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Genetic Algorithm Implementation for Intersubject Motor Imagery Classification

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Introduction: The classification of EEG signals for motor imagery (MI) presents significant challenges, particularly in recognizing new subjects based on limited instances. For this reason, this project explores whether shared characteristics among subjects can allow the recognition of new individuals using a set of well-known methods to tackle this problem. After that, we assess whether the methods' performances could be improved using genetic algorithms (GA) to find a good set of models' parameters and features that allow for this purpose. These approaches allow us both to detect patterns from minimal instances of new subjects without extensive retraining of the models and to optimize the performances of the models, ultimately streamlining the classification process in BCI applications.

Material, Methods, and Results: This work analyzes a 62-channel EEG dataset comprising recordings from 20 participants during two motor imagery tasks (left and right hand). This dataset was chosen because it has few instances for each subject, 20 epochs per subject (10 epochs for each class). We followed a leave-one-subject-out scheme for the evaluation, i.e., using only one subject to test the model. To estimate the performance of non-optimized methods with their default parameters, the EEG signals were cleaned and filtered to remove artifacts and noise, ensuring high-quality data for analysis. Later on, several sets of features were extracted from the signals in different domains (time, frequency, and fractal dimension) [1]. Then several classifiers of different types such as Random Forest, SVM, Linear Discriminant Analysis (LDA), Convolutional Neural Network (CNN), and EEGNet were implemented to evaluate model performance [2]. On the other hand, to assess whether an optimization process could improve the performance (accuracy) of the aforementioned methods, a GA was implemented (See Figure 1 for consult its main parameters) to explore different combinations of preprocessing methods, feature extraction techniques, and classifiers. Before applying genetic algorithms, the initial accuracies were as follows: SVM at 48.5%, RF at 48.25%, LDA at 45%, and CNN at 70%. Whereas, using the GA for the optimization stage, CNN achieved 80% accuracy, Support Vector Machine (SVM) reached 57.75%, Random Forest (RF) 65.5%, and LDA 47%.

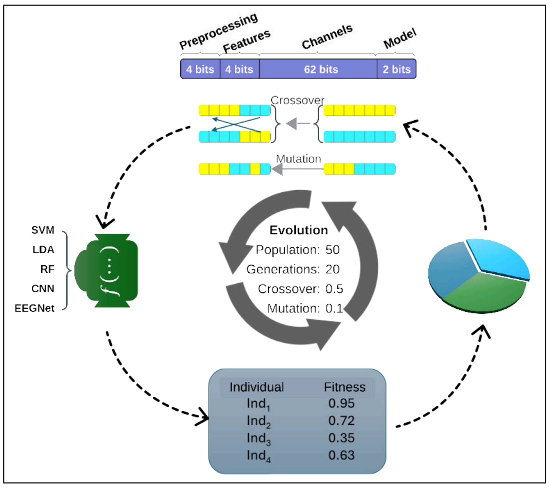

Figure 1: *Diagram of the configuration of the genetic algorithm with the probabilities in each evolution and the genes that will change.*

Conclusion: Our experiments suggest that the classification of EEG signals related to motor imagery of a new subject using fewer instances is feasible in an intersubject scheme. Two approaches were assessed, highlighting the approach based on GA to optimize the models. A better performance could be reached by applying fine-tuning to the model for a new subject using a few instances of this.

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