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Controlling Gestures of a Social Robot in a Brain Machine Interface Platform

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Introduction: Neural-based robotic platforms have become increasingly attractive option as a mean of direct communication between the brain and environment without any further physical contact. The information extracted from the brain signals will determine the degree and level of control in robot control tasks. Brain-robot interaction capability has shown great promise in development of forward control compatible with a patient's intentions and in cognitive training or rehabilitation using neurofeedback approach. Here, we propose a novel Brain Machine Interface (BMI) robotic platform using a personalized social robot in order to assist human participants during mind training. Brainwaves of a human participant were collected in a noninvasive-based BCI system during tasks of imaginary movements. The imagined body kinematics parameters were decoded to control a cursor on a computer screen during a fast training protocol (~ 10 minutes) and then the trained subject was allowed to interact with a social robot in our real-time BMI robotic platform. This wireless interaction not only can be useful for mind control of social robot's movements, but also could set foundations for the next stage application in rehabilitation of the cognitive abilities such as enhancing attention and memory of individuals with brain injury by providing real-time neurofeedback from social robot.

Material, Methods and Results: During a fast training protocol, EEG signals were acquired by using an Emotiv EPOC device with 14 channels and through BCI2000 software (with high pass filter at 0.1Hz and low pass filter at 30Hz). By engaging the subject in our three-phase protocol including training, calibration, and test, the subject could achieve satisfactory control of a computer cursor after a short-time of training and based on imagined body kinematics paradigm. Then, the trained subject was allowed to make interaction with our BMI robotic platform to control the various gestures of a social robot in real-time course. As robotic interface, an affordable social robot called "Rapiro" was employed to provide neurofeedback to the subject. Simulink program was applied as interface software and was responsible to map the control signals (from BCI2000) to the correct pre-defined gesture in Rapiro. Figure 1 shows one example of real-time reactions of robot during mind-control of cursor in 2D space by a human subject.

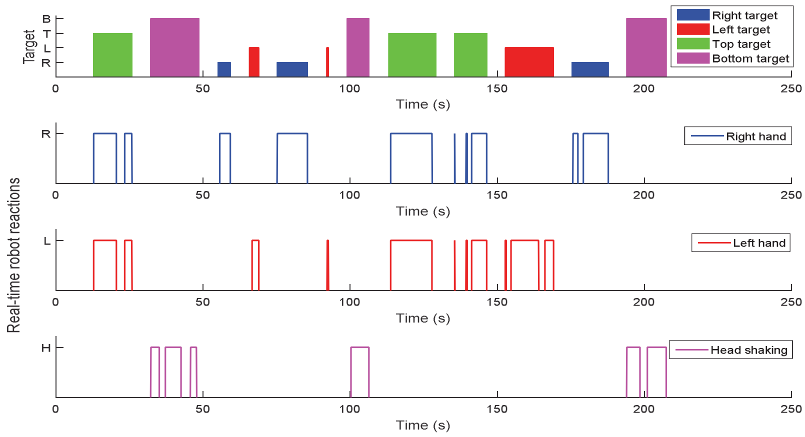

Figure 1. *Mind controlled robot gestures (Right hand movement/left hand movement/both hands movement/head shaking) in real time. The figure illustrates cursor control task performance in 2D space during 12 trialsof a trained human subject. The mirrored robot movements served as simultaneous neurofeedback to the subject. It was programmed as such that the right target control activated the right hand movement; the left target control activated the left hand movement; the top target control lead to both hands movements and the bottom target control caused head shaking neurofeedback from the robot.*

Discussion: As it is shown in Figure 1, a human subject was able to activate the correct gesture in social robot and achieved satisfactory performance. As the result of guiding cursor in wrong direction by the subject in some moments of inter-trial times, some discontinuities were observed in activating of robot neurofeedback.

Significance: Several BMI platforms have been developed for patients with motor disorders during recover of the cortical plasticity underlying movements. However, limited research has applied robot as neurofeedback back to the human. Hence we offered a novel BCI robotic platform with possible future application for neurorehabilitation in patients with cognitive or mental disorders such as attention deficits. The presented BMI system using human-robot interaction can be further developed as a portable, wireless, and affordable platform to be used by patients.

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