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Evaluation of spatial and frequency features for improving the classification of motor imagery

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Introduction: The classification of Motor Imagery (MI) is an essential component in the development of Brain-Computer Interfaces (BCI), given its potential in clinical applications such as rehabilitation of impaired motor functions. However, current systems face significant challenges to achieve optimal performance due to the complexity and volume of the features involved [1, 2]. In this context, EEGNet model has emerged as an efficient alternative, enabling classification even directly from raw EEG signals. This study addresses two key questions: first, we examine whether EEGNet performance can be improved implementing two additional stages, a scheme of filters based on MI-related rhythms followed by a feature extraction stage in two domains (spatial and frequency); and second, we evaluate whether the proposed additional stages for EEGNet outperform two commonly used classification models such as Support Vector Machine (SVM) and Linear Discriminant Analysis (LDA).

Material, Methods and, Results: The present proposal focused on characterizing EEG signals from the sub-bands associated with MI, by extracting features to subsequently generate a feature vector, the dimensionality of which was reduced using the Relief-F algorithm before proceeding with performance evaluation. The evaluations were carried out using frequency-based features through Discrete Wavelet Transform (DWT) for the first evaluation, and spatial features using Common Spatial Pattern (CSP) for the second evaluation. The overall framework of the study can be seen in Fig.1a). For model evaluations, the IVa dataset from the III BCI Competition[3] was used, which includes the 118-channel EEG recordings from 5 subjects performing imagined movement tasks (right and left hand). The evaluations were performed using 5-fold cross-validation, obtaining the results shown in Fig.1 b). These show that the EEGNET+DWT model outperforms others, achieving an average of 71.13% (see Fig. 1 c)).

Conclusion: The results suggest that the combination of EEGNet with features extracted in the frequency domain (EEG+DWT) can be effective for binary classification of motor imagery tasks. In subject *aw*, the EEGNet+DWT model did not outperform traditional classifiers. However, no significant differences in performance were observed. Furthermore, spatial features did not contribute to enhancing EEGNet's performance (EEG+CSP). As future work, we will analyze if the fusion of both temporal and spectral features is relevant for this task, complemented by inter-subject regularization techniques, in order to improve the model's ability to generalize to new subjects. Last, an automatic channel selection method will assessed to discard redundant or non-relevant channels.

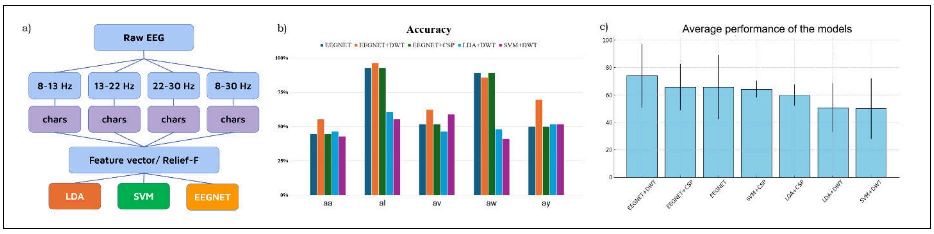

Figure 1: *a) Model evaluation framework, b) Comparison of models and features, c) Average performance.*

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