Architecture to Acquire EEG Data in Human- Robot Collaboration

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Architecture to Acquire EEG Data in Human-Robot Collaboration

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Introduction

The disruptive deployment of collaborative robots, named cobots, in Industry 5.0 has brought the attention to consider safety and ergonomic aspects in industrial human-robot interaction (HRI) tasks. In particular, the study of the operator's mental workload (MWL) in HRI activities has been the research object of a new branch of ergonomics, called Neuroergonomics, to improve operator's wellbeing and the efficiency of the system.

To pursue a human-centered design system, HRI applications have also deployed for Ergonomic assessments. In HRI, cognitive ergonomics is of pivotal importance to monitor the physiological state of operators. This analysis is possible through the deployment of electroencephalogram (EEG) devices. In this way, an objective, real-time, analytical, and non-obtrusive analysis allows to better understand the cognitive state of the operator while co-working with the cobot.

Methods

To monitor the human state, wearable devices are chosen depending on the tasks to be executed and the workplace characteristics and requirements. In general, the physiological sensors should be selected to ensure a reliable monitoring of the workers' state. Indeed, not all of them might be selectively optimal since they are sensitive to the physical activity. In our laboratory experiments, we collected neuronal physiological data through the electroencephalography (EEG) cap. The data were collected through the electrodes mounted on the cap to the scalp of 3 participants. Each electrode measured the voltage produced by the neuronal activity from the region of the brain in which it is placed. The trials consisted lasted 90 minutes with a monitoring of the data for 30 consecutive minutes (3 halves).

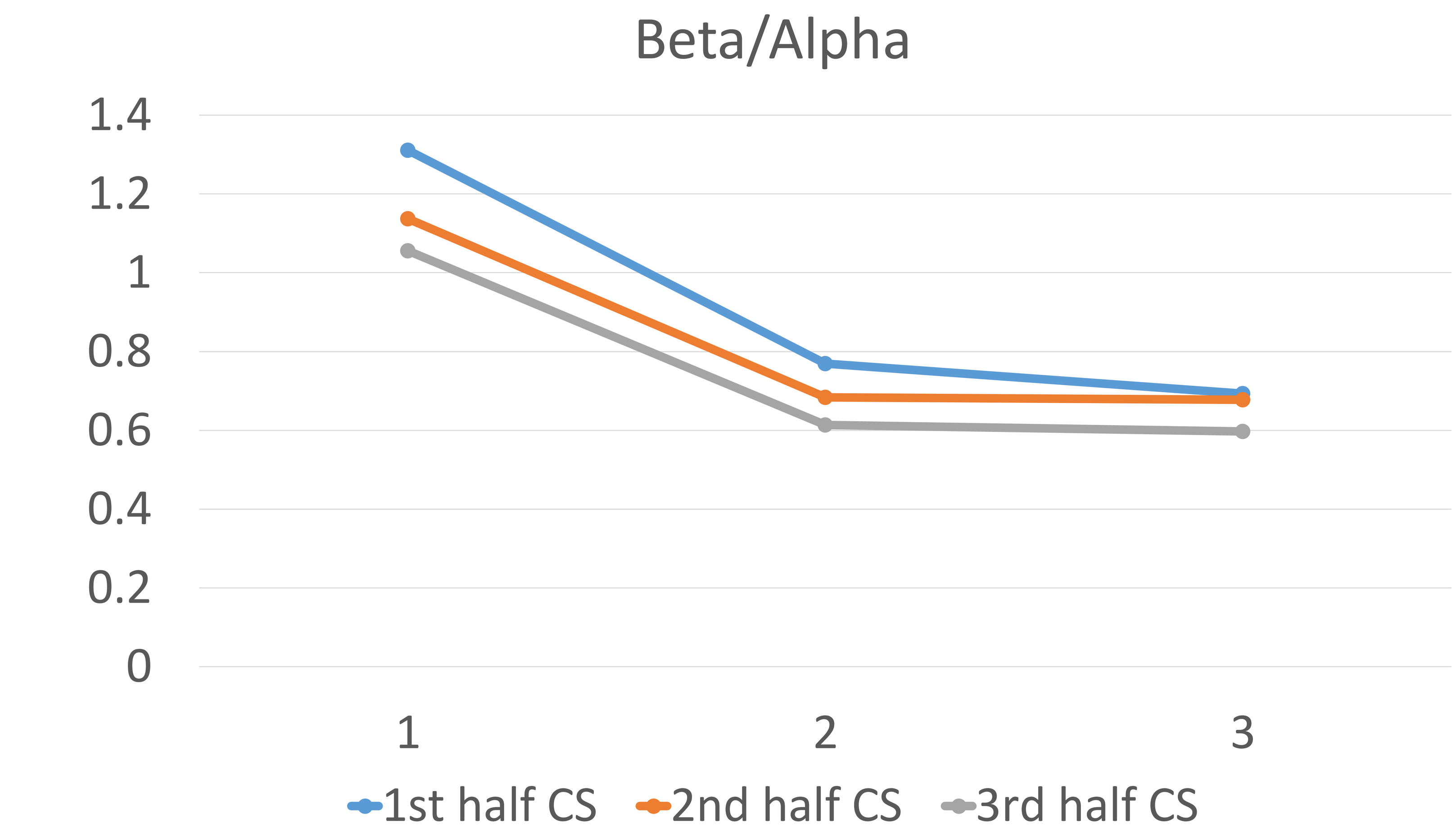
Results

EEG signals are very sensitive to artifacts and noise, whose source are not the brain. Regarding the noise, a band-pass filtered 1-40 Hz is applied for its reduction. Possible sources of artifact in EEG signals include either technical reasons or person's own behavioural and physical activities. These artifacts can be inspected manually by expert eyes, but automatic artifacts detection is encouraged in automated system designs, otherwise artifacts can corrupt the results. Different methods are applied to remove artifacts. In the pre-processing phase, authors applied the Independent Component Analysis (ICA) to remove these artifacts. Finally, EEG signals were re-referenced to their average value.

Feature extraction is the further step after the pre-processing phase of EEG signals. In this study, we evaluated the engagement index (EI) as the fraction between Beta waves (engagement/stress indicator) and Alpha waves (relaxation indicator)

$$EI = \frac{\beta_{frontal}}{\alpha_{parietal}} \qquad (1)$$

The index is shown in the figure below in the collaborative scenario (CS, with the interaction with the robot).



The analysis showed a diminution of the index during the trials. This might be due to the fact the participants felt less engaged during the task.

Conclusions

The analysis of EEG data has shown that it is possible to analyze the mental state of the operator during a HRC activity. Further research will be set to evaluate these parameters allowing to have a better comprehension of the mental state of the operators.

Reference

Savkovic, M., Caiazzo, C., Djapan, M., Vukicevic, A.M., Pušica, M., & Macuzic, I. (2022). Development of Modular and Adaptive Laboratory Set-Up for Neuroergonomic and Human-Robot Interaction Research. *Frontiers in Neurorobotics, 16*.

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