Human-Robot interaction using Brain Computer Interface Based on EEG signals

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Abstract

While the field of human-robot interaction (HRI) using brain-computer interface (BCI) based on electroencephalography (EEG) signals holds great potential, there are several challenges that need to be addressed. A BCI is a communication system that enables direct interaction between the human brain and external devices, such as computers or robots, without the need for traditional motor pathways like muscles or nerves. Brain-controlled mobile robots based on EEG signals offer a unique and potentially transformative approach to human-robot interaction it establishes a direct link between the brain's neural activity and the control of external devices, allowing individuals to communicate, interact, or control their environment using their thoughts. At present, a significant challenge lies in comprehending the EEG signals generated by the brain to gain more immediate insights into the domain of human-robot interaction using brain-computer interface technology.

This research is dedicated to the formulation of a comprehensive strategy for tele-operating robots, with a unique emphasis on mind-control mechanisms. The primary objectives include advancing mapping and trajectory planning through the integration of human feedback and achieving real-time control over multiple robots. While the remote control of mobile robots boasts diverse implementation methods, a critical aspect of this research is addressing the specific requirements for working with immobilized individuals. This necessitates the establishment of contactless communication between the person and the robot.

A central proposition in this study involves the application of EEG signal decoding to revolutionize human-robot interaction. By harnessing the neural signals from the brain, we aim to enable precise control of robots and seamlessly integrate human behavior into the control paradigm. This approach not only enhances the efficiency of tele-operation but also contributes to a more intuitive and responsive collaboration between humans and robots. Furthermore, our research extends its focus to the exploration of incorporating eye feedback and other sensor inputs. This multifaceted approach seeks to enrich the learning process of robots by capturing additional dimensions of user interaction. The integration of eye feedback, along with other sensor data, is anticipated to contribute to a more nuanced understanding of the user's intentions and preferences. Moreover, it plays a crucial role in augmenting the assessment phase, ensuring a comprehensive and accurate evaluation of the system's performance.

In pursuit of our goals, the last year was dedicated to exploring the topic extensively through a comprehensive analysis and review of the literature. This intentional approach has allowed us to invest significant time in understanding the basics needed to get off to a strong start. The results of this work have yielded key findings for our research efforts. A pivotal finding of this study is the inherent diversity of brain-computer interface (BCI) applications, especially with regard to the neural models that can be harnessed for control. Among the neuro-paradigms, Motor Imagery stands out prominently. This approach empowers users to control the BCI by mentally envisioning specific actions. It takes use of the brain's capacity to produce distinctive neural patterns linked to envisioned motions. Therefore, motor imagery becomes a powerful tool that is commonly used in applications for motor control and rehabilitation. Cognitive Control, another significant neuro-paradigm, broadens the scope of BCI applications. It involves using the BCI to affect the user's cognitive processes and decision-making skills, providing adaptability outside of motor-centric operations. The study also clarifies the usefulness of visual stimulus paradigms. Users can effectively control the BCI by paying attention to or reacting to visual inputs. In activities requiring focus and decision-making, visual stimulus paradigms are useful and offer a flexible alternative for motor-centric strategies.

In summary, this research aspires to pioneer advancements in the field of human-robot interaction through a multifaceted strategy. The integration of mind-control, coupled with EEG signal decoding, eye feedback, and sensor inputs, aims to redefine the capabilities of tele-operated robots, particularly in scenarios involving immobilized individuals. The outcomes of this study are anticipated to have far-reaching implications for the design and implementation of intelligent and responsive robotic systems.

***Index Terms*—Human–robot interaction, Brain-computer interfaces, Electroencephalogram (EEG), Assistive robotics, Robot navigation, Motor Imagery, Visual stimulus, Machine learning, Deep learning.**