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EEG-Based Control of a Unidimensional Computer Cursor Using Imagined Body Kinematics

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Introduction: Brain computer interface (BCI) are systems that can extract information from brainwaves to control a computer or an external device. A computer cursor controlled by brain activity, one of the interesting neuro-prosthetic devices in BCI, was first offered to the patients with spinal cord injury using invasive measurements of brain activities. More recently, techniques based on noninvasive measurements such as Electroencephalography (EEG) have become popular. Here, we investigate the activation and control of a computer cursor in one dimension by engaging brain signals collected using EEG sensors and through a novel paradigm called “imagined body kinematics.” In contrast to the earlier techniques using sensorimotor rhythms, the method here intends to directly extract information of imagined body kinematics from EEG and thus can significantly reduce training time.

Materials and Methods: The experimental procedure included three phases. During the experimental procedure, 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). Phase 1 was the training phase. The subject was asked to sit comfortably in a fixed chair with hands resting on the laps. The subject’s face was kept at an arm’s length from the monitor. The subject was instructed to track the movement (up-down/right-left) of a computer cursor, whose movement was controlled by a practitioner in a random manner. The training phase consisted of 5 trials, each of which lasted 60 seconds. Phase 2 was the calibration phase, during which a decoder model was constructed to model the velocity of the cursor as a function of the EEG waves of the subject. For more accurate reconstruction and prediction of the imagined kinematics at each point, 5 previous points (time lag) of EEG data were also included in the decoding procedure. Then, the developed decoder was fed into BCI2000 software to test the performance of the subject in phase 3 (test phase). In the test phase, the subject was asked to move the cursor using their imagination to a target that randomly appeared on the monitor.

Results and Discussion: Five healthy subjects with no prior experience in BCI studies were recruited for this work. In the control phase, six continuous trials were illustrated to the subject and they were asked to reach the presented target in a 15 second period by imaging the movement of the cursor. The trial was marked as success if the cursor hits the target within 15 seconds; otherwise failure. Table 1 shows the results of cursor movement using imagined kinematics.

Table 1. Results of cursor movement using imagined body kinematics

	Vertical Direction	Horizontal Direction
Number of Trials	30	24
Success Rate (standard deviation)	83.3% (+/- 11.7%)	100% (+/- 0%)

Results are based on 5 subjects. Four subjects each conducted 6 trials of vertical movement and 6 trials of horizontal movement. One subject conducted 6 trials of vertical movement and did not conduct horizontal movements.

Conclusions: A noninvasive BCI system was developed using scalp EEG to decode imagined body kinematics. It was shown this paradigm required just a short amount of time in training in contrast to previous algorithms based on sensorimotor rhythms. The subjects were able to gain a high success rate in controlling and hitting targets which is noteworthy compared to previous works. The current studies included one-dimensional movements in both vertical and horizontal direction. In future work, we will extend the research to conduct 2- and 3-dimensional movements. The developed algorithms have the potentials to be used in convenient, efficient assistive devices of BCI technology.

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