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WAVELET TRANSFORM BASED CLASSIFICATION OF FINGER AND TONGUE MOVEMENT

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Abstract: Advancements in signal processing techniques leads the Electroencephalography (EEG) signal to be more extensively used in the field of Brain Computer Interface (BCI). Brain Computer Interface is the method of communication between human brain and an external device. People who are incapable to communicate conventionally due to serious injury like that of spinal cord, needs Brain Computer Interfaces to communicate with external world. BCI is an interfacing system that uses electrical signals (EEG) taken from the brain as an input and used them to control other devices such as a computer, robotic arm etc. The data for present work have been taken from BCI Competition 3rd data set-I. This data set presents the recordings from 64 channels but present work is based on only two channels (channel 12 and channel 29). There are a number of features (Averages, Standard deviation, Kurtosis, Skewness and Wavelet energy) that can be

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extracted by different signal processing techniques. In the present work, Wavelet

transform is used as a signal processing technique for feature extraction.
Continuous wavelet transform is used. For the classification purpose, Support vector machine (SVM), k-nearest neighbor (k-NN), linear discriminant analysis (LDA) classifiers are used for the classification of finger and tongue movement from EEG signals. The classification accuracies and other metrics are compared for these classifiers. The highest classification accuracy, sensitivity, specificity and Kappa are 97 %, 98 %, 95% and 94 % respectively for k-NN classifier.

Index terms: Brain Computer Interface, Electroencephalography, FFT, Wavelet transform, Classifiers.

I. Introduction

BCI is direct communication pathway between the brain and external device, which facilitate the user to control special applications by using brain thoughts. Many research groups have examined this and used different methods to achieve this. Most of them are based on electroencephalography (EEG) which is recorded from the scalp [1]. The EEG signal is recorded when the user moves the finger and the tongue. Depending on the BCI, preprocessing and feature extraction methods are applied to the EEG sample of certain length. Then it is possible to identify the task-specific EEG signals or patterns from the EEG samples with a specific level of accuracy [2]. The main use of BCI is to prevent a non-muscular communication and organize channel to convey message and control the external environment for severely disabled persons. EEG signals are the most popular way of recording the brain activities in the domain of non-invasive BCI.

The present work uses the EEG signal processing for the classification of small finger and tongue movement by Support vector machine (SVM), k- nearest neighbor (k-NN) and Linear discriminant analysis (LDA). In order to extract features, FFT based continuous wavelet transforms is applied to each trial and each channel separately. By using Morlet wavelet transform, the statistical feature analysis demonstrated that the averages, standard deviation, kurtosis, skewness and wavelet energy of the absolute values of the WTCs of the 12th and 29th channels can be used for classification of the finger and tongue movement.

II. Methodology

The complete work has been done on Matlab software. This work is divided into three parts: (1) Preprocessing (2) Feature Extraction (3) Classification algorithm.

Preprocessing step includes the amplitude spectra of all trials for channel 12 and channel 29 for training and test by using FFT. A normalization process should be implemented to the training set and the test set in order to alleviate the impact of the magnitude change.

Feature extraction part uses the FFT based wavelet transform. So, firstly calculate the magnitude of all trials for channel 12 and channel 29 and then apply wavelet transform. In this work, in order to extract features continuous wavelet transform is applied to each trial and each channel separately. Therefore, Wavelet

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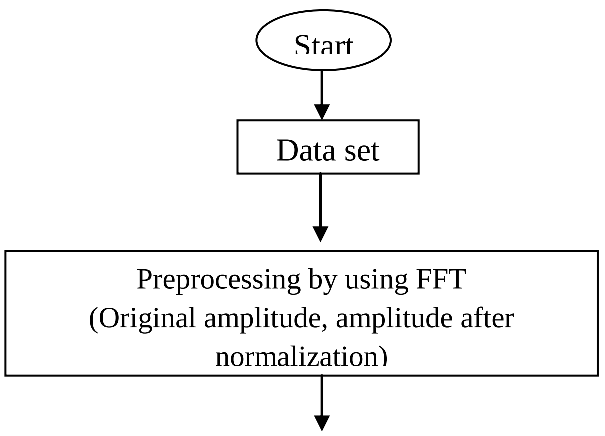
transform coefficients are calculated for each channel separately. By using Morlet wavelet transform, five features (Averages, standard deviation, kurtosis, skewness and wavelet energy of the absolute values of the WTCs of the 12th and 29 channels) are calculated and then they can be used for classification of the finger and tongue movement.

Classification part includes the SVM, k-NN and LDA classifiers and in order to train the classifiers two popular techniques are used which is K-fold cross validation (K-FCV) and leave one out cross validation (LOOCV). Here value of K=10 for determining the folds. From each trial, features are extracted to form a feature vector which is used as the representation of corresponding trial. Feature vector set is obtained by extracting features from training trials, and then used to train classifier. In the testing phase, trained classifier decides the class label according to extracted feature vector from corresponding test trial.



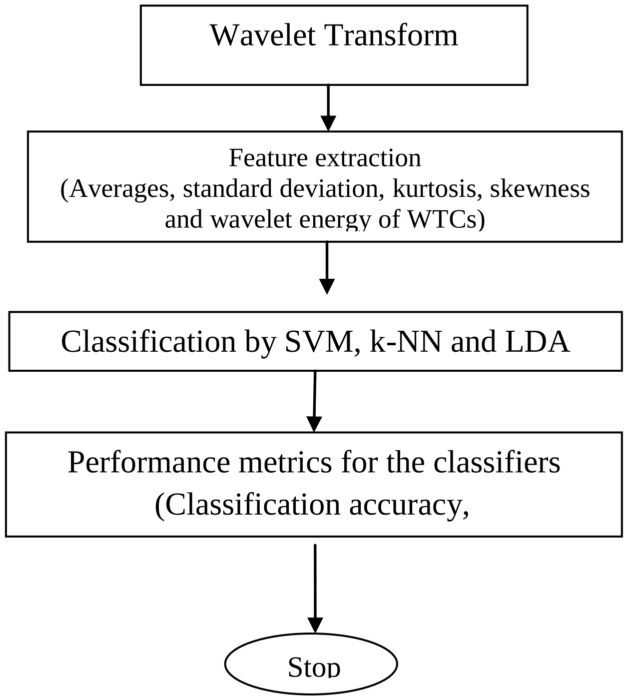


Fig.1. Flow chart for Classification of tongue and finger movement from EEG Signals.

III. RESULTS AND DISCUSSIONS

The data set for this work have been taken from Brain Computer Interface Competition IIIrd data set-I [3]. Results obtained at each step during implementation of the proposed methodology are discussed below :

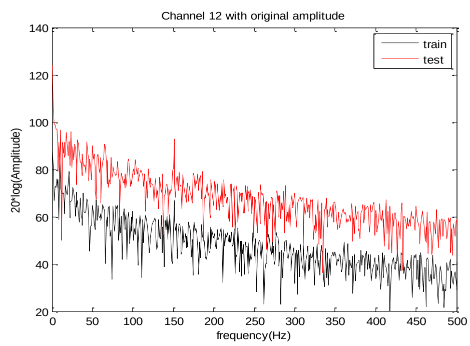


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Fig.2. Plot of the averaged amplitude spectra of all trials in the training set and test set for the channel 12.

The normalization process is necessary in order to alleviate the impact of the magnitude change in between the training set and test set.

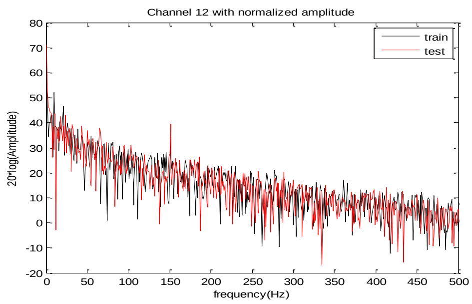

Fig.3. Plot of the averaged amplitude spectra after normalization for channel 12.

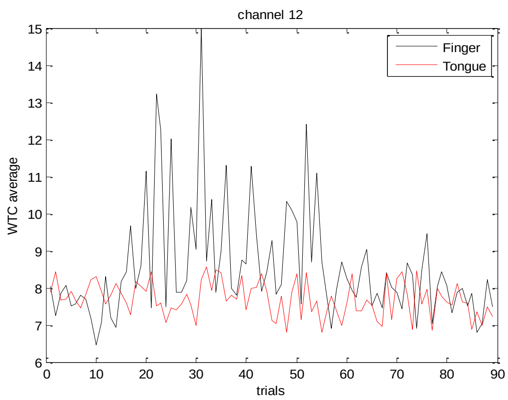

Fig.4. Plot of the Extracted feature vector f1 (average of channel 12).

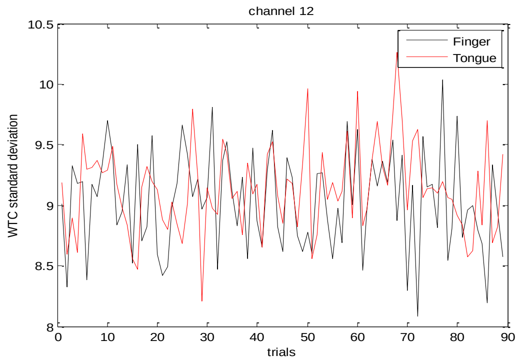

Fig.5. Plot of the Extracted feature vector f2 (std. deviation of channel 12).

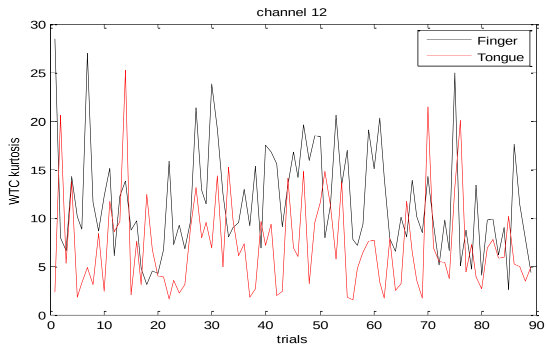

Fig.6. Plot of the Extracted feature vector f3 (kurtosis of channel 12).

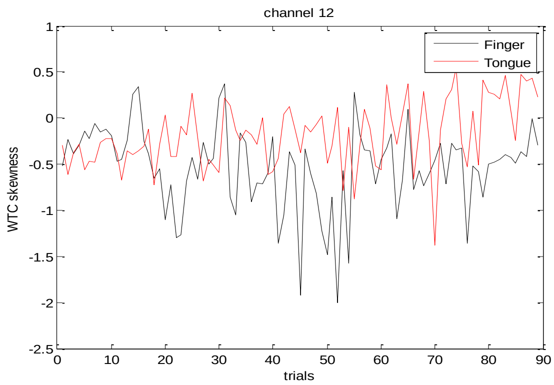

Fig.7. Plot of the extracted feature vector f4 (skewness of channel 12).

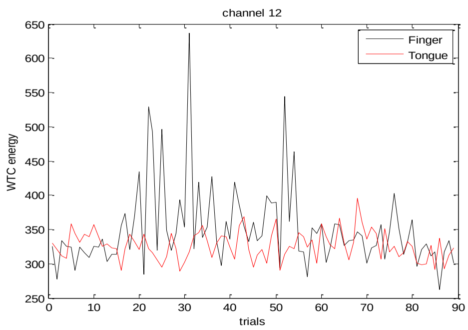

Fig.8. Plot of the Extracted feature vector f5 (wavelet energy of channel 12).

Table 1: Comparisons of CA, Sensitivity, Specificity and Kappa.

Name of the classifier	Classification accuracy (CA)	Sensitivity (SE)	Specificity (SP)	Kappa
SVM	95.5%	100 %	92%	91%
k-NN	97%	98%	95%	94%
LDA	80.5%	81%	79%	61%

Table 2: Classification performance of different methods.

Study	NOC (number of channel)	NOF (number of feature)	Classifier	CA
Qingguo et al. [4]	64	3	SVM	91
Qin et al. [5]	32	20	SVM	90
Yan Li et al. [6]	It is said "some channels"	4	LDA	92
Ince et al. [7]	64	3	LDA	93
Onder AYDEMIR et al. [8]	2	2	k-NN	94
Proposed work	2	5	k-NN	97

IV. CONCLUSIONS

In this present work, attempt has been made to develop a system that classifies the movement of tongue and finger with 97% accuracy with k-NN. Also, the techniques employed in this work are quite easier to implement as compared to many other techniques. The method used for feature extraction is wavelet transform [9]. The computation of the WTCs is fast and simple. In present work five features (averages, standard deviation, kurtosis, skewness and wavelet energy) are calculated. For classification , SVM, k-NN and LDA algorithms are used. The classification accuracy achieved is 97% by using k-NN in case of 10-fold cross validation technique. In this case, the all three metrics reached the highest values, where sensitivity=98 %, specificity=95 % and Kappa=94 %. It concludes that present work gives high accuracy as compare to previous results.

V. ACKNOWLEDGMENT

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