technological artefacts (Emery & Trist, 1960). In this sense, the academic legacy of Computer Supported Cooperative Work (CSCW) studies constitutes a valuable basis to explore the impact of robots on teamwork, with the note that most of the research in CSCW is limited to the use of non-autonomous technologies as supportive tools (Sebo et al, 2020). Sebo and colleagues (2020) present an exhaustive systematic review of studies on the interaction between robots and groups of workers. The authors highlight the need for repeated studies with a more extended time horizon and a more robust methodology to ensure the reproducibility of results (Sebo et al., 2020). This is a commonly recognized problem in the Human-Robot-Interaction community typically addressed by proposing new frameworks to guide and assess the quality of research (Weiss, 2021) and alternative approaches to the design of interactive

robotic systems (Lupetti, Zaga & Cila, 2021). These current trends stress the importance of the use of a plurality of epistemological standpoints and of mixed methods (qualitative and quantitative) to inform HRI research. An HRI practitioner should be able to wear many hats and be a philosopher, user advocate and maker while leading the development of cobotic systems as an ongoing core practice that is under constant review by all participants. The mission is to engage all participants of the socio-technical system to improve their subjective experience and objective performance.

3. COBOTS SIGNALLING TO FOSTER SITUATIONAL AWARENESS

A way to observe the composition and dynamics of such complex HRC infrastructures could be through the lens of awareness systems and the relative spatial metaphors. These are abstract models of work environments that allow to experiment with HRI configurations and identify the optimal way to distribute awareness information via the mutual display of cues by the entities interacting in a context with to accomplish a shared task (Fitzpatrick, 1998: Rittenbruch & McEwan, 2009). These research prototypes can be compared to hybrid physical and digital architectures between a digital twin of the workspace and a permeable social network that links all the parties, transmitting internal and external events (Rittenbruch & McEwan, 2009; VanDerHorn & Mahadevan, 2021). An informed design of the modalities of this transmission is thus critical to enable human-robot collaboration. Research prototypes represent a valuable tool to co-create effective ways to convey intention between a cobot and a team of human operators: they can be used a realistic simulation to test different qualities of signaling channels and variations of information distribution configurations at multiple levels and assess qualitatively and quantitatively how they affect the performance of the system.

CONCLUSION AND OUTLOOK

My doctoral project focuses on the visualization of robotic intentions to support non-dyadic human-robot collaboration in mixed human-robot teams. I will depart from a concrete case study on the use of a cobotic system to perform robotic-assisted surgery. Adopting a participatory design approach, my plan is to engage the target users of the robotic system in co-design sessions to develop human-robot collaboration configurations that foster situational awareness and facilitate the coordinated performance of shared tasks by human and robots.

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