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# Electroencephalograph Signal Classification Using Support Vector Machine for Detection of Parkinson's Disease

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## ABSTRACT

For detecting brain disorder, a non-invasive technique using Electroencephalograph (EEG) is used. Because it is not difficult to understand and complex to use Electroencephalograph is used. Nowadays in the application like neuromarketing, social interaction, human factors and biomedical etc. uses the electroencephalograph technique. In our proposed work which is based on Brain-Computer Interface, it is useful in clinical diagnosis and in medical fields. There are some series of the pattern which we have to study and understand that pattern from that we can predict that the person is having Parkinson's disease or not. In proposed work, to detect Parkinson's disease we have performed analysis of EEG signals. Our system uses Fourier Transform to take electroencephalograph signal in frequency domain only. Fourier transform is used to extract features of signals. In this work, Fourier transform is used to take the signal in frequency domain. To extract features of EEG signals, Fourier Transform is useful. There are many applicable features of EEG signals, according to that classify the EEG signals and predict results of person. For classification of EEG signal through advanced machine learning algorithms like SVM, Naïve Bayes, Random Forest etc. using different frequency band and detecting brain disorder. For classification, these signals with relevant features Support Vector Machine is used. Support Vector Machine is applicable for classification signals on the basis frequency as a feature and to detect Parkinson's disease. By taking an average of the frequency band of each channel of EEG cap statistical features are calculated. Average of frequency which is input to classifiers. For classification, Machine Learning algorithms are used with promising accuracy.

## INTRODUCTION

Nowadays, with the increase in Population number of diseases are also increased. The major group of diseases is neuro-generative, which effect on people. In our brain, there are some cells, which cause some abnormalities by producing the dopamine in the Parkinson's disease. The cells, which are responsible for the movement, are become abnormal due to the nerve cells break down and low level of the dopamine. In the middle age or in the late age (after 50) Parkinson's disease can happen to the person. It progresses gradually for 10-15 years, because of that person become weaker and disable. Some of the abnormalities in the Parkinson's disease are like resting tremor, rigidity, postural instability.

In our brain, some activity of the neurons is happening from that activity so that we record that activity from the scalp of the person that is the electroencephalograph. In the clinical context, some electrodes are placed on the scalp and the brains spontaneous electrical activity over a short period was recorded. In this paper, our main aim is to diagnose the Parkinson's disease. The signals, which are produced from the brain, are sinusoidal wave shape, we measured it from peak to peak and the amplitude of that is generally 0.5 to 100 μV. According to their frequencies, it is classified into 4 frequency bands as follows:



β (beta) frequency (>13Hz),

α (alpha) frequency (8-13Hz),

θ (theta) frequency (4-8Hz),

δ (delta) frequency(0.5-4)

In the analysis of the EEG signal, we have to perform two basic steps: Feature Extraction and Signal Classification. Feature extraction is based on the domain, frequency, time and time-frequency domain. For the feature extraction, Fourier analysis is the best option, we can analyze the signal from the Fourier transform because it breaks down the signal into the different frequencies in the sinusoidal form. We perform discrete Fourier transform(DFT) on the signal.

In this work, we used the algorithm for the DFT for the feature extraction and windowing technique is used in the filtering for the better result and SVM classifier is used to detect the PD patients from EEG signals.

**Table 1-Classification of frequency ranges**

| Type | Range | State |
|---|---|---|
| Delta(δ) | 0.5 Hz to 4 Hz | Severe |
| Theta(θ) | 4 Hz to 8 Hz | Moderate |
| Alpha(α) | 8 Hz to 13 Hz | Mild Moderate |
| Beta(β) | 13 Hz to 30Hz | Mild |

**Related Work:-**

1. As there are many novel technologies like DIMENSION (Diagnostic Method of Neuronal Dysfunction), NAT (Neuronal Activity Topography) which are based on fluctuations in EEG. But these therapies are only applicable for the limited data set.

2. There are many methods used for feature extraction like Fourier transform and short time Fourier transform. But these techniques shows EEG signals in frequency domain only. Also due to alteration in signal whole Fourier series is affected which can affect on Classification and prediction of disease. Fourier transform waves are not specially localized.

3. For the feature extraction of the time domain analysis is used then there is no information about where frequencies are located in time.

**Methodology:**

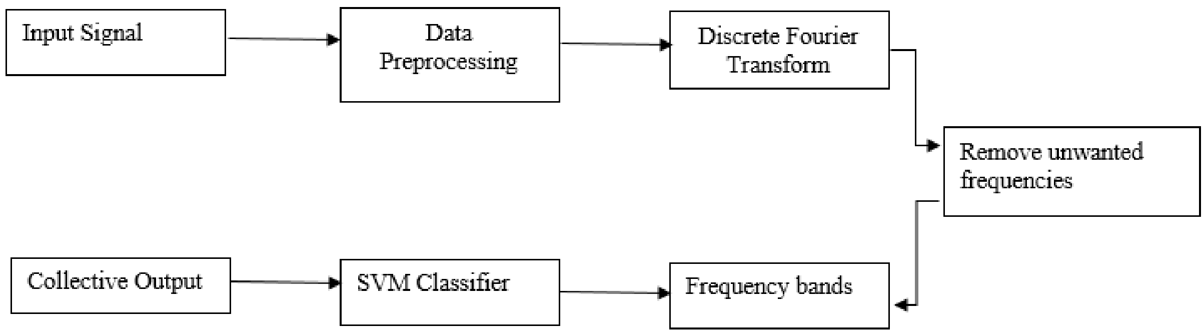


**Fig. 1 Framework of Proposed System**

**Steps involve in Brain-Computer Interface:**

**1. Data Acquisition**: Silver/Silver chloride (Ag/AgCl) electrodes are used to record brain activities using EEG cap. By connecting these electrodes on the scalp, electrical brain activities are recorded.

**2. Signal Processing:** After recording the EEG signals which contain the noise and artifact. So that there is need to clean them. In this step, noise and artifacts are removed i.e. clean these EEG signal [6].

**3. Feature Extraction:** In Feature Extraction process, Fourier transform(FT) Technique is going to use for extracting features of EEG signals. To present EEG signals in the time domain is the somewhat time-consuming task. While Fourier Transform is used for feature extraction of signal and to show or represent it in the frequency domain. The Fourier transform is the general mathematical method for EEG signal processing in many Brain Computer Interface application. The main function of Fourier transform is act as artifact removal which divides the signals into frequency band as per requirements. Fourier transforms consisting of function breaking down the signal into the frequency and we can divide that frequencies in the desired bands of frequency, for computing the DFT of the sequence FFT is the efficient algorithm. It is generally not a separate transform. We can implement the DFT on the periodic signals, digital signals x[n] or discrete time. The DFT of the signal is shown below:

$$X[k] = \sum_{n=0}^{N-1} x[n] e^{-j\frac{2\pi}{k}n} \qquad \text{……………..(1)}$$

From this given equation(1),X[k] shows periodic discrete time-signal x[n].Observe that only N samples of the time signal x[n] are used to compute X[k] (for k=-∞, ∞) and also only N of the coefficients X[k] used in the inverse transform. A periodic discrete time-signal has a periodic spectrum (just like any other discrete time signal), i.e .X [k + N] = X [k]. The X[k] terms are evenly spaced samples of the continuous spectrum.

**Properties of the Discrete Fourier Transform:**

1. Linearity: Let $\{X_0, X_1, \dots, X_{N-1}\}$ and $\{Y_0, Y_1, \dots, Y_{N-1}\}$ be the two sets of the discrete samples with corresponding DFT is given X(m) and Y(m) then the DFT of the samples set $\{X_0 + Y_0, X_1 + Y_1, \dots, X_{N-1} + Y_{N-1}\}$ is given by X(m)+Y(m).

2. Periodicity: We have evaluated DFT at m=0,1,…,N-1. There after (M>N) is shows periodicity.

3. DFT Symmetry: Extracting in the frequency domain $X_0, \ldots, X_{N-1}$ seems to be counter-intuitive if the samples are real. Here we derive 2N of the information in the frequency domain from the n information in the time domain. It suggest that the there is some relationship between X(0)…,X(N-1) as per DFT symmetry property, X(N-m=X*(m)) m=0,1,…N=1 where symbol * indicates complex conjugative.

4. DFT phase shifting: It states that, for the periodic sequence with periodicity N i.e.X(m)=X(m+iN), I as an integer, an offset in the sequence manifests itself as the phase shift in the frequency domain. In other words, if we decide to sample X(n) starting at the n equal to some integer k, s opposed to n=0, the DFT of those time-shifted samples.

X shifted (m)=$e^{j2\pi\frac{km}{n}}$ Xm

**4. Feature Vector Calculation:** In this step, we use the percentage power formula on the frequency component which is obtained from the previous results of the power spectral density. We here obtain the different frequency bands from this and we can apply it to the next step for the classification. Power spectral density gives the power of the signal at the particular frequency. That power spectral density is used in the further calculation.



**5. Feature Classification:** For the feature classification we here use the classifier SVM(Support Vector Machine). SVM(Support Vector Machine) is based on the hyperplane. The discriminate hyperplane is used to identify the classes. The selected hyperplane is having the maximum margins, i.e. distance from closest training data point. For increasing the generalization capabilities we can maximize the margins. For enabling the accommodation to the outlier allows error on the training set an SVM uses regularization parameter C.

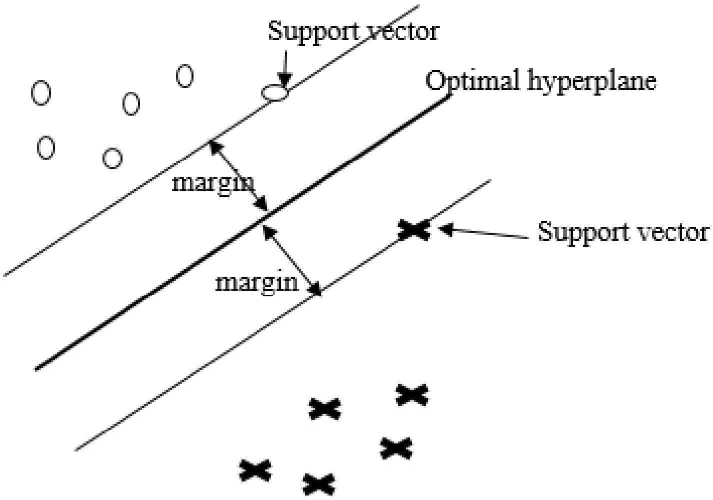


**Fig.3 SUPPORT VECTOR MACHINE AND HYPERPLANE GENERALIZATION**

Using linear decision boundaries the classification is done is known as the linear SVM It is possible to generate nonlinear decision boundaries by using kernel trick with only a low increase of the classifier's complexity. Using a kernel K(x,y), implicitly mapping of data or transformation of data to another space i.e. create feature space, generally of much higher dimensionality is done. The kernel here used is the RBF kernel:

$$K(x,y)=\exp\left(\frac{-||x-y||^2}{2\sigma^2}\right)$$

It is known as the RBF SVM.

Pros and Cons of Classifiers:

Support Vector Machine:-

Pros-

1. Gives maximized the width of margin (degree of separate) in training data.

2. SVM is flexible in threshold attributes, due to use of the kernel.

3. Training of data, again and again, is not essential.

4. For BCI application those contain noise gives better results.

5. Low error rate.

6. SVM gives good results in case of high dimensionality and smaller training set because BCI EEG data contain high dimensionality.

Cons-

1. High Complexity O (n^2).

2. SVM performance is low, in the testing phase.

3. Wastage of memory

**6. Detection of brain disorder:** In detection step, frequency >30Hz that person is ‘normal'. If frequency <30Hz, a person is ‘abnormal'.

## RESULTS AND DISCUSSION

In this proposed work, we captured EEG signals of normal and Parkinson’s disease’s person in order to detect Parkinson’s disease. EEG signal recording was divided into sub frequency band such as alpha, beta, delta, theta using Discrete Fourier Transform. Then this frequency sub-band classify by using Support Vector Machine.



Dataset:-

The dataset of electroencephalograph (EEG) signal used for this system is collected from UCI repository which contains normal and PD person, by using 8 channel EEG cap. That means EEG signal recorded using 8 channel. This dataset contains 8 channel data for each person and each channel consists of 2048 samples with its amplitude.

**Performance Analysis of classifiers:-**

**Table 2-Performance of classifier**

| No. of Samples | Accuracy |
|---|---|
| 15 | 93.33% |
| 20 | 95% |
| 25 | 96% |
| 30 | 96.55% |

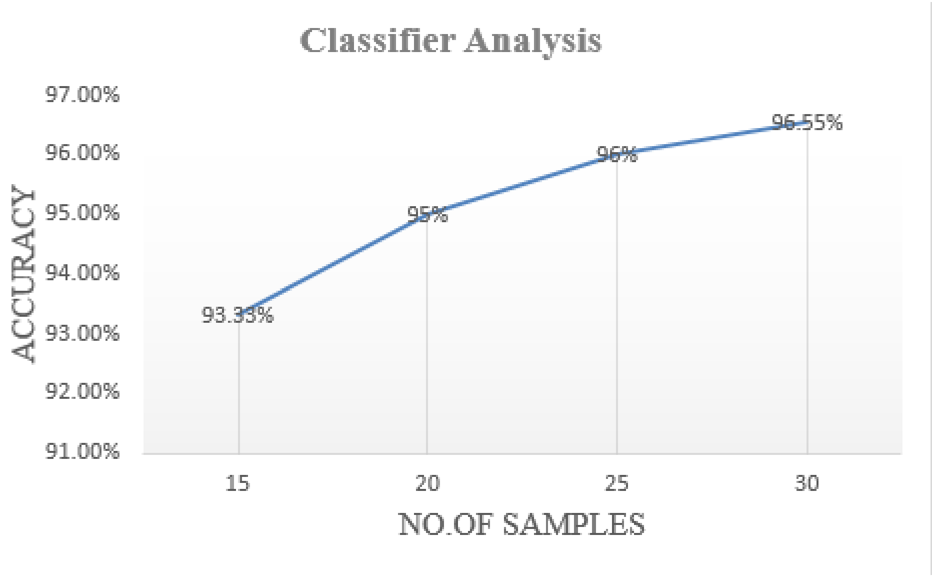


**Fig. 3 Classifier Analysis**

**Table 3-Evaluation of classifier**

| No. of trained Signal | No. of tested Signal | Correctly classified | Misclassified | Accuracy |
|---|---|---|---|---|
| 30 | 30 | 30 | 0 | 96.55% |



**Analysis of Classifiers:**

It can be easily represented Support Vector Machine achieve the highest accuracy (96.55%).Support Vector Machine gives balanced classification.


**Fig. 3. Classifier Performance**

**Future Scope:-**

In proposed work, we tested results for detection of Parkinson's disease by using Support Vector Machine. In this proposed work, 8 channel EEG signal system is used for the brain-computer interface. This process can become easy and more accurate if more channels system is used e.g 64 or 16 channel for analysis and implementation. Also, it can be performed by using the multiplexer and 1 electrode we can capture EEG brain signals.

## CONCLUSION

EEG is the noninvasive technique which is used in the BCI approach which will be useful in medical diagnosis by detecting brain signals which are malfunctioning and those are helpful in the detecting different diseases which are useful for society. In brain computer interface, EEG is a simple and not much expensive method for interfacing between brain and computer to identify diseases. EEG signal can be classified into different bands of frequency, which are taken as the feature extraction. In the proposed method the Fourier transform is used for the feature extraction, because of the advantages of frequency domain analysis. In the proposed method, Parkinson's disease is detected on the basis of frequency bands by using classification algorithm in machine learning algorithm.

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