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EEG-based Automatic Emotion Recognition Using Machine Learning

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Introduction: The field of EEG-based emotion recognition has been widely explored in the last decade. Methods proposed by recent literature mostly use complex deep learning methods to achieve good predictions. To obtain comparable results using simpler machine learning techniques would be preferable as these models are much more intuitive to implement and understand. This work explores support vector machine (SVM) classifier on two datasets (DEAP and SEED) and compares the performance with more complex models.

Material, Methods and Results: This work uses the publicly available datasets, DEAP [1] and SEED [2], to evaluate SVM. The preprocessed EEG data from DEAP is segmented into one-second epochs without overlapping, resulting in total 2400 epochs. Further, it is filtered into four frequency sub-bands using the Butterworth bandpass filter. The data from SEED is also segmented into epochs of one second without overlapping, resulting in a total of 3394 epochs. Several features and their different combinations are extracted from each epoch of the EEG signal. For DEAP, the same features are derived for each one-second epoch in a three-second baseline recording. The computed features for each trial are corrected by subtracting the average value of the baseline features. To decipher the emotions, the extracted features are used as an input to SVM with RBF kernel and K-nearest neighbor (KNN) classifiers. The performance of SVM is found to be superior as compared to KNN. The best average accuracies achieved for each dataset are presented in Table 1. For DEAP, the most suitable feature set is the combination of Hjorth mobility (HM), Hjorth complexity (HC), differential entropy (DE), frequency bands energy (FBE), and Hjorth mobility spectrum (HMS). For SEED, the feature HM is found to be more useful than the combination of several features in detecting human emotion. The performance of the SVM on both datasets is verified using a 5-fold cross-validation approach.

Dataset	Feature	Accuracy
DEAP arousal	HC, HM, DE, FBE, HMS	96.71 %
DEAP valence	HC, HM, DE, FBE, HMS	96.50 %
SEED	HM	83.87 %
SEED	HC, HM, DE, FBE, HMS	63.76 %

Table 1: *Mean accuracies*

Discussion: It can be observed from the obtained results that the simple machine-learning techniques can produce satisfactory predictions for EEG-based emotion recognition. The obtained results for the model proposed for DEAP are comparable to the ones obtained with deep learning [3]. For SEED, deep learning methods outperform the best-performing proposed model by almost 11 percentage points [4]. Nevertheless, both the proposed models show promise for utilizing simpler models in EEG-based emotion recognition. In future work, a new dataset will be developed to test the generalization of the proposed machine-learning method. And, a channel selection approach will be adopted for complexity reduction of the models. Related studies [2,5] have shown that the number of electrodes can be reduced significantly without decreasing the prediction accuracy of the model.

Significance: The potential for emotion recognition devices will be huge both medically and commercially given that only a few electrodes in combination with simple and fast models perform well.

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