Hybrid brain-computer interface for effective communication of decisions

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Hybrid brain-computer interface for effective communication of decisions

1.AIM

- To develop a novel hybrid brain-computer interface (BCI) user interface through synergetic combination of an event-related de-synchronization (ERD) BCI and gaze modalities wherein the user can make sequential decisions in minimum time with fewer iterations.

2.INTRODUCTION

- Non-invasive BCI and eye-tracking technologies open up new communication pathways for both healthy and disabled people [1], [2].
- However, the performance of BCI and eye-tracking are currently too low to be of wide practical use [3].
- One of the main challenges of BCI is the reliable selection of a choice out of multiple options based on brain activity responses.
- A major issue with gaze based selection of choice is the Midas-Touch problem: differentiating attentive saccades with the intended goal of communication from lower level more random eye movements.
- This work overcomes these issues by combining the BCI and gaze modalities within our proposed graphical user interface, in which the user can make sequential decisions in minimum time with fewer iterations.

3.METHODS AND RESULTS

- Our hybrid BCI system is designed to include a gaze and motor imagery (MI) signals such that choice target selection can be achieved with the same interface layouts for 3 different modes of use:
  - An eye-tracker;
  - MI signals; and
  - A portable eye-tracker combined with MI signals.
- Specifically, the eye-tracker system can search and select the desired command among 8 possible commands by gaze coordinates and dwell time, respectively (Fig. 1 (A)).
- The MI signal can be used as a 2 class ERD/ERS BCI system to search and select an item, based on neurofeedback received from support vector machine classifier (Fig. 2 (B)).
- To use eye-tracker with MI simultaneously, users can employ their gaze to any of 8 target boxes so that the position of command objects remains the same, and the MI signal is used for the selection of one of the 8 objects (Fig. 3 (C)).
- The performance is evaluated by the number of commands executed and the time to complete the task.
- We show that the average activity index for MI signals is significantly reduced (~ 45%) with our proposed hybrid BCI layout.

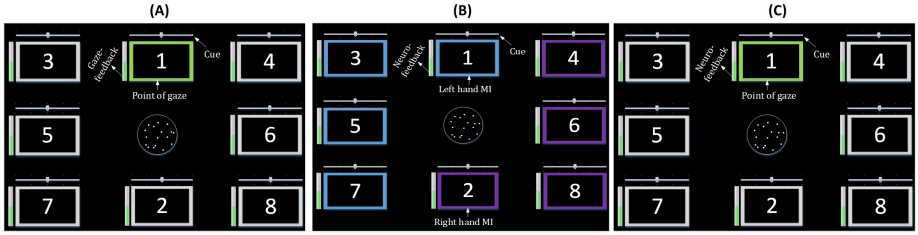

Fig. 1. The proposed multimodal graphical user interface (GUI) without altering the positions of the command objects for different modalities. The centre circle represents a random dot motion stimulus in each GUI. The search and selection of the items are performed by **(A)** eye-tracker only, **(B)** MI signals only, and **(C)** eye-tracker and MI signals.

4.DISCUSSION

- This study provides a proof-of-concept for designing a multimodal graphical user interface (e.g. a hybrid BCI) without altering the positions of the command objects for different modalities.
- The Midas-Touch problem can be overcome using MI neurofeedback, aided by the proposed hybrid BCI interface. An additional MI neurofeedback may improve the usability of the system.
- It also provides flexible modality options for the user to choose according to their needs.
- Our future work will focus on further improving the performance of the hybrid system including the decision making concept based on response time, time to completion, error rate and different type of feedbacks for each modality so that it can be used in psychological experiments, controlling machines e.g. wheelchair [4], [5], [6] and in augmentative and alternative communication (AAC) system for disabled people [7].

5.SIGNIFICANCE

- Our hybrid BCI graphical user interface has relatively higher performance compared to individual eye-tracking or BCI technique with 2-class ERD/ERS-based BCI to select and search the desired command.
- It can overcome the Midas-Touch problem of the eye-tracking based system [6].
- The outcomes have implications in various applications including psychological and clinical studies.

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REFERENCES

[1] Y. K. Meena, H. Cecotti, K. Wong-Lin, and G. Prasad, "Towards increasing the number of commands in a hybrid brain-computer interface with combination of gaze and motor imagery," in 37th annual int. conf. of the IEEE Engineering in Medicine and Biology Society, 2015, pp. 506–509.

[2] Y. K. Meena, H. Cecotti, K. Wong-Lin, and G. Prasad, "Simultaneous gaze and motor imagery hybrid BCI increases single-trial detection performance: a compatible-incompatible study," 9th IEEE-EMBS International Summer School on Biomedical Signal Processing, 2015, pp. 1.

[3] Millán, J. d. R. et al., "Combining Brain–Computer Interfaces and Assistive Technologies: State-of-the-Art and Challenges." Frontiers in Neuroscience 4 (2010): 161.

[4] Y. K. Meena, A. Chowdury, H. Cecotti, K. Wong-Lin, S. S. Nishad, A. Dutta, and G. Prasad, "EMOHEX: An eye tracker based mobility and hand exoskeleton device for assisting disabled people". Conf. of IEEE Systems, Men, and Cyberntics, pp 2122-2127, 2016.

[5] Y. K. Meena, H. Cecotti, K. Wong-Lin, and G. Prasad, "Powered wheelchair control with a multimodal interface using an eye-tracking and a soft-switch", 7th Annual Translational Medicine Conference, pp1, 2015.

[6] Y. K. Meena, H. Cecotti, K. Wong-Lin, and G. Prasad, "Towards increasing the number of commands in a hybrid brain-computer interface with combination of gaze and motor imagery," in 39th annual int. conf. of the IEEE Engineering in Medicine and Biology Society, 2017, pp. 1–4.(Accepted)

[7] Y. K. Meena, H. Cecotti, K. Wong-Lin, and G. Prasad, "A Novel Multimodal Gaze-Controlled Hindi Virtual Keyboard for Disabled Users," Conf. of IEEE Systems, Men, and Cyberntics, pp 3688-3693, 2016.

Yogesh Kumar Meena, KongFatt Wong-Lin, Hubert Cecotti, Girijesh Prasad

Intelligent Systems Research Centre

School of Computing & Intelligent Systems

Ulster University, Derry BT48 7JL, Northern Ireland, UK

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