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Diagnosis of Parkinson Disorder through Speech Data

Chethan C R[1], Abhishek M S[2], Divitha D[3], Nagaraju T R[4], Aditya C R[5]
[1, 2, 3, 4, 5]Computer Science and Engineering, Vidyavardhaka College of Engineering, Mysore, India

Abstract: Parkinson's disease is a central nervous-system disorder. 90% of people with parkinson disease are reported to have speech and voice disorders. Vocal folds are normally weakened by this disorder and the patient talks improperly. Various elements of the speech patterns of healthy people and those with parkinson disease were studied for prediction of parkinson's disease. Optimized features affecting the data classification process were then identified using genetic algorithms and the KNN classification method was used to eventually classify the data based on different numbers of optimized features.
Keywords: Parkinson's, Symptoms, KNN, Data, Jitter, Shimmer.

I. INTRODUCTION

The disease of PARKINISON was first identified in 1817 by the British scientist James Parkinson, so that it was named after him. Following Alzheimer's disease Parkinson is considered to be the most severe neurodegenerative disorder [1]. This results from the death of dopamine in substantia nigra, including neurons. These neurons produce dopamine that carries midbrain messages to another part of the brain called corpus striatum. Such signals match the motions of the body. Although in substantia nigra the dopaminergic neurons die, other regulating units of body movements function irregularly. The disruptions in the activity of brain control systems triggers Parkinson's disease symptoms. [2] The disease is a brain condition that is more common in people over the age of 60. The disease prevalence is around 1 per cent of people over the age of 60. While younger people are 5-10 per cent of cases. Some of the symptoms of the disease are: tremor (especially when the limbs are stable), stiffness and slowness of movement in the entire body, lowering of the forefoot leading to an awkward gap between the two legs and improper walking, facial changes, speech changes (the speech weakens), depression [1]. While speaking, people with the disease have a shaky rough breathy voice, and generally speak softly and loosely. Their tone of voice is reduced, and the words cannot be pronounced well. Both of these have an impact on quality of speech. Such disruptions occur when the muscles regulating speech are not functioning properly. This disorder weakens the vocal folds, and their unsuitable vibration contributes to the formation of an unnatural voice [3]. Disorders of speech are increasingly isolating the individual from society and influencing his or her personal and social life. Visiting health facilities for medical purposes is too daunting for many of the patients with Parkinson's disease. At the other hand, major advancements and advances in telemedicine systems have allowed some of the patients to be treated without going to a doctor and via telemedicine systems [4]. Though using this technology needs resources that are highly reliable and relevant. It is estimated that nearly 90 per cent of people with Parkinson's disease are vulnerable to vocal disorders. In other words, we might suggest speech disorders can be among the disease's early-stage symptoms [5],[6]. Voice signal recording is simple and non-invasive so it is a notable parameter for symptom progression identification and monitoring.

In many researches, voice analysis has been used to detect various diseases specifically the Parkinson's disease. In such studies, the subject 's voice is captured using a microphone in a typical experiment, and particular features are then extracted from the recorded signal and analyzed using different methods [7]-[11].

M. Ene[10], 2008, extracted usual nonlinear characteristics from the same data used in this paper and achieved a maximum classification accuracy of 81.28 percent using 22 features. M. A. Little and his colleagues [8], 2008, extracted similar features to those used in [10] and achieved a 91.4 classification accuracy after choosing four tailored features based on the correlation equation and using the SVM process. M. F. Caglar and his colleagues [9], 2010 used MLP, RBF and ANFC classification methods and extraction characteristics close to those extracted in [10] and managed to achieve 93.1 per cent classification accuracy with four characteristics.

The data [26] is first defined in this paper and then specific standard characteristics are extracted from it. Optimized features are chosen using genetic algorithm to decrease the vector dimension of the function and finally the data from healthy people and people with Parkinson's disease are categorized using the KNN test.

II. FEATURE EXTRACTION

The most important and specific voice signal factors have been used in this research to extract the features. The considerations are: F0 (fundamental frequency or pitch), the ratio of jitter, shimmer and noise to harmonics. Studies show that the improvement in these variables is significant as compared to healthy people in people with Parkinson's disease. Out of each captured voice signal, 13 different features were extracted. The functions were measured using the praat software [12]. Every of the functions is explained below [13]:

1) *Fo (Hz):* Mean fundamental frequency.
2) *Fhi (Hz):* maximum fundamental frequency.
3) *Flo (HZ):* minimum fundamental frequency. Jitter (%): This is the average absolute difference between consecutive periods of fundamental frequency, divided by the average period (expressed as a percentage)
4) *Jitter (ABS):* This is the average absolute difference between consecutive periods of fundamental frequency, in microseconds (µs)

$$Jitter(ABS) = \frac{1}{N}\sum_{i=1}^{N-1} |T_i - T_{i+1|} \qquad (2)$$

5) *Jitter (RAP):* This is the Relative Average Perturbation, the average absolute difference between a period of fundamental frequency and the average of it and its two neighbors, divided by the average period.
6) *Jitter (DDP):* This is the average absolute difference between consecutive differences between consecutive periods, divided by the average period [17] [18].
7) *Shimmer:* This is the average absolute difference between the amplitudes of consecutive periods, divided by the average amplitude

$$Shimmer = \frac{\frac{1}{N-1}\sum_{i=1}^{N-1} |A_i - A_{i+1}|}{\frac{1}{N}\sum_{i=1}^{N} A_i} \qquad (3)$$

Where Ai are the peak to peak amplitude of window number "i" and N is the total number of windows. [19]

8) *Shimmer (dB):* This is the average absolute base-10 logarithm of the difference between the amplitudes of consecutive periods, multiplied by 20

$$Shimmer(dB) = \frac{1}{N-1}\sum_{i=1}^{N-1} 20\log(A_i - A_{i+1}) \quad (4)$$

9) *Shimmer (APQ3):* This is the three-point Amplitude Perturbation Quotient, the average absolute difference between the amplitude of a period and the average of the amplitudes of its neighbors, divided by the average amplitude.
10) *Shimmer (APQ5):* This is the five-point Amplitude Perturbation Quotient, the average absolute difference between the amplitude of a period and the average of the amplitudes of it and its four closest neighbors, divided by the average amplitude [20][21].
11) *Shimmer (DDA):* This is the average absolute difference between consecutive differences between the amplitudes of consecutive periods.
12) *HNR:* harmonics to noise ratio [25].

III. CLASSIFICATION BASED ON THE K-NEAREST NEIGHBOR (KNN) METHOD

In pattern recognition, the K-nearest neighbor (KNN) is a tool for classifying objects in feature space based on nearest training examples. The KNN is a basic simple method for pattern recognition and when data distribution knowledge is not adequate the method is among the first methods of classification selected [16]. This approach involves two parts: a) determining close neighbors to K, b) determining the form of class using those near neighbor's. Suppose the space D of training data defined as equation. (5)

$$D(X) = \{X_1, X_2, \dots X_n\} \qquad (5)$$

Which includes *n* samples and each sample *Xi* is defined by *f* features as

$$X_i = (x_{i1}, x_{i2}, \dots x_{if}) \qquad (6)$$

In pattern recognition, the K-nearest neighbor (KNN) is a tool for classifying objects in feature space based on nearest training examples. The KNN is a basic simple method for pattern recognition and when data distribution knowledge is not adequate the method is among the first methods of classification selected [16]. This approach involves two parts: a) determining close neighbors to K, b) determining the form of class using those near neighbours. Suppose the space D of training data defined as equation. Euclidean distance between *X'* and *Xi* along with the feature dimension, *f*, is defined as equation (6)

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$$d = \sqrt{(x_{i1} - x`_1)^2 + (x_{i2} - x`_2)^2 + \cdots + (x_{if} - x`_f)^2} \quad (7)$$

In order to use this method, 70 percent of the data was considered for training and the remaining 30 percent was considered as test data [23][24].

IV. METHODOLOGY

We use a bank of safe and Parkinson's sufferer's audio files [26] to create our dataset by doing some audio measurements. When our dataset is developed, we will train a K Neighbors Classifier (KNN) model to make our predictions with the scikit-learn library. Finally, we are going to create a Python library which can then easily be incorporated into programs.

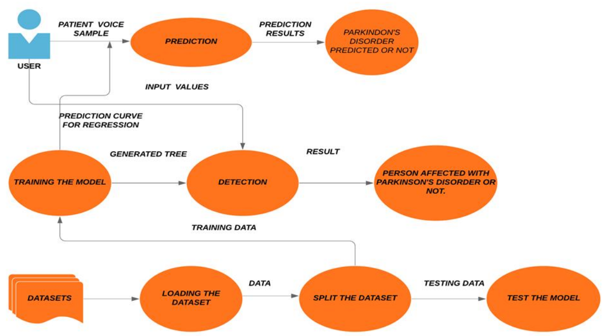

Figure 1 System Design

Dataset Creation-- To begin, we need to transform our audio files [26] into a table containing the audio measurements and an indication of whether the patient is healthy or not as 0 and 1 respectively.

Next, we will create a function that allows you to take various complex measurements on an input audio file. These measurements are taken to the Parselmouth library, which allows you to use Praat in Python code. Then we create lists for each type of measurement and another to indicate whether the patient is healthy or not. This will be used to build the dataset once the lists have been filled in.

Finally, we have to transform these lists into a dataset by grouping them into a single table using pandas and NumPy libraries.

Making the Model --- Now we have to create a model that will represent the heart of the project. It is the one that will allow us to make predictions.

We will use the KNN algorithm of scikit-learn. This algorithm will allow us to classify (0 or 1) subjects according to several parameters (measurements). To begin, we will train our model by specifying the parameters (measurements) as well as the label (0 or 1) in order to carry out supervised training.

We obtain a precision of 0.85 or one-third of correct predictions, which is rather satisfactory considering the limited data for the creation of the dataset.

Once we have obtained a satisfying precision, we have to fit the model and make it exportable in order to use it in our library. once model is trained, exported, and ready to be used by our library which is saved in format of *.sav.

```
import joblib
joblib.dump(clf, "trainedModel.sav")
```

1) *Library Creation:* To get a library that can be used by another program. To do this, we will create three functions:

a) Model loading

b) Measuring audio (already used to build the dataset)

c) Predict

```
from RecognitionLib import *
path = "... /trainedModel.sav" #model Path
clf = loadModel(path) #Model loading
print (predict (clf, "…/../audio/ok.wav")) #Prediction
```

once model built, we build web-based application using trained model to predict the Parkinson's disease using real-time patient voice.

V. RESULTS

After selection of optimized features by genetic algorithm, for various numbers of optimized features, data classification was done between the data of healthy people and those of patients with Parkinson's disease, using the KNN classification method.

By having at least 9 configured features, the highest amount of classification accuracy was obtained which is around 98.2 percent. The findings also show a 94.8 percent classification accuracy for at least 7 optimized features, a 93.1 percent classification accuracy for at least 4 optimized features and a 75.8 percent classification accuracy for fewer than 4 optimized features. Table I listed the apps chosen for optimization.

Table 1. Name of selected optimized features

Number of Features (N)	Feature	Classification Accuracy (%)
N=9	F0(Hz), Fhi(Hz), Flo(Hz), Jitter(%),Jitter(ABS), Jitter(RAP), Shimmer, Shimmer(APQ5), HNR	98/2
N=7	F0(Hz), Fhi(Hz), Flo(Hz), Jitter(ABS), Jitter(RAP), Shimmer, Shimmer(APQ5)	94/8
N=4	Fhi(Hz), Flo(Hz), Jitter(RAP), Shimmer(APQ5)	93/7

Considering the results of the study, it has been seen that a classification accuracy of 93.7 per cent has been obtained using 4 streamlined apps, which is obviously a notable outcome relative to other tests. Other test findings include: 94.8% classification accuracy for 7 optimized features and 98.2% classification accuracy for 9 optimized features. These findings may not have been obtained through comparable studies, and it indicates that the genetic algorithm has been effective in choosing the right features that have had the greatest effect on the process of data selection between data from healthy individuals and data from patients with the disease.

VI. CONCLUSION

Throughout this work, it was attempted to derive valuable information from captured voice signals using various methods of extraction of functions. In order to which the complexity of calculations, standardized and powerful characteristics have been observed using a genetic algorithm and, ultimately, data classification has been done using the KNN classification system. A variety of experiments have recently been conducted to diagnose disorders such as Parkinson's disease using speech signal processing. Among the work performed, only the normal voice signal characteristics have been derived and the nonlinear aspects, like more complicated equations, have been over looked. One noteworthy benefit of this work may be the use of a genetic algorithm to identify optimal functionality. Another advantage of this work is the use of a basic classification system for non-complex calculation (KNN) and the achievement of measurable results. The findings of this study suggest that Parkinson's disease affects the human voice in particular. It is also possible to diagnose the illness by means of a speech examination that may be used for different applications especially for telemedicine purposes.

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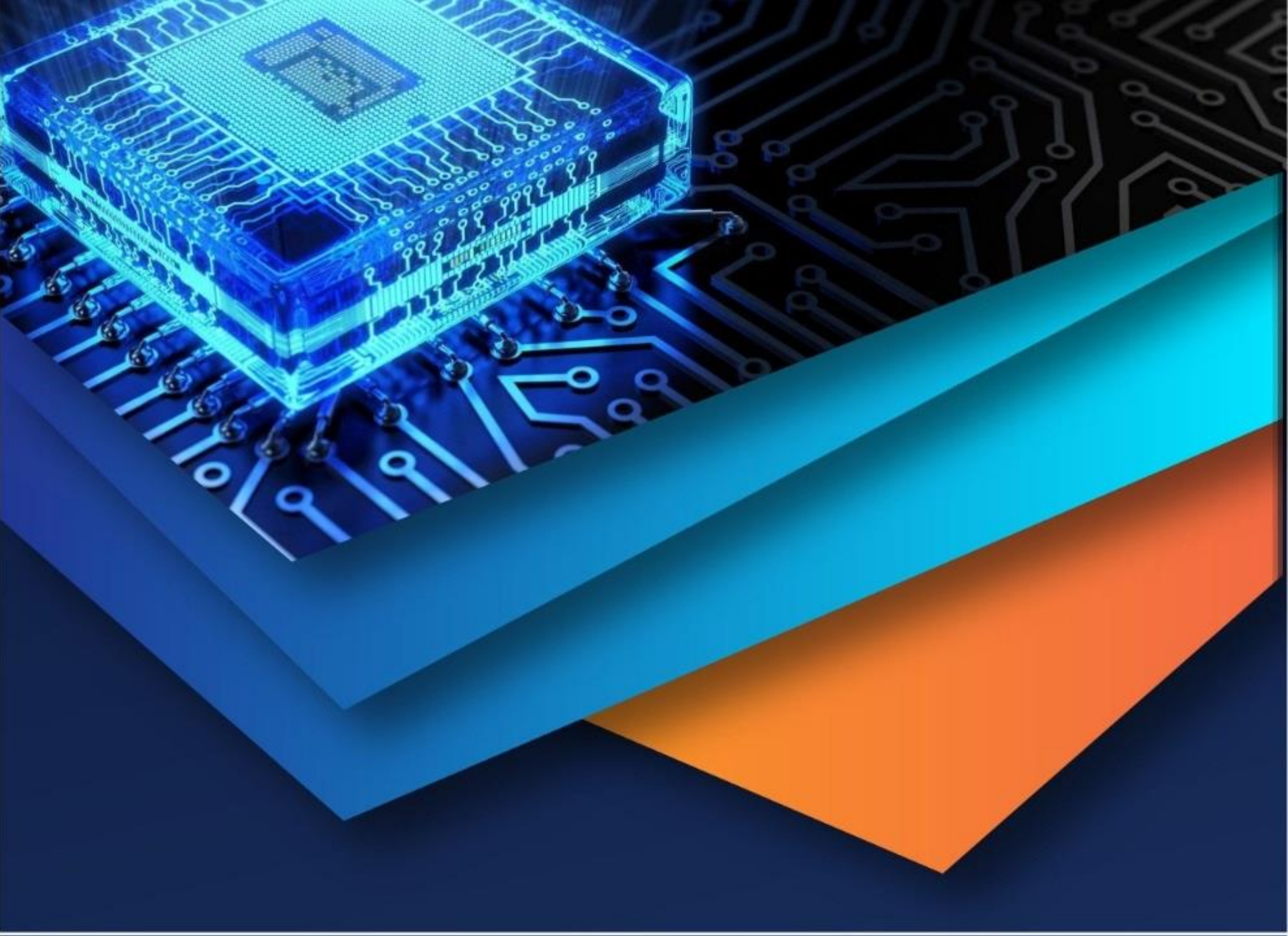

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