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Integrating EEG and MEG information to enhance motor-imagery classification in brain-computer interface

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Brain-computer interface (BCI) is a potential tool for rehabilitation and communication that mainly relies on the electroencephalography (EEG). Despite its clinical applications, BCI faces both engineering and user-oriented challenges to improve its spreading. In this work, we assess the possibility of integrating electroencephalographic (EEG) and magnetoencephalographic (MEG) signals to enhance the classification performance in motor imagery-based BCI. By adopting a matching-score fusion approach (in an offline fashion) that optimizes the choice of the features in each individual, we reached an average classification improvement of 12.8% as compared to separate EEG and MEG classifiers. These results could promote multimodal BCIs development.

BCI protocol
Fifteen healthy subjects (aged 2813 ± 410 years, seven women) participated to the protocol.

Fig. 1: BCI experiments performed at the CENIR. MEG and EEG are simultaneously recorded with, respectively, an Elekta Neuromag TRUX machine® (254 planar gradiometers and 102 magnetometers) and a 74 EEG-channel system. The task consists in a 1D, 2-target, right-justified box task where the subject performs a sustained MI (grasping) of the right hand to hit up-targets, while remaining at rest to hit down-targets.

Fusion approach
No artifact removal method applied here to simulate online scenarios.

Fig. 2: Classifier fusion approach for a given frequency bin. The variables p and λ stand for the posterior probability and the weight parameter associated with the modality i.

Semi-automatic procedure to extract features:
1. Focus an motor area contralateral to the imagined movement
2. Nonparametric cluster-based permutation t-test between power spectra of MI and rest epochs
3. Extraction of the Ni most discriminant features within the standard frequency bands

Classification fusion enables a significant performance improvement

Inter-subject variability: attributed weights

Fig. 3: AUC distributions across the 15 subjects, for all the modalities, and for different numbers of features within the alpha band. White circles correspond to the median values. In all frequency bands, the type of modality significantly affected the AUC values (ANOVA, p < 0.05), whereas the number of features did not have a significant impact (p > 0.05).

Fig. 4: Contribution of different modalities to the individual performance. Pie-diagrams show the 𝜆 values (in percentage) obtained for each modality via the fusion approach.

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