 DOI: 10.3217/978-3-99161-050-2-146

Closed-loop applications for deep brain stimulation and code-modulated visual evoked potentials on Dareplane

M. Dold[1,2,3*], J. Pereira[2,1], B. Sajonz[2], V. A. Coenen[2,3], J. Thielen[1], M.L.F. Janssen[4,5], M. Tangermann[1]

[1]*Data-Driven NeuroTechnology Lab, Donders Institute for Brain, Cognition and Behaviour, Radboud University;* [2]*Department of Stereotactic and Functional Neurosurgery, University Medical Center of Freiburg University;* [3]*Center for Deep Brain Stimulation, Freiburg University*; [4]*Department of Clinical Neurophysiology, Maastricht University Medical Center;* [5] *Mental Health and Neuroscience Research Institute, Maastricht University*

*P.O. Box 9010, 6500 HE Nijmegen, The Netherlands, E-mail: matthias.dold@donders.ru.nl

***Introduction**:* The Dareplane platform [1], introduced as a modular open-source platform at the brain-computer interfacing (BCI) conference in 2023, enables BCI applications, ranging from classical BCI spellers to adaptive closed-loop deep brain stimulation ((a)DBS). We now present two use cases as proofs of principle with a single aDBS session using markers derived from electrocorticography (ECoG) signals, as well as results from three healthy participants using a code-modulated visual evoked potentials (c-VEP) speller, exemplifying a timing critical BCI application based on electroencephalography (EEG).

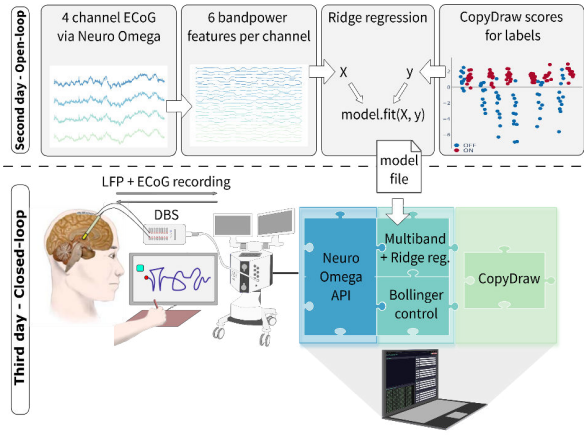

Figure 1: Schematic of the aDBS experiment with neural decoding model trained on the second day and applied on the third.

***Methods and Results**:* An aDBS use case was conducted with a single patient receiving a DBS system for the treatment of Parkinson's disease. The patient temporarily obtained an epidural four-contact ECoG electrode over the left primary motor cortex. It was removed during the second part of a two-stage implantation. DBS and ECoG leads were externalized between stages. During three measurement days, the patient conducted the CopyDraw task [2]. We used the ECoG signals to decode the CopyDraw performance scores, thus extending our previous work on EEG [2]. Power estimates of six frequency bands per ECoG channel formed the input to a ridge regression model, leading to on average 71% Pearson's correlation between predicted and observed CopyDraw scores in a chronological 6-fold cross-validation on the second measurement day. On the third day, this model provided input to a Bollinger band control to realize a fully closed-loop aDBS strategy.

The c-VEP speller use case replicated the work of Thielen et al. [3], with an eight-channel EEG system and a speller layout with 63 symbols. Per participant, data from 10 cued trials (42 seconds) were used to train spatial and temporal filters of a decoding model, realized by a reconvolution embedded in a canonical correlation analysis [2]. Each subject then conducted three online runs of spelling a target sentence, resulting in on average 13 correct symbols per minute and an information transfer rate of 82 bits/minute.

***Conclusion**:* These two proofs of principle provide evidence for the claimed closed-loop capability of the Dareplane platform, including its use in the clinical aDBS setting. The c-VEP experiment was configured using a simple setup script, which can be found at https://github.com/thijor/dp-cvep. It is a good starting point for exploring the Dareplane platform and allows for easy replication of the results, which are in line with previously reported performance metrics [2].

Acknowledgements: The project is funded by Hersenstichting and Health~Holland, The Hague, The Netherlands.

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