 DOI: 10.3217/978-3-85125-962-9-199

Transitional Gestures for Enhancing ITR and Accuracy in Movement-based BCIs

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Introduction: BCIs using imagined or executed movement enable subjects to communicate by performing gestures in sequential patterns. Conventional interaction methods have a one-to-one mapping between movements and commands [1] but new methods such as BrainBraille [2] have instead used a pseudo-binary encoding where multiple body parts are tensed simultaneously. However, non-invasive BCI modalities such as EEG and fNIRS have limited spatial specificity, and have difficulty distinguishing simultaneous movements [3]. We propose a new method using transitions in gesture sequences to combinatorially increase possible commands without simultaneous movements. We demonstrate the efficacy of transitional gestures in a pilot fNIRS study where accuracy increased from 81% to 92% when distinguishing transitions of two movements instead of two movements independently. We calculate ITR for a potential transitional version of BrainBraille, where ITR would increase from 143bpm to 218bpm.

Material, Methods and Results: Our pilot study was run on two participants: one male 25-year-old and one non-binary 21-year-old. The study was run using the NIRx NIRSport, a wearable fNIRS system containing 39 optodes in a custom configuration. Participants tensed their left hand first, then their right hand and vice versa in a random order for 40 trials each. We identified the 10 most significant channels using a GLM, applied a 0.09Hz third-order low-pass Butterworth filter and then performed independent component analysis. Using a support vector machine, classification in left vs. right obtained 81% accuracy while left-to-right vs right-to-left obtained 92% accuracy.

Next, we applied the transitional gesture method to BrainBraille. BrainBraille maps different body parts onto Braille characters (Figure 1) for high speed text entry [2]. BrainBraille's prior reported ITR is reduced due to the constrained dictionary for increasing accuracy, so we consider the results without the dictionary, 143bpm at 87% accuracy. Whereas BrainBraille selected 27 out of a maximum 2^6=64 commands to ensure no more than 3 body parts were activated at the same time, transitional BrainBraille can permutatively reach up to P(6,3)=120 commands with same constraints, achieving 218bpm even when accuracy is kept constant.

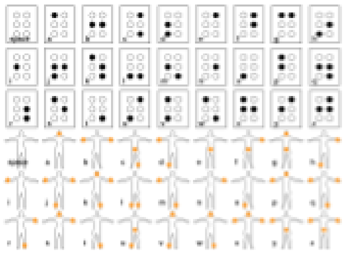

Figure 1. BrainBraille layout mapping characters to body parts for movement-based text entry.

Discussion: While gesture sequences in transitional gestures allow more commands, they may also last longer than traditional gestures due to multiple movements. However, this effect may be the reason for the accuracy benefits as it results in multiple spikes or waves in hemodynamic signals. As we run a complete study of transitional BrainBraille, we expect the effects to become clearer.

Significance: We showed that transitional gestures can be integrated into existing movement-based BCI communication methods to increase the accuracy of responses and convey information at faster rates with a greater range of commands. Our method will help advance new movement-based interaction techniques for BCIs that are faster and more reliable.

References: [1] C. Guger et al., "Complete Locked-in and Locked-in Patients: Command Following Assessment and Communication with Vibro-Tactile P300 and Motor Imagery Brain-Computer Interface Tools," Frontiers in Neuroscience, vol. 11, 2017.

[2] Y. Zhao et al., "Brainbraille: Towards 100+bpm typing with a haemodynamic response-based brain-computer interface," Proceedings of the 2021 BCI Meeting, vol. 63, no. 2, p. 84, 2021.

[3] R. Alazrai, H. Alwanni, and M. I. Daoud, "EEG-based BCI system for decoding finger movements within the same hand," *Neuroscience Letters*, vol. 698, pp. 113–120, Apr. 2019.

 Article ID: 144606