Analogue Mouse Pointer Control via a Online BCI using SSVEP

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Background and Objective

The Steady State Visual Evoked Potential has proved a robust paradigm for viable Brain-Computer Interfaces with high transfer rates. Discrete analysis techniques are appropriate for applications that are inherently discrete in nature, such as selecting numbers on a keypad to dial a telephone number or letters from an alphabet to spell words. However the most prevalent human-computer interface is the point and click of the mouse pointer, an intrinsically analogue control method. Applying common discrete control methods to analogue interfaces results in a cumbersome, frustrating experience for the end user and common performance measures become meaningless. We introduce a novel online BCI for fully analogue four directional mouse pointer control in which a binary decision is never made. The system is tested by six subjects through an online game moving a reticule to hit targets and compared to a traditional discrete system.

Methods

The stimulator/feedback engine contained a pointer reticule surrounded by four distinct reversing gratings. The user could move the reticule around the screen by simply attending the stimulus corresponding to the direction they wished to move. Single cycle lengths of EEG corresponding to each of the four stimuli were sequentially extracted and presented to an FFT and the complex results used in significance tests for discrete control and to calculate phase coherence for analogue control. At each decision step discrete control resulted in a cursor movement of 0-1 pixels whereas analogue control provided a range of movement from 0-5 pixels. Six subjects were required to complete four distinct ‘Games?for both control modes requiring the movement of the target reticule over a set of subsequently appearing targets. Pointer trajectorys and time taken were recorded .

Results

Analogue Control took the least time to complete 17 out of a possible 24 games across all subjects. The average time to complete a game using Analogue Control was significantly less ($p < 0.01$) than using Discrete Control. A wrong move was counted as a move in x or y direction that resulted in the pointer being further away from the current target than on the previous iteration. Analogue Control had a significantly higher ($p < 0.01$) percentage of wrong moves than Discrete Control.

Discussion and Conclusions

There was significant difference in time taken to complete a game between Discrete and Analogue Control but the latter suffered from significantly higher percentage of wrong moves. It is clear that the higher sensitivity of Analogue Control is more susceptible to contamination from other stimuli or by ongoing brain rhythms overlapping with stimuli frequencies compared to the statistical test threshold employed in Discrete Control. To address this a further control method combining the high threshold for initial movement of Discrete Control and the proportional movement of Analogue control was explored with excellent results . It is important to always relate the control method of the BCI to the application at hand. In this way a BCI can be constructed that truly fits the application rather than augmenting applications to fit the BCI.

Keywords

SSVEP; Analogue; Online Pointer; Phase Coherence