

A Review on Detection of Parkinson's disease

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ABSTRACT

This paper present different methods of diagnosis of Parkinson's disease through voice in early stages. The aim of this study is to provide a simple, fast, cheaper method of detection of Parkinson's disease for the patients as there is no cure for this disease and the available therapies which provide some relief to them are too much costlier for this disease. Voice has different parameters that tell meaningful variations between normal people and Parkinson's patient like pitch, jitter, formant, shimmer, Mel-frequency Cepstral Coefficient (MFCC) and glottal pulse were founded out and analyzed.

Keywords :- *Parkinson's Disease; Speech Analysis; Genetic Algorithm; Support Vector Machine.*

INTRODUCTION

Parkinson's disease (PD, also known as idiopathic or primary parkinsonism, hypokinetic rigid syndrome (HRS), or paralysis agitans) is a degenerative disorder of the central nervous system mainly affecting the motor system. The motor symptoms of Parkinson's disease result from the death of dopamine-generating cells in the substantia nigra, a region of the midbrain. The causes of this cell death are poorly understood. Early in the course of the disease, the most obvious symptoms are movement-related. These include shaking, rigidity, slowness of movement and difficulty with walking and gait. Parkinson's disease is more common in older people, with most cases occurring after the age of 50; when it is seen in young adults, it is called young onset PD (YOPD).

The main motor symptoms are collectively called parkinsonism, or a "parkinsonian syndrome". The disease can be either primary or secondary. Primary Parkinson's disease is referred to as idiopathic (having no known cause), although some atypical cases have a genetic origin, while secondary parkinsonism is due to known causes like toxins. Many risks and protective factors have been investigated: the clearest evidence is for an increased risk of PD in people exposed to certain pesticides and a reduced risk in tobacco smokers. The pathology of the disease is characterized by the accumulation of a protein into Lewy bodies in neurons, and from insufficient formation and activity of dopamine in certain parts of the midbrain. Where the Lewy bodies are located is often related to the expression and degree of the symptoms of an individual. Diagnosis of typical cases is mainly based on symptoms, with tests such as neuro imaging being used for confirmation.

Treatments are effective at improving the early motor symptoms of the disease. This is typically with the medications L-DOPA and dopamine agonists. As the disease progresses and dopaminergic neurons continue to be lost, these drugs eventually become ineffective at treating the symptoms and at the same time produce a complication marked by involuntary writhing movements. Diet and some forms of rehabilitation have shown some effectiveness at improving symptoms. Surgery and deep brain stimulation have been used to reduce motor symptoms as a last resort in severe cases where drugs are ineffective. Research directions include investigations into new animal models of the disease and of the potential usefulness of gene therapy, stem cell transplants and neuroprotective agents. Medications to treat non-movement-related symptoms of PD, such as sleep disturbances and emotional problems, also exist.

In 2013 PD resulted in 103,000 deaths up from 44,000 deaths in 1990. The disease is named after the English doctor James Parkinson, who published the first detailed description in *An Essay on the Shaking Palsy* in 1817. Several major organizations promote research and improvement of quality of life of those with the disease and their families. Public awareness campaigns include Parkinson's disease day (on the birthday of James Parkinson, 11 April) and the use of a red tulip as the symbol of the disease. People with parkinsonism who have increased the public's awareness of the condition include actor Michael J. Fox, Olympic cyclist Davis Phinney, and professional boxer Muhammad Ali. Parkinson's not only affects humans, but other primates as well, which have often been used in researching the disease and testing approaches to its treatment.

Literature Review:

The detection of Parkinson's disease has major 3 steps to follow,

1. Database collection of voice signals (Voice signal of patients affected with PD and normal patients).
2. Feature extraction.
3. Disease detection.

1. MFCC(Mel-frequency Cepstral Coefficients):

Here author used MFCC (Mel-frequency Cepstral Coefficients), Formants, Pitch and Jitter and shimmer. It is used for speech recognition. Mel-frequency cepstral coefficients MFCC are derived from a type a of cepstral representation of voice signal. In this method voice signal is passed through pre emphasis block. This signal splits into smaller frames of 15-40 ms duration. After that smaller signal are used for frame blocking then window function is multiplied with bunch of frames. Then it passed through FFT block to convert signal into frequency domain. Mel-filter block converts this signal into Mel-frequency. Logarithm is used for normalization. Then it is applied to DTC block gives MFCC values. Formants are the spectral peaks of the sound spectrum of voice. Formants distinguish the vowels for this, author used different software like MATLAB , PRAAT. It uses MATLAB for calculating MFCC.

Pitch depends upon the vocal folds vibrations. PD affected patients have swallowing on face, neck and pitch depends on emotions, mood. Due to this more vibrations in vocal folds, that result in more vibrations in pitch values. Jitter and shimmer are measures of the cycle-to-cycle variation of fundamental frequency of amplitude respectively. It is used for the description of pathological vice quality.

2. Forward-flexed posture detection

In this paper author focused on posture disturbances, such as festination ie. rapid shuffling steps and a forward-Flexed posture while walking.

The forward-flexed posture can be monitored by the detection of the upper body lean forward angle. The tilting angle indicates the Forward-flexed posture and calculated from the accelerometer attached on the chest.

2.1 Time less Tilting Angle Transformation Method:

The upper body lean forward angle when walking is good index for the deflection of people whether having forward flexed posture or not. In this they used vest, in this vest there is embedded accelerometer for the detection of the upper body tilting angle. A positive angle indicates a backward- flexed posture and a negative angle indicates a

forward-flexed posture. From this vest raw data was collected (Az) and from this they analysis the Q . A linear relationship between Q and Az is observed.

2.2 Advantages in Angle Averaging and accuracy Testing with Real applications

Here require the averaged angles for certain amount of time instead of the tilting angles in real time for every set of data sampling of accelerometer.

To calculate the average angle over a pride of time with the time-less algorithm, it accumulate the raw data only in each interrupt which is incurred by an accelerometer sampling event. After that take the average of accumulated raw bit when the time interval ends and transform to the angle value. If the number of angle to be averaged are set of the power of two, averaging can be down with a simple shifting operation. By using the inverse trigonometric function, every angle has to be calculated and accumulated during each interrupt end then the angle average can be taken at the end of time interval since the calculations to obtain the tilting angle are non-linear.

3. Detection of arousals in Parkinson disease patients.

In this paper author proposed an algorithm which uses features form EEG ,EMG and the manual sleep stage scoring as input to feed-forward artificial neural network. The performance of the algorithm has been assessed using polysomnographic (PSG) recordings from a total of 8 patients diagnosed with PD. And the result got form this algorithm is high compared to previous algorithms which were used to detect PD.

3.1 Subject

Eight PD patients selected form the patient database

3.2 Data acquisition

All subject underwent one night of polysomnographic (PSG) including six leads of EEG , Surface EMG of the left and right anterior tibialis muscle and the sub mental muscle, electrocardiography (ECG) of vertical and horizontal electrooculography (EOG)

3.3 Biomedical signal processing

For signal processing, author decide to use only the two central and two occipital EEG channels and the sub mental EMG channel. All EEG signal were bandpass filtered with a 3db cut off frequency between 0.3 of 35 hz. And the EMG signal was bandpass filtered with a 3db but off frequency between 30 and 100Hz. Also a 50-hz component with more than 100db.

The frequency content of the EEG signal was assessed by calculating the short time fourier transform of the EEG signal form this fast fourier Transform of small signal segments was calculated to get the frequency Spectrum for a specific time of the recording. Before the calculation of FFT, each segment was multiplied by a Haning window.

In order to measure the performance of the algorithm, the true positives, false positives and false negatives were defined.

4. Parkinson's disease Detection With SVM classifier and Relief-F Features Selection Algorithm

MATERIALS AND METHODES

In this paper author performed conduction on the PD data set taken from UCI machine learning repository. The data set is a voice recording originally done at University of Oxford by Max Little. The recording consists of 195 entries collected from 31 people whom 23 are suffering from Parkinson's Disease(PD). From the 195 entries, 147 are of PD and the remainders 48 are of normal character.

The attributes are computed from the vocal recording and they describe changes in fundamental frequency, amplitude variations, noise to tonal components and other nonlinear voice measurements. It should be noted that there is no missing values in the data set, and the whole features are real valued.

After that Relief F Features selection is used. The basic idea of Relief-F is to draw instances at random, compute their nearest neighbours, and adjust a feature weighting vector to give more weight to features that discriminate the instance from neighbours of different classes. It tries to find a good estimate of the following probability to assign as the weight for each feature F. After that Support Vector Machines is used. SVMs obtain very promising results in classifying the possible Parkinson's disease. It is of two type, Linear SVM and Non-linear SVM. It compare the PD patient and normal patient according to database.

By defining a linear mapping, a linear boundary is inappropriate SVM can map the input vector into a high dimensional feature space. By defining a non-linear mapping, the SVM construct an optimal separating hyperplane in this higher dimensional space. In this paper the SVM classifier shows a great performance obtaining the following results: 97.22% in specificity, 95.83% in sensitivity and the total classification accuracy of 96.88%.

This study presents a SVM classification of Parkinson's disease, and a feature selection is implemented, to reduce number of features.

5. Speech Analysis for Diagnosis of Parkinson's Disease Using Genetic Algorithm and Support Vector Machine

5.1 Support Vector Machine

The most representative example of local neural network is the Support Vector Machine (SVM) of the Gaussian kernel function. It is a two layer neural network employing hidden layer of radial units and one output neuron. The procedure of creating this network and learning its parameters is organized in the way in which it deal only with kernel functions instead of direct processing of hidden unit signals. Basic SVM is linear but it can be used for non-linear data by using kernel function to first indirectly map non-linear data into linear feature space. Basic SVM is also a two-class classifier however; with some modification, multiclass classifier can be obtained.

SVM training involves solving a convex quadratic programming (QP) problem with equality and inequality constraints obtained by the objective of margin maximization. In multiclass SVM, many two class SVMs are trained and in classification, voting schemes are used for selecting the correct class. SVM is preferred here because it can directly measure the extent to which people with Parkinson can be discriminated from healthy controls on the basis of measures of dysphonia, Addressing the problem of classifying subjects as healthy or PD.

5.2 Dataset

The dataset was taken from Max Little of the University of Oxford, in collaboration with the National Centre for Voice and Speech, Denver, Colorado, who recorded the speech signals. The original study published the feature extraction methods for general voice disorders. The data consists of 195 sustained vowel phonations from 31 male and female subjects, of which 23 were diagnosed with PD. The time since diagnoses ranged from 0 to 28 years, and the ages of the subjects ranged from 46 to 85 years (mean 65.8, standard deviation 9.8). Averages of six phonations were recorded from each subject, ranging from one to 36 seconds in length. The phonations were recorded in an IAC sound-treated booth using a head-mounted microphone (AKG C420) positioned at 8 cm from the lips. The voice signals were recorded directly to computer using CSL 4300B hardware (Kay Elemetrics), sampled at 44.1 kHz, with 16 bit resolution. Although amplitude normalization affects the calibration of the samples, the study is focused on measures insensitive to changes in absolute speech pressure level. Thus, to ensure robustness of the algorithms, all samples were digitally normalized in amplitude prior to calculation of the measures.

5.3 Features Extraction

In this dataset, 22 linear and non-linear features were extracted from the data. 14 features are based on four factors: F0 (fundamental frequency or pitch), jitter, shimmer and noise to harmonics ratio, which are the most important factors of the voice signal. It was concluded that the change in these factors is remarkable in people with Parkinson's disease compared to healthy people, therefore, optimized features are selected among them.

In this paper, a method based on combination of genetic algorithm and SVM network, for classification of healthy people and people with Parkinson of various numbers of features, was investigated. Results showed that the highest accuracy was achieved with extracting 4 optimized features: F_{hi} (Hz), F_{ho} (Hz), jitter and shimmer.

6. Performance Comparison of Heterogeneous Classifiers for Detection of Parkinson's Disease Using Voice Disorder (Dysphonia)

The present study implemented linear and nonlinear classifiers for binary classification (PD vs Healthy). In the prediction system, 22 attributes extracted from dysphonia measurement of people were used to identify PD patient. The data is imbalanced in terms of the binary class distribution. The complete classification process was performed in the environment of WEKA (version 3.6) and MATLAB R2012b. Java based API of WEKA was used from MATLAB to run the classifier. In order to verify the effectiveness of the classification accuracy using the dataset, we have used three popular machine learning (ML) classifiers. To get robust classification result, two layered FBANN was employed comprising 22 input nodes, one hidden layer with changeable neuron to get two outputs from the output layer. Levenberg- Marquardt (LM) algorithm was used as training algorithm of FBANN which interpolates between the Gauss–Newton algorithm (GNA) and of gradient descent (GD) method.

The FBANN network was provided maximum 1000 iterations to converge with minimum error goal 0.01 in every iteration. Hyperbolic tangent sigmoidal function was employed as an activation function in both hidden and output layer to get desired output. After the network has configured, initial weights and biases were chosen randomly for both hidden and output layer. The complete process of each classifier training and testing has various steps. Firstly, complete dataset was divided randomly from 195 samples into 10 training and 10 test sets. Test set dimension was 50% of training set dimension. We trained each classifier 100 times. A popular 10-fold CV method was used to evaluate the classification accuracy of all classifiers to get an unbiased estimation of the accuracy of generalization. In this 10-fold CV procedure, each time one of the 10 subsets (10% of the feature set) is used as the test set and the remaining 9 subsets (90% of the feature subset) are used as a training set for classifier learning and generalization. The training and test sets are independent and more reliable results were achieved from the classifier. After finalizing 10 fold cross validation, average mean square (MSE) error were computed. To evaluate more robust performance of the data set, 10-fold cross validation method was repeated of 100 independent trials and the results were averaged.

7. Automatic Detection of Different Walking Conditions Using Inertial Sensor Data

7.1 Wireless Foot Sensor Unit

Two wireless foot sensor units were developed for this experiment. Each unit was equipped with a Sparkfun IMU digital combo board with 6 degrees of freedom (DOF) consisting of an accelerometer - ADXL345 and a gyroscope- ITG3200 used to measure the distal foot accelerations and rotations .

1). The ultra low-powered tri-axis accelerometer is capable of measuring $\pm 16g$ in full-scale with a sensitivity of 31.2 LSB/g and possesses maximum of 3200 Hz bandwidth. The ITG3200 16 bit digital gyroscope has sensitivity of 14.375 LSBs per $\frac{1}{\text{sec}}$ and a full-scale range of $\pm 2000 \frac{1}{\text{sec}}$. The sensing unit was powered with a Sony Ericsson BST-41 Li-Polymer rechargeable Battery. The embedded onboard system was implemented by a Freescale Semiconductor MCU (8-bit MC9S08SH8) and Bluetooth 2.0/EDR communications were used to (Sena ESD200/210) transfer the sensor data to computer. A MATLAB GUI was written to communicate with the sensor units.

7.2. Data Collection

A group of 5 healthy young subjects consisting of 4 males and 1 female with no known gait disorders were recruited for this study.

7.3. Data processing

The data collected from IMU were processed in Matlab v7.2, (Mathworks, USA). The sensor outputs were first converted into acceleration and angular velocities from voltage readings using their respective sensitivities. Inertial sensor signals were band-pass filtered twice with a lower cut-off frequency of 1Hz and a higher cut-off frequency of 35Hz to remove electrical noise and bias drifts. Butterworth filters of order 10 were used to guarantee designed filter stability. The signals were filtered in the forward and backward direction to minimize phase shift effects using the `filtfilt` function in MatLab.

7.3.1. Gait event detection

Gait event detection i.e., identifying gait cycles using the inertial sensor data was done by using the maximum toe angular velocity in the sagittal plane, i.e., rotation about the medio-lateral axis (GyroX), following the method.

7.3.2. Features Extraction

After gait event detection, the prominent acceleration and rotation values near the toe-off point were extracted using maximum/ minimum point around the toe-off point.

This study reports a novel experimental protocol which included assessment of walking function using GAIRite mat and computational intelligence techniques. The three walking tasks included walking with subjects' preferred walking speed, with a glass of water (a challenging gait task that would interfere with the walking balance) and blind folded (where the sensory visual feedback would be missing).

8. Conclusion

Parkinson's disease is known as the second common neurological disorder after Alzheimer. It influences several aspects of human's functions in which speech disorder is the most prominent. Several researches have been proposed for diagnosis of PD with voice analysis. In this paper, a method based on combination of genetic algorithm and SVM network, for classification of healthy people and people with Parkinson of various numbers of features, was investigated. Results showed that the highest accuracy was achieved. It is observed that there is no major difference between accuracy of our technique and Reference.

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