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Voice Feature based Detection of Parkinson's Disease using Machine Learning Approach

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***Abstract*— At present Parkinson's disease (PD) is the second largest neuro effected disease. Its symptoms resemble daily life activities, which are not identified by the patient. There is no solely technique or measures for detection and confirmation of PD in patients. In this study, it employs that machine learning algorithms plays a major role in identification of PD and in analysis of complex PD representing data types. KNN algorithm is used for this case study to contribute to the growing field of Voice-based analysis that incorporate key features like shimmer, Jitter, frequency to understand the evolution of PD symptoms. This paper presents a comprehensive calculated regression analysis of PD in affected patients. By this study and experimental results, the proposed methodology helps to effectively detect the PD and incorporate into health care for diagnosis purpose**

***Index Terms*— Parkinson's disease, ML algorithm, KNN algorithm, regression analysis, shimmer, jitter, frequency, neurodegenerative disease**

I. INTRODUCTION

Parkinson's disease, which is commonly known as PD and second largest neurodegenerative disease which is tailing Alzheimer [1]. It mainly occurs due to increase of alpha-synuclein, which is produced in brain and the part is Basal gland has shown in below Fig1.1. In general, after lots of scientific study and researches done, it is classified into 2 types: they are motor symptoms and non-motor symptoms [2]. In motor symptoms, the name itself defines like tremor, slowness of moment called as bradykinesia, stiffness, and poor balance of body postures as shown in below Fig1.2. Non-motor symptoms like mood disorders, pain, sensors and cognitive dysfunction and dysautonomia are identified in PD affected patients.

Speech disorders [3] which come under motor symptoms are quite common in patients. Disturbances such as very fast and sudden slow voice are occurring generally in most of patients. A qualitative analysis of speech signals for the purpose of classification is treated as a fundamental and noninvasive method. Clinicians and neurobiologists are increasingly attracted to noninvasive PD detection and prediction technologies [4]. Additionally, this helps for pre-identification and in reducing the danger. This gives more effect on body both internally and externally. Research in areas such as multimodeling signal processing and artificial intelligence has been a major focus of this research for speech diagnosis. Some of the results in speech analysis showed a brief peek phonation time, an increase in jitter and shimmer which also have reduced the range of pitch and increase in frequency. These factors have led to the use of machine learning models for detection of PD.

The dominant Machine algorithms (ML) also have two broad categories one is traditional ML methods and Deep

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learning techniques [5].

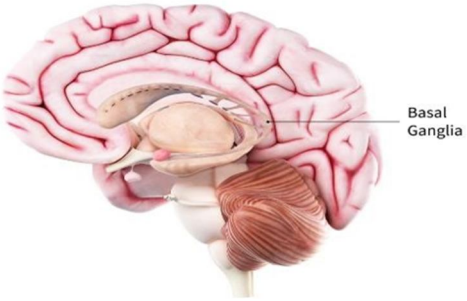

Fig 1.1. Basal gland in brain

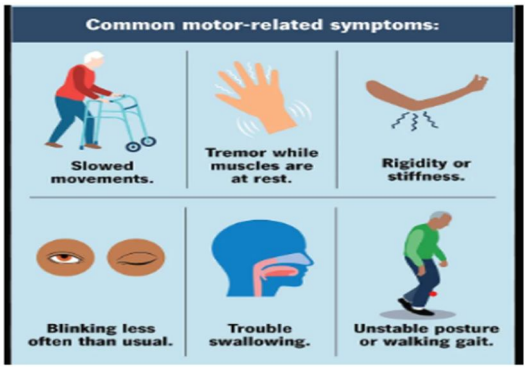

Fig 1.2. PD Motor symptoms

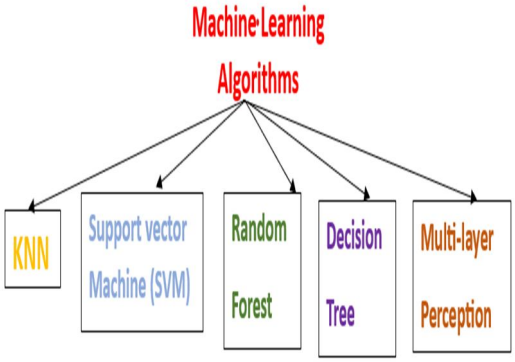

Fig 1.3. Types of ML Algorithms

The search for effective static features for PD speech classification has been carried out in most previous studies. For some studies, constant speech functions were used with no regard for the interdependence between sequences of features [6]. Communication features related to detection of Parkinson's disease, including phonation, prosody, neuralgibility, etc. have a variety of dimensions. Phonation characteristics are mainly related to measure perturbations [7, 8] such as jitter, Amplitude Perturbation Quotient (APQ), shimmer and Pitch Perturbation Quotient (PPQ).

Fig.1.5 shows the contour of basic frequency measured over monophonic and a short sentence, which both subjects pronounced the similar short sentence. Represented separately as (a) HC speaker (b) PD patient, both speakers use mandarin as their native tongue. For the analysis of phonation's [9,10], NeuroSpeech software is used. The below Fig 1.4 shows basic frequency measure over monophony and a short sentence, the contour of the sample1 is more stable compared to the contour derived from PD patients. Articulation features have a principal influence on reduced amplitudes and volume of mouth includes velocity of lips, tongue, or jaw movements

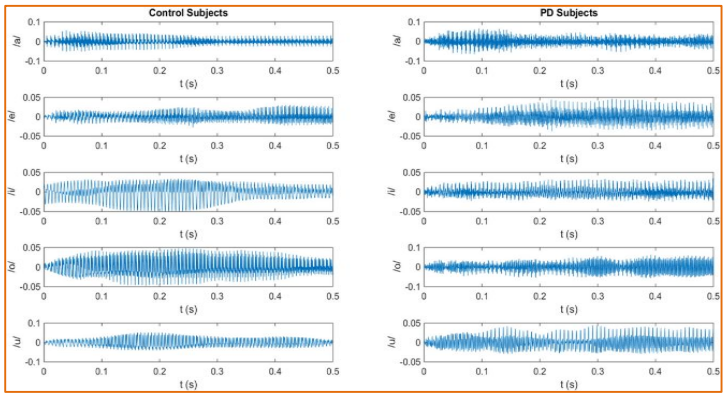

Fig 1.4. Pronunciation of words by normal people and PD affected patients

II. LITERATURE SURVEY

A case study from Hassan II University of Casablanca, Mohammadi, Morocco which is related to PD based on Vocal features. In the case study DT, KNN, SVM algorithms are used for getting accuracy. In order these algorithms depend on each other for getting the accuracy. For the purpose of evaluating the predictability performance of a classifier, precision, sensitivity, AUC and specificity shall be used as evaluation metrics.

In the case study of Irving Luna Ortiz on PD with vocal data set, the improvement of the smallest normalized difference associative memory algorithm by means of a learning reinforcement phase, which improves SNDAM classification when applied to the diagnosis of PD, is mentioned. The complexity of application is increased by this change and a chance of error due to human error.

To distinguish between healthy and sick patients' voice signal characteristics, the Raya Alshammri study applied Multilayer Perceptron, Random Forest, Support Vector Machine, K-Nearest Neighbor, and Decision tree. Dataset obtained from the UC Irvine's Machine Learning Repository. Dataset is obtained from the UC Irvine's ML Repository. Each algorithm given accuracy is quite not similar other there is a percentage of 2-5 of difference which is not neglizable in the field of medicine and disease.

A case study by Anik Pramanik and Amlan Sarker scholars of kulma university of technology and engineering performed the test of vocals on PD data set based on the k-nearest Neighbour, Support Vector Machine, Random Forest, AdaBoost, Logistic Regression and achieved accuracy of 0.8. Which can be a dilemma this is due to the parameters like cross fold validation, Hyper-parameter tuning, and grid search are used to increase the accuracy. Which in the end lead to question on confirming the PD.

A published article by SN Computer science that opted unsupervised feature selection which is challenging methodology for detection PD in this precision of success is low. i-Detect algorithm is used for the detection of informative features, where the feature subspace identified has the following properties: Maximizes the sum of total volume of space covered by the feature subset with respect to the sum of cluster volumes in embedded manifolds.

Article by Antonio suppa an Giovanna Costanini, HR of Neurosciences Dept., Sapienza University of Rome, Italy and IRCCS Neuromed Institute Italy made research on Parkinson's disease based on voice features. Published by Front.Neurol on 15 February 2022. The main drawback of this article is it is very time taking process [11].

R. Arefi Shirvan and E. Tahani belongs to Electrical and Biomedical Engineering from Islamic Azad University in Baedaskan and Mashhad Iran. Published an article on Parkinson's disease based on voice features on 15 march 2012 and published by IEEE in Tehran Iran. DOI Number: 10.1109/ICBME.2011.6168572. The authors considered the data based on genetic algorithm which requires huge study and vast knowledge in genetics. This may lead to a little error in accuracy.

III. PROPOSED WORK

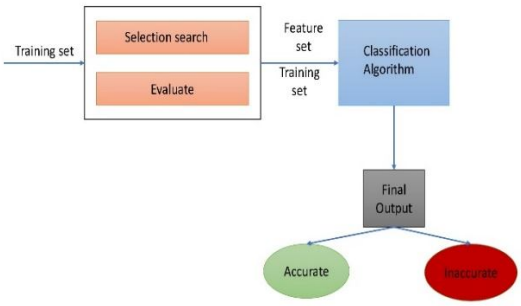

Fig 3.1. Model architecture

The above Fig 3.1 represents the architecture of the proposed model, which uses dynamic speech features to detect PD. For the detection of Parkinson's disease, this following model is used to capture speech signal characteristics. The dynamic time series articulation features of the speech signal, as defined in the data such as jitter, shimmer and frequency modulation are taken into account in this model. We applied this model to capture characteristics of speech signals for detecting PD. This model takes the dynamic time-series Articulation Features (AFs) of the speech signal as of mentioned in data like shimmer, jitter, and frequency modulation. In this training of model there are types of training models such as:1. Score combination, 2.Score conditional training, 3.Embedded

condition training, 4. Score and embedded condition training. Each have its own uniqueness. In this research, embedded conditional training model is considered in which job tasks are carried out in a real time manner. It is more powerful than traditional learning and it encourages the learner to be more engaged in a task-oriented manner. A popular ML algorithm [12] called KNN is used and implementation should be done with python. The major modules like NumPy, pandas, matplotlib, seaborn, plotly, and sklearn are chosen. K-Nearest Neighbour which is famously known as KNN algorithm and it is non-parametric, instance-based machine learning algorithm used for the regression analysis. The name of algorithm itself tells we finding the k-training sets which are given as input sample on majority class among these most are neighbours which are used for classification task. The KNN algorithm does not have any specific formula or any process like other algorithms. Instead, it depends on the distance calculation between two points.

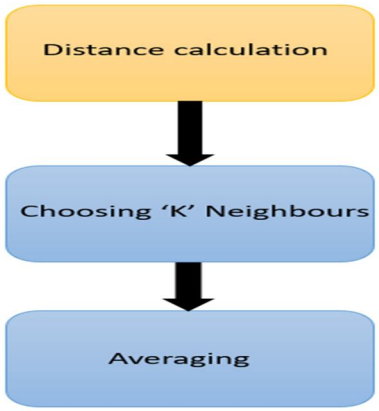

Fig 3.2. Basic work flow of KNN

A. Dataset Description

Here the voice data is collected in minimum and maximum and their average all three ways are considered and the data is collected by accurate sensors and getting precise values. After getting the voice data of patients, the data is stored in a CSV format and given as input to KNN algorithm.

In the dataset, it is considered a count of 147 Pd samples of both male and female patients are collected and maintained as a .csv file. From the dataset, it is observed that, the value of shimmer for a normal person exists in between 16 and 0.05. But for a person with PD, it exists in between 35 and 0.1. It can be slight difference for both men and women as shown in below Fig 3.2.

The above Fig 3.2 describes about PD samples of both male and female which are further classified as noise and no-noise samples. For a PD affected patient, having irregularity in voice production is treated as noisy data. In the KNN algorithm the raw data is given as input parameter, the algorithm calculates the distance between the conditioned value and remaining values. If the distance between points exceeds the mentioned threshold value, then it is considered as irregularity in the data.

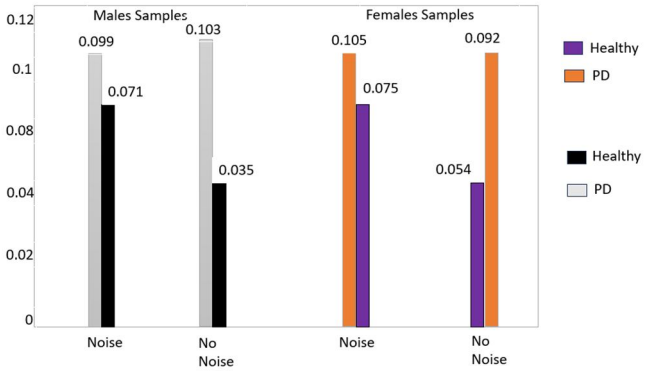

Fig 3.3. comparison of patient data samples

IV. EXPERIMENTAL RESULTS

For calculation of accuracy rate and other parameters like specific rate, the confusion matrix is used in the Algorithm. The major reason for including confusion matrix is to resolve the problem of classification when two or more classes are present. The matrix is used to organize both inputs and outputs in such a way that the output is displayed conspicuously to the analyst. It helps effectively in predictive analysis and in evaluation of data.

	Predicted without variant	Predicted with variant
Actual number without the variant	True Negative	False Positive
Actual number with the variant	False Negative	True Positive
	Total predicted value	Total predicted value

Fig 4..1 calculation of confusion matrix

Accuracy score () is commonly used measure in ML to find the accuracy of a classification-based predictions. It will take the input values as 2 arguments the 1st one is y_pred it will define as rf_classifier. predict(X_test): This line of code predicts the labels for the test data (X_test) using a random forest classifier (rf_classifier). y_pred contains the predicted labels for the test data. This line accuracy = accuracy_score (y_test, y_pred): calculates the accuracy score by comparing the true labels (y_test) with the predicted labels (y_pred). The accuracy_score function calculates accuracy as the proportion of correctly predicted occurrences to the total occurances.
The calculation of the matrix involves in recall rate, specificity rate, accuracy rate misclassification rate.

Confusion matrix:

- ✓ Recall rate = (True_positive value)/ (Actual positive value)
- ✓ Specificity rate = (True_Negative value) / (Actual Negative value)
- ✓ Accuracy rate = (True_positive value + True_Negative value)/(Total number of samples)
- ✓ Misclassification rate = (False_positive value + False_negative value)/ (Total number of samples)

By applying KNN algorithm for voice dataset, it leads an accuracy of approximately 93% in detection of Parkinson's disease as specified below:

```
Accuracy: 0.9230769230769231
Confusion Matrix:
[[5 2]
[1 31]]
```

The below Fig 4.2 explains about comparative distribution of numerical features between healthy and unhealthy individuals using side-by-side histograms. This visualization makes it easier to see how the feature distributions are differing from one another.

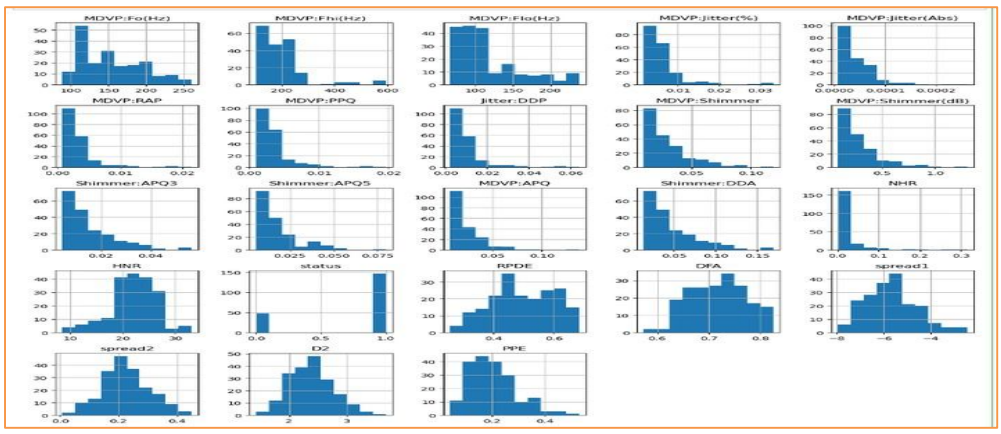

Fig 4.2. Histogram analysis for healthy and unhealthy people based on voice features

V. Conclusion And Future Scope

The use of ML methods in the detection of voice changes in PD patients has been demonstrated to be a promising method for Parkinson's disease early detection. The speech features and structure of ML models have a central role to play in the performance of an ML based method for detecting PD. In this research, a KNN approach is used for Prediction of PD which is implemented in Python. Applying KNN algorithm on dynamic voice features which is a comprehensive dataset, it is to be demonstrated that an accuracy of nearly 92%is achieved that helps researchers to predict the occurrence of Parkinson's disease effectively. The results illustrate the potential of this approach to assist healthcare professionals with diagnostic and intervention at an earlier stage, which would lead to improved patient outcomes. Here the KNN algorithm works independently without any interdependency. In futuristic analysis, the research is made on diagnosis of PD from multiple voice recordings and applies deep learning models on it.

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