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Identification of Parkinson's Disease in Patients using Vocal Features

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Abstract:
Parkinson's disease (PD) is a nervous system disorder and it is progressive neurodegenerative which affects multiple motor and non-motor characteristics like movement. The early stage of the Parkinson's disease is face vocal impairments The recent research area or study in Parkinson's disease based on the diagnosis systems based on vocal disorders. To deal with, this paper proposes a new framework that uses Support Vector Machine (SVM). The work of SVM is for classification of Parkinson's disease with the feature like set of vocal (i.e.,) speech. Input given to the SVM has different feature set as combined. The training dataset taken from UCI Machine Learning repository for the Proposed model. The performance of model is accessed based on accuracy and sensitivity. The proposed model gives better result to distinguish between healthy person with PD patients and also boost up the discriminative power of the classifier.

Keywords**:** Machine Learning, Classifier, Support Vector Machine (SVM), Vocal, Speech Signal Processing.

1. Introduction

The booming of the Health informatics is used to monitor and detect various deadly and common diseases. Parkinson's disease is one such disease. Parkinson's disease, affect the people over the age of 60 years. Genetic and environmental factors are the two main reasons for Parkinson's disease. It damages Substatia nigra, part in the brain which is involved in the secretion of dopamine.

Dopamine, a hormone and a neurotransmitter acts as a transmitter between nerve cells. Dopamine pathways in brain controls motor and behaviour motivated by reward. People with decreased dopamine secretion suffer deterioration in various activities controlled by brain. Other cause of the PD is high and frequent exposure toxins, herbicides and pesticides.

The symptoms of the people with Parkinson's disease are Hypokinesia (lack in movement), Bradykinesia (slowness in movement), and rigidity in the wrist, shoulder and neck and rest tremor. More than 90.01% of affected people suffer from dysarthria, a slurred or slow speech, monotone voice and difficulty in fast paced conversations.

There are five different stages in the chain of the Parkinson's disease. First stage includes tremor and rigidity. Second stage exhibits loss of facial expression, decreased blinking and rigidity in muscles. The third stage results in loss of balance. Fourth stage results in complete loss of balance, thereby requiring assistance for daily activities. Fifth stage accompanies delusions and hallucinations.

Even though there is no treatment to cure PD yet, the life time of the patient be able to increased in case of early detection and treatment. Therefore, several machine learning techniques were employed in detection of the disease.

If the PD is detected earlier, the lifetime of the patient is increased. For that the effective health Informatics i.e., health information system with high accuracy is necessary. The system must also improves the clinicians workload and must compatible with healthcare application. Several types of instruments are used to recognize the rigorousness of the patients symptoms to detect PD. In early stage, the main symptoms of PD is

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vocal disorder and many of the patients affects with face vocal defection. In this study, Clinically needed features are get from various techniques of speech signal processing. Then the features extracted are given to various learning algorithm to make correct and reliable decision in PD classification. The common algorithm used for classification are Artificial Neural Network (ANN) and Support Vector Machine (SVM). Also, uses the some classification algorithm because of ease understanding and simple like Random Forest method and K- Nearest Neighbors method.

The estimation of the performance of the system is unfair due to the dataset because the dataset has many voice recording per person.

The dataset used in this study has unbalanced distribution of the classes (i.e.,) the number of the instances in the majority classes may be larger than number of the instances in minority classes. Classification algorithm gives better result and performance based on the smooth distribution of the classes. So, the unbalanced dataset will directly affect the performance of the classification. To measure the performance of classifier with unbalanced dataset, choosing the relevant evaluation metrics. In most of the machine learning studies, one of the main metrics used to evaluate the performance based on accuracy. For, imbalanced dataset along with the accuracy need to select the different measures for performance evaluation of the classification. By considering all this, the proposed framework considers accuracy and F-Measure for the performance evaluation. This paper implements the SVM method to construct the classifier to classify the PD and the dataset taken to train the classifier are public dataset.

The paper organised as follows:

- General idea of PD classification studies.
- Dataset details
- Classification methods and evaluation measures
- Results of the classification methods.
- Conclusion

2. Related Work

This section deals with study on PD classification with machine learning algorithm and also recent deep learning methods in PD classification PD classification improves based on the feature extraction from the available dataset and methods. In the literature study, many paper used the same public dataset with 31 instances includes 23 PD patient and 8 healthy patients with 195 vocal sound recording. Other dataset [15] has 40 samples includes 20 PD and 20 healthy persons data with multiple sound (speech) recordings. Bothe the public dataset used the features like vocal fundamental frequency, measures of variation in fundamental frequency, measures of variation in amplitude etc. These features are used in many studies and implementation of classification. So, these are generally considered as baseline features. In addition to the baseline features, signal processing techniques also included in detection. The signal processing tools like SNR (signal to noise ratio), Tunable Q-factor Wavelet Transform (TQWT), Mel-frequency cepstral coefficients (MFCC) tools used to extract the important feature for PD classification[16]. Combination of the individual feature types are used in most classification studies. Feature selection methods [2] reduces the extended feature space. Also, PD patients subjected to slow movements, posture deficiency, balanced deficiency, dysphonia. So, many studies are interested and concentrated on speech based PD classification. Main issues faced by PD patients includes face vocal defections which directly related to vocal loudness, frequency abnormality and instability. Impaired vocal quality and voice breaks also seen in PD patients. PD related vocal features are used to detect anomalies of the speech using speech signal processing. In recent years machine learning algorithms are used to detect the PD patients from health persons.

Two framework are proposed by Gunduz [1] based on CNN to classify the PD using the features like set of speech (vocal) The frameworks differed in the number of 1D convolution layers. Tunable Q-factor wavelet transform (TQWT) applied in Sakar et al [2]. The above said is high frequency resolution than the traditional wavelet transform. TQWT performance compared with the other methods of wavelet transform, TQWT performance is effective when compared with others. For early diagnosis of PD Ravichandran et al [3] used artificial intelligence methods for classification. Feature selection uses the weights derived from Multi-Layer Perceptron (MLP) and the input ranked by their moduli. The reduced set of the features given as a input to Support Vector Machine(SVM) classification. EEG signal used by Yuvaraj et al [4] and taken 20 PD and normal persons. Diagnostic performance of value 0.0001 by using CNN architecture. The model given the performance of 88.25% accuracy, 91.77% specificity anf 84.71% sensitivity. Random forest, ANN and SVM classifier used in Wroge et al[5] study to classify the PD with the speech signal feature. SVM produced best accuracy value of 85% when compared with ANN and Random Forest. To classify the PD with the evaluation of ability of vocal features with the machine learning algorithm by Sakar et al. (2017) [6]. Used dataset consists of samples of less rigorousness of speech impairments and healthy subjects. Classifier used for binary classification. SVM produced 96.4% of accuracy. Speech impairment based on PD classification done in Caliskan et al [7]. Auto encoder and softmax classifier in deep neural network classifier proposed. A new hybrid model k-means clustering-based feature weighting (KMCFW) method and a complex-valued artificial neural network (CVANN) combined in Gürüler [8]. The proposed hybrid method dchieved 99.52% accuracy. Peker [9] used a method and entitled k-medoids clustering-based attribute weighting (kmAW) for data pre-processing. For classification SVM is preferred. To evaluate the efficiency of the model the following are taken for consideration like Classification accuracy, specificity, sensitivity analysis, f-measure, kappa statistics value and

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ROC analysis. Convolutional neural networks (CNN) in Pereira et al [10] for PD identification with 308 images of 224 patients and 84 control samples. Ten patients data with PD using inertial measurements collected in Eskofier et al. [11]. Moto task are labelled for classification, to detect the Bradykinesia. Classification done by machine learning and deep learning, out of which deep learning performed well. Dr.Y.S. Rao et al [12] proposed system by taken the gait characteristics to identify the PD. A range of statistical feature vectors were considered and then classified using a Gaussian radial basis function kernel based Support vector machine (SVM) classifier. The good accuracy achieved as 83.33%. 31 people of 23 with PD and 8 healthy people dataset with bio-medical voice signal used in Sharma et al [13]. Multi-Layer Perceptron, KNN and SVM classifier model used. Shahbakhi et al. [14] uses voice analysis for classification. Genetic algorithm used to extract the optimized features and SVM applied on the dataset. Sakar et al [15] uses voice sample and extracted 26 linear and time frequency based features. SVM and K-NN classifier used. Little et al.[16] proposed a method to test how accurately the novel algorithms can be used to discriminate PD subjects from healthy controls. 132 dysphonia measures were computed from sustained vowels. Then, four parsimonious subsets of these dysphonia measures were selected using four feature selection algorithms, and mapped to a binary classification response using two statistical classifiers: random forests and support vector machines. The overall accuracy was 99%. Rouzbahani et al [17] used 31 people speech dataset. Extracted features fed to three different classifier like SVM, KNN and some discrimination function based were used. KNN achieves 0.9382 accuracy with another classifier.

3. Dataset

The dataset was taken from UCI Machine Learning repository [2]. It comprises acoustic features extracted from three voice recording replications for each one of the 80 subjects. Out of these, 40 subjects were diagnosed with Parkinson's disease and 40 subjects were normal individuals. The age of PD patients ranged from 33 to 87 years and the healthy subjects ranged from 41 to 82 years old. During the data collection, frequency response of the microphone was fixed to 44.1 KHz, and frequent repetition of the vowel /a/ letter of individual was collected with three replicates.

Table 1 describes the features used for the classification.

Table 1: Detailed Explanation of Features

Feature	Description
ID	Subjects's identifier
Recording	Number of the recording
Status	0=Healthy; 1=PD
Gender	0=Man; 1=Woman
relative jitter (Jitter_rel), absolute jitter (Jitter_abs)	Pitch local perturbation measures
Jitter_RAP	relative average perturbation
Jitter_PPQ	pitch perturbation quotient
local shimmer (Shim_loc), shimmer in dB (Shim_dB)	Amplitude perturbation measures
Shim_APQ3	3-point amplitude perturbation quotient
Shim_APQ5	5-point amplitude perturbation quotient
Shim_APQ11	11-point amplitude perturbation quotient
HNR05	harmonic-to-noise ratio in the frequency band 0-500 Hz
HNR15	harmonic-to-noise ratio in the frequency band 0-1500 Hz
HNR25	harmonic-to-noise ratio in the frequency band 0-2500 Hz
HNR35	harmonic-to-noise ratio in the frequency band 0-3500 Hz
HNR38	harmonic-to-noise ratio in the frequency band 0-3800 Hz
MFCC0, MFCC1,..., MFCC12	Mel frequency cepstral coefficient-based spectral measures of order 0 to 12
Delta0, Delta1,..., Delta12	Derivatives of MFCCs
RPDE	Recurrence period density entropy
DFA	Detrended fluctuation analysis
PPE	Pitch period entropy
GNE	Glottal-to-noise excitation ratio

4. Methodology

In this section, a detailed explanation on the construction and implementation of the SVM classifier is given.

Support Vector Machines (SVM)

Support Vector Machine is a new generation learning system purely based on recent advances in statistical learning theory and can be used for both linear and non-linear data. It uses the original to find a hyper plane for separation of the data using essential training tuples called support vectors. A Support Vector Machine is a discriminative classifier formally defined by a separating hyper plane. In other words, given labelled training, support vector machine constructs a hyper plane or set of hyper planes in a high or infinite dimensional space, which can be used for classification, regression, or other tasks. Intuitively, a good separation is achieved by the hyper plane that has largest functional margin, since the larger margins reduce the generalization error of the classifier.

Implementation

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The proposed framework consists of an SVM based classifier model which is trained to classify Parkinson's disease. The dataset is obtained from UCI machine learning repository. The dataset consists of features extracted from the speech recordings of 80 individuals with three recordings per individual. Of these, 40 individuals were diagnosed with Parkinson's disease. There are a total of 240 instances with 46 feature attributes for each instance. The above mentioned dataset is used to train the SVM classifier. The dataset is divided into training and testing set. The SVM classifier model is trained using the training set of data. The testing set of data is used to test the performance of the constructed and trained SVM classifier model. Since the dataset has a balance between the classes, misclassification errors are considerably reduced. The performance of the developed SVM classifier model is evaluated with evaluation metrics such as accuracy, sensitivity, specificity etc… It was found that the constructed SVM classifier produced an accuracy of 84.44%.

5. Experimental Results

In this section, the results obtained from the classification of Parkinson's disease using SVM classifier are explained. The proposed framework was trained using a dataset obtained from the UCI machine learning repository. The dataset consisted of 240 instances obtained from speech recordings 40 individuals with 3 instances per individual. Of the 80 individuals, 40 were diagnosed with Parkinson's disease and the remaining individuals were normal. Each instance had 46 parameters obtained from the recorded speech signal. The dataset was used to train an SVM model. The model was used as a classifier for Parkinson's disease. The performance of the constructed model was measured with the following parameters.

accuracy = (tp+tn)/N
=0.8444
sensitivity = tn/(tn+fp)
= 0.2500
specificity = tp/(tp+fn)
= 0.9730
precision = tp/(tp+fp)
= 0.6667
recall = tp/ (tp+fn)
= 0.2500
f_measure = 2*((precision*recall)/(precision + recall))
= 0.3636

- tp - true positive (sick people correctly diagnosed as sick)
- tn - true negative (healthy people correctly identified as healthy)
- fp - false positive (healthy people incorrectly identified as sick)
- fn - false negative (sick people incorrectly identified as healthy)
- N – Number of entries in the testing dataset

Table 2: Confusion Matrix of the SVM classifier

tp=36	fn=1
fp=6	tn=2

The parameters mentioned above indicated that the SVM classifier provided an accuracy of 84.44%. The high degree of accuracy was due 2 reasons

- Large number of attributes was considered into account for each instance.
- There was a balance in the number of instances between the two classes.

The table 2 explains the confusion matrix of the implemented SVM classifier. The table not only explains the performance of the classifier, but also helps us to identify any misclassification in the constructed model which can be used to calculate the misclassification costs.

6. Conclusion

In this work, SVM classifier was used to classify Parkinson's disease. The dataset consisted of 240 instances with 46 attributes for classification. The result obtained by the SVM classifier had both a high precision level of the confusion matrix regarding the different measurement parameters (accuracy, sensitivity, specificity, recall and F- measure). It showed a high degree of certainty. Furthermore, some of the parameters reach very high accuracy of 84.44%. As illustrated, our system allowed finding out which instances are correctly or incorrectly classified. A future line of the system is an elaborative study of all the fields to determine why the errors occurred, and to learn how to avoid this from happening in the future.

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