 DOI: 10.3217/978-3-85125-962-9-124

Calibration methods during EEG signal acquisition and their impact on motor imagery decoding

Arnau Dillen[1,2*], Fakhreddine Ghaffari[2], Olivier Romain[2], Bram Vanderborght[3], Kevin De Pauw[1]

[1]Human Physiology and Sports Physiotherapy Research Group, Vrije Universiteit Brussel, Brussels, Belgium;

[2] Equipes Traitement de l'Information et Systèmes, UMR 8051, CY Cergy Paris Université, ENSEA, CNRS, F95000 Cergy, France ;

[3]Robotics and Multibody Mechanics Research Group, Vrije Universiteit Brussel and IMEC, Brussels, Belgium

Introduction: Motor imagery (MI) based brain-computer interfaces (BCI) enable users to spontaneously send a command to a device by imagining a movement [1]. To reliably decode MI for an individual, sufficient data from this person is necessary to train or fine-tune a machine learning (ML) model [2]. Furthermore, a balance between qualitative data and data that are representative of real-life conditions is desirable. However, data acquisition is a time-consuming process that currently requires the involvement of specialized technicians [3]. Improved methods for calibrating a decoding model are therefore necessary to ensure reliable decoding and an optimal user experience.

The aim of this research is to develop a calibration procedure that is both user-friendly and effective. For this purpose, the amount of data that is necessary to achieve satisfactory decoding accuracy without over-fitting and finding the best approach to calibration regarding user experience were investigated.

Materials and Methods: Electroencephalography data were acquired from 15 participants (14 male, 1 female) aged between 18 and 50 years. Each participant visited the laboratory for 5 sessions. The first two sessions were familiarization and the remaining sessions consisted of data gathering with feedback. Feedback entailed a textual cue indicating whether the predicted movement matches the requested movement. Several ML models using common spatial patterns and linear discriminant analysis were trained on data from individual participants and fine-tuning methods that also include data from other participants were investigated.

Results: Using data from individual participants, an average decoding accuracy of 0.67 was achieved using 15 training samples per movement without feedback and 8 samples per movement with feedback. The decoding accuracy greatly varies between individuals with a standard deviation of 0.15 and a maximum and minimum of 1.0 and 0.33 respectively.

Discussion: The results show that it is possible to train an MI decoding model with limited data. However, due to variability in the data and changes in the users signals over time, multiple recalibrations will likely be necessary. Hence, it would be advisable to focus future research on making the calibration process practical and feasible for the user, and automatically detecting when recalibration is necessary while limiting the calibration time.

Significance: Introducing a new user to a BCI control system should be a straightforward process that the user should be able to perform without any assistance beyond donning the recording equipment. Therefore, determining the optimal methods for user calibration, with a focus on user experience should be an essential step towards real-life BCI control systems.

References

[1] X. Gu *et al.*, 'EEG-Based Brain-Computer Interfaces (BCIs): A Survey of Recent Studies on Signal Sensing Technologies and Computational Intelligence Approaches and Their Applications', *IEEE/ACM Trans. Comput. Biol. Bioinform.*, vol. 18, no. 5, pp. 1645–1666, Sep. 2021, doi: 10.1109/TCBB.2021.3052811.

[2] M. Rashid *et al.*, 'Current Status, Challenges, and Possible Solutions of EEG-Based Brain-Computer Interface: A Comprehensive Review', *Front. Neurorobotics*, vol. 14, 2020, doi: 10.3389/fnbot.2020.00025.

[3] C. Pernet *et al.*, 'Issues and recommendations from the OHBM COBIDAS MEEG committee for reproducible EEG and MEG research', *Nat. Neurosci.*, vol. 23, no. 12, Art. no. 12, Dec. 2020, doi: 10.1038/s41593-020-00709-0.