Enriched collaborative Human-Robot Interaction: going further using cognitive state characterization based on electrophysiological features

Context

This internship is part of the EPIIC project (ElectroPhysiological Involuntary Inputs for Collaborative robotics enhancement) funded by ANR (French national research agency). In human-machine interaction research, be it for driving, flying, gaming or medical teleoperation applications, user experience is still to this day under evaluated compared to other technical aspects, and particularly so in the human-robot interaction field. However, part of the community is now aware that there is a need for a richer and better evaluation of HRI, both at the metrics level and at the experimental design level (Hoffman, 2019; Hoffman and Zhao, 2020). In HRI research, the usual metrics to assess the quality of interaction (QoI) are subjective ones, i.e. users' reported feelings acquired through questionnaires, or – more recently – objective ones such as performance metrics (Mayima et al., 2020, 2021). Yet these metrics do not allow for a continuous and online assessment, nor for a direct assessment of the users' cognitive state.

In recent years, the development of physiological computing methods including that of brain-computer interfaces has enabled the rise of symbiotic systems that adapt the interaction using involuntary user inputs (Lotte and Roy, 2019; Roy et al., 2020). Yet, to our knowledge, this technology has never been applied to human-robot interaction (HRI) in the context of mobile and collaborative robotics. This project will provide the first evaluation of the usability of electrophysiological metrics from wearable sensors for a rich, out-of-the-lab and online quality of interaction (QoI) assessment for collaborative robotics.

The main objectives of this internship will be to characterize the users' cognitive state -i.e. cognitive effort and automation surprise- during collaborative HRI using involuntary electrophysiological features elicited by a standard collaborative robotic task, i.e. an interactive manipulation task, using the PR2 LAAS' robot from the LAAS ADREAM facility (figures 1 and 2), along with existing robot architectures for both human-aware motion and task planning (Sisbot et al., 2007; Khambhaita and Alami, 2017), motion capture, and with wearable sensors from ISAE-SUPAERO's Neuroergonomics' lab (cerebral, ocular, cardiac and electrodermal activity acquisition devices).

Figure 1: The LAAS ADREAM facility equipped with various robots and sensors including motion capture.

Content and outline

- Standard experimental approach: Literature review, design of an experimental campaign, robotic task implementation, data acquisition and analysis;
- Ethical and open science framework: Ethical proposal writing and submission, study pre-registration, standardized data formatting and analysis;
- Other: Master thesis writing and defense.

Candidate's profile

- Currently completing a Master of Science or Engineering degree in Robotics, human-computer interaction or biomedical engineering;
- Strong programming skills;
- Autonomous, hard-working, problem-solver;
- Interested in Cognitive Science and Human Factors.

Additional information

- Salary: This internship is financially supported by the ANR, it offers a net salary of 578 euros per month.
- Nationality: Open, although security checks will be performed in compliance with the 'ZRR' (restricted access zone)
- Starting date: Early 2022
- Duration: 6 months
- Supervisors: Dr Raphaëlle N. Roy, ISAE-SUPAERO, and Dr Aurélie Clodic, LAAS CNRS, Toulouse, France.
- Collaborators: LAAS senior researcher Dr Rachid Alami, and ISAE-SUPAERO full professor Pr Frédéric Dehais.
- Application procedure: Formal applications should include a detailed CV, a motivation letter, at least one reference letter, and transcripts of degrees. The documents should be sent to: raphaelle.roy@isae-supaero.fr and aurelie.clodic@laas.fr
- Possibility of pursuing in PhD (funding acquired).

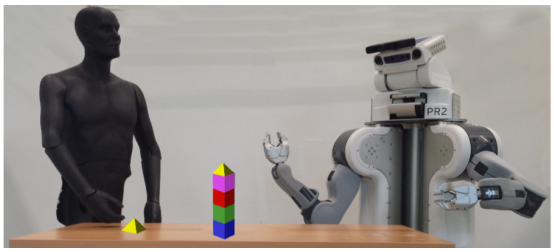

Figure 2: LAAS' PR2 robot from Willow Garage (figure from Clodic et al. (2017)).

References

Clodic, A., Pacherie, E., Alami, R., and Chatila, R. (2017). Key elements for human-robot joint action. In *Sociality and normativity for robots*, pages 159–177. Springer.

Hoffman, G. (2019). Evaluating fluency in human–robot collaboration. *IEEE Transactions on Human-Machine Systems*, 49(3):209–218.

Hoffman, G. and Zhao, X. (2020). A primer for conducting experiments in human–robot interaction. *ACM Transactions on Human-Robot Interaction (THRI)*, 10(1):1–31.

Khambhaita, H. and Alami, R. (2017). Assessing the social criteria for human-robot collaborative navigation: A comparison of human-aware navigation planners. In *2017 26th IEEE international symposium on robot and human interactive communication (RO-MAN)*, pages 1140–1145. IEEE.

Lotte, F. and Roy, R. N. (2019). Brain–computer interface contributions to neuroergonomics. In *Neuroergonomics*, pages 43–48. Elsevier.

Mayima, A., Clodic, A., and Alami, R. (2020). Toward a robot computing an online estimation of the quality of its interaction with its human partner. In *2020 29th IEEE International Conference on Robot and Human Interactive Communication (RO-MAN)*, pages 291–298. IEEE.

Mayima, A., Clodic, A., and Alami, R. (2021). Towards Robots able to Measure in Real-time the Quality of Interaction in HRI Contexts. *International Journal of Social Robotics*.

Roy, R. N., Drougard, N., Gateau, T., Dehais, F., and Chanel, C. P. (2020). How can physiological computing benefit human-robot interaction? *Robotics*, 9(4):100.

Sisbot, E. A., Marin-Urias, L. F., Alami, R., and Simeon, T. (2007). A human aware mobile robot motion planner. *IEEE Transactions on Robotics*, 23(5):874–883.