Hand Movement Classification using LDA, K-NN, and SVM

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ABSTRACT

Brain-computer interface (BCI) is an artificial intelligence system that permits the control and communication between the human brain and a machine or an external device by acquiring a subject's brain signals using the electroencephalogram (EEG) and converting the electrical activity into meaningful information for the machine. This interface is designed to improve the lives of people who have lost motor function to regain their independence and quality of life. EEG stands out as the mostefficient and widely used measurement method, due to its non-invasive nature, portability, and affordability. The objective of this work is to classify left and right-hand movements performed bythree subjects based on the brain activity of motor imagery with the dataset BCI competition IIIb. For that, statistical features are used and different linear discriminant analysis (LDA), k-nearest neighbors (KNN), and support vector machine (SVM) algorithms of classification are used. In the findings, theSVM method showed the highest classification accuracy of 76.9%.

Keywords: Brain-computer interface, Electroencephalogram, Classification

1 Introduction

The BCI systems were initially designed to help people suffering from locked-in syndrome, and have now become a revolutionary technology that opens the door to innovative solutions in the fields of medicine, communication, and mobility, thereby improving the quality of life of many people. The goal of our workis to classify motor imagery of left and right hand movements, a key area of research that has a significant impact on many disciplines including neuroscience, robotics and rehabilitation [1]. It is important to emphasize that BCIs offer a promising solution by opening a vast field of possibilities for the improvement of human life.

2 Methodology

To carry out our work, we used the dataset named (IIIb) provided by the Institute for Human-Computer Interfaces, University of Technology Graz – BCI Lab. This set is composed of two classes which contain EEG data obtained using C3 and C4 electrodes from three subjects (O3, S4, and X11). In this experiment, the participants were asked to imagine themselves moving either their left or right hand after hearing a beep. The experiment consists of 3 sessions for every subject and each session consists of 4 to 9 runs. The recordings were done using a bipolar EEG amplifier from g.tec. The EEG was sampled with 125 Hz and filtered between 0.5 and 30 Hz with Notch filter on, as reported in the dataset description [2]. Then, we created a feature vector that includes relevant information about brain signals with which we proceeded to the classification.

3 Results and Discussion

Because of the nonstationarity of EEG signals, it is necessary to work with features that manage the aspect of the time-frequency domain. We worked with 26 features and we chose statistical features and energy. The proposed features are defined by the following expressions where E is the energy and P is the powerspectral density (PSD). Features are not used separately, they are all used as one group of features.

$$F_i = (i)4 - E(i)3 \qquad i = 1 \dots 10 \qquad (1)$$

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$$F_j = (j)4/E(j)3 \qquad j = 11 \ldots 20 \qquad (2)$$

$$F_{21} = mea(P_4)/mean(P_3) \qquad (3)$$

$$F_{22} = media(P_4)/median(P_3) \qquad (4)$$

$$F_{23} = \min(P_4)/\min(P_3) \qquad (5)$$

$$F_{24} = ske(P_4)/skew(P_3) \qquad (6)$$

$$F_{25} = va(P_4 + P_3)/var(P_3 - P_4) \qquad (7)$$

$$F_{26} = kurtosis(P_4)/kurtosi(P_3) \qquad (8)$$

Table 1 and Figure 1 show the average of classification accuracy (CA) (%) of the best results obtained for each subject using the LDA, K-NN, and SVM methods.

Table 1: *Average of classification accuracy (%) using the LDA, K-NN, and SVM methods.*

	O3	**S4**	**X11**	**Average of CA (%)**
LDA	72.54	76.8	72.59	74
K-NN	78.74	62.46	60.56	67.3
SVM	80.1	77.4	73.2	76.9

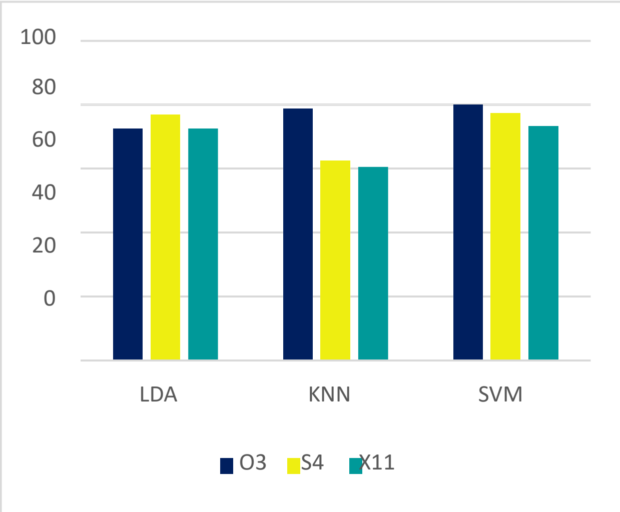

Figure 1: *Classification accuracies (%) of all subjects using the LDA, K-NN, and SVM methods.*

The CA (%) of all subjects using the LDA, K-NN, and SVM methods show that the highest accuracy is obtained while using SVM which resulted in a classification accuracy of 76.9%.

4 Conclusion

In this work, we focused on the classification of imagery left and right hand movements performed by three subjects using three different classifiers. After obtaining experimental motor imagery EEG data for three subjects, we started by configuring these signals by removing any anomalies found. We worked with statistical features in order to constitute the feature vector which is necessary for the most important stepwhich is the classification where we compared between LDA, K-NN, and SVM algorithms and we obtained the best classification accuracy of 76.9%. Future work focuses on using optimization approaches to select relevant features and increase classification accuracy.

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