One-Dimensional Imaginary Movement Cursor Control Using Disc and Tripolar Electrodes

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Abstract. We performed a one-dimensional imaginary task for a brain-computer interface (BCI) comparing disc and tripolar concentric ring electrodes (TCREs). Three human subjects acquired substantial control of the cursor with an average success rate of 30 - 66% for disc EEG, and 44 - 100% for TCRE EEG (tEEG).

Keywords: BCI, one-dimentional imaginary task, tripolar concentric electrode, TCRE, TCRE EEG, tEEG

1. Introduction

Brain-computer interface (BCI) is an alternative means of communication with computers that does not depend on the peripheral nerves and muscles, which implements the direct communication and control between the brain and computer devices [Wolpaw et al., 2002]. A BCI may be useful for people who are severely paralyzed to communicate and interact with their environment. Recently, there has been much interest in the area of BCI such as to “move cursor: up, down, right, and left”. The electroencephalogram (EEG) is a non-invasive recording of neural brain electrical activity. Digital processing of EEG signals is an important part of the design of BCI [Wolpaw et al., 2002]. Unfortunately, EEG signals have low signal to noise ratio (SNR), low spatial resolution, and are contaminated by various artifacts from other sources. These characteristics limit measuring the spatial distribution of brain electrical activity and thus necessitate significant preprocessing [Wolpaw et al., 2002]. Recently, enhancements have been applied to EEG making it more accurate by increasing the spatial resolution. One such enhancement is the application of the surface Laplacian to the EEG. The tripolar concentric ring electrodes (TCREs) were shown to estimate the Laplacian significantly better than bipolar concentric ring electrodes and conventional disc electrodes [Besio et al., 2006; Koka and Besio, 2007]. The TCRE EEG (tEEG) provides approximately a four times enhancement in the SNR, three times enhancement in spatial resolution, and twelve times enhancement in mutual information compared to disc electrode signals [Koka and Besio, 2007].

2. Material and Methods

This research is based on recording, analyzing, and comparing disc EEG vs. tEEG based BCIs for real-time one-dimensional cursor control. Three healthy male subjects (1-3, ages 24-40) were the BCI users in this study group. The subject’s task was to move a computer cursor from the center of the screen to a target that appeared in the left or the right of the periphery of the screen. During BCI operation, subjects were seated in a chair, facing a computer screen which was placed about 1.5 meters in front of the subject. The subjects were asked to remain motionless during the recording process. The BCI2000 [Schalk et al., 2004] software application was used to acquire signals recorded from eight surface electrodes (C3, C1, Cz, C2, C4, FC1, FCz, FC2) according to the international 10-20 system, with reference and ground from the right mastoid process. Signals from all the channels were amplified (g.tec GmbH, Schiedlberg, Austria), filtered (0.1-100 Hz) and digitized (sampling frequency was 256 Hz). There were 20 trials in each of 10 runs (one session comprises ten runs). Subjects 1 and 2 had one session and subject 3 had 2 sessions. The mean of the two sessions was used for subject 3. Each trial began with the appearance of the target. The subject’s goal was to move the cursor so that it hits the target.

3. Results

Table 1 shows the accuracy of imaginary cursor movement for each subject using either disc EEG or tEEG. The average accuracies achieved by the three subjects ranged from 30 - 66% for disc EEG, and between 44 - 100% for tEEG. Fig. 1 shows the subjects had significant control from the beginning. A general factorial design of analysis of variance (ANOVA) was used with a single categorical factor being the type of the electrode used (conventional disc EEG vs. TCRE Laplacian tEEG) and the response variable being the BCI trial success rate percent. The effect of the controllable factor that is the human subject was blocked with three levels of blocking factor corresponding to three human subjects who participated in the study. The measurements of response variable (10 replications) were repeated for each type of electrode in three levels of the block factor. There was a significant difference between EEG and tEEG accuracy.

Table 1. *One-dimensional cursor control; accuracy for each subject was calculated for disc and tripolar electrode.*

Runs #	Subject 1 Hit Acc (%)		Subject 2 Hit Acc (%)		Subject 3 Hit Acc (%)	
	EEG	tEEG	EEG	tEEG	EEG	tEEG
1	60	68	43	50	51	62
2	51	64	30	45	55	60
3	54	64	41	58	60	61
4	48	60	35	50	64	57
5	52	58	53	52	61	70
6	54	60	45	47	55	68
7	57	65	47	44	57	85
8	53	63	50	58	60	88
9	60	66	46	78	55	74
10	59	70	51	69	66	100
Mean	54.8	63.8	44.1	55.1	58.4	72.5

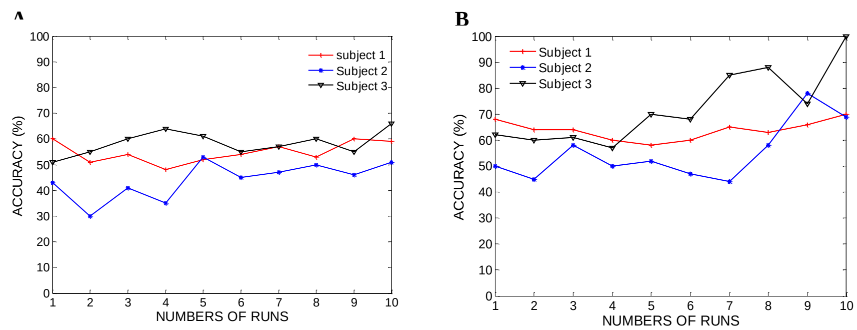

Figure 1. *Hit accuracy of (A) disc electrode, and (B) tripolar concentric ring electrode (TCRE).*

4. Discussion

These results show there is a significant difference in accuracy of the tEEG to disc EEG for new users in real-time one-dimensional center-out cursor control. The tEEG accuracy on average was higher than for the disc EEG. We suspect this advancement is due to the improvement of: four-fold in signal-to-noise ratio, three-fold in spatial selectivity, and twelve-fold in mutual information of tEEG compared to EEG [Koka and Besio, 2007]. In summary, this abstract describes the comparison of one-dimensional BCI control using disc EEG and tEEG by beginner subjects.

Acknowledgements

We would like to thank Dr. Oleksandr Makeyev for his assistance with statistical analysis.

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