Detection of Parkinson’s Disease Using Voice and Spiral Drawings on Machine Learning Approaches

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Abstract: *Parkinson's disease (PD) is a neurologically development disease that beginnings with a mild quivers in limbs and affect firmness of the body. Over 6 million individuals around the globe are affected due to this disease. It’s very hard to identify PD in the early stages as there is no particular analysis for this condition and limited expert specialists at present. This recommended procedure for diagnoses of PD by using spiral drawings and speech taken from the patient using eXtreme-Gradient Boosting (XGBoost) algorithms and Random-Forest algorithm pilot to higher efficiency and higher than 74%. The speech samples of the person are studied to identify this sickness. The data from the patients affected by this disease, and non effected people are considered while training this algorithm. From the dataset 40% of voice data is utilized for testing the model, and 60% of spiral data is utilized for training the model. The speech data is represented in 24 columns, represents the status of the person either diseased or healthy. These factors are considered in identifying the disease where 1’s in status column indicate affected person and 0’s indicate healthy person. Mean, standard deviation, jitter, noise to harmonics and harmonics to noise ratio are some of the parameters taken into consideration for predicting the disease for the speech data.*

Keywords:

Dataset, efficiency, random forest algorithm, XGBoost, Parkinson's disease

1. Introduction

The PD is incurable disorder which initially affects the nervous system of the body gradually developing tremors in limbs which may be inconspicuous in the beginning but this leads to critical situations affecting the movement and reflexes of limbs and also affect rigidity of the person [1].

Development of quivering is common with increasing age but some tremors are inconspicuous in the early stage but may lead to vicious consequences. Tremors developed in the patients affected by PD cause aggregative sickness in the person affecting the nervous system. The quivering, that can lead to PD. It starts at the joints and can be difficult to detect in the beginning phases. The tremors alter the motion of muscles, such as the hands as well as the thumbs, legs and fingers and cause them to become rigid that can cause Parkinson's disease [2].

Person affected by this disease may slowing lose the ability to give facial expressions as a normal person and may not be able to wave their hands while moving. They will speck indistinctly. The condition of the person may become dreadful over a period of time [3]. In spite of that this sickness is incurable but early detection the disease helps in reducing the effect of this sickness. In some cases surgeries are also options to regulate some parts of brain.

A. Symptoms of Parkinson’s Disease

The effect of PD will be different from person to person. The symptoms of this disease are unnoticeable in the beginning. Tremor affects the lower limbs of one side the body and affects the posture of the body and become more vicious over time. The usual symptoms of this disease are reducing the speed of gestures, stubborn muscles, and frail body position and may not be able to do unconscious gestures and may become hard in writing and speaking. The diseased people might not be able to sleep properly, have nightmares and have restless sleep which might disturb brain functions [4].

In the beginning the limbs of the body experience the quivering, that means tremors. The fingers and thumbs of the patients hand may quiver. Despite of body position limbs may quiver continuously. In the end the patient may not be able to walk properly. Decisiveness may take place in muscles. The main cause of PD is nerve cells impaired or die in basal ganglia, a part of brain that control movements of the body. This sickness will also affect the position of the body [5]. This leads to inability of performing the basic movements like smiling; blinking of eyes, moving the limbs etc. so that the patient may not be able talk quickly and it become difficult for a person to show the facial expressions.

B. Necessarily of Early State Detection of Parkinson's Disease:

In many scenarios the detection of disease is being done at a stage where there is huge lose of nerve cells which is very serious and dangerous. Certain body organs are affected as well in crucial stages. The signs and symptoms are described in fig.1 [24]. It is very important to consult a doctor have therapies and get necessary treatment. At that stage it is difficult to treat to stop this sickness from spreading or lead to Neuroprotection [6]. This means it is essential to discover this disease in the early stages. Early detection of this disease so that the treatment so that the disability become minimum. The aim of this research is to find the features of movements in limb of the patient and use machine learning to identify the stage of sickness [7].

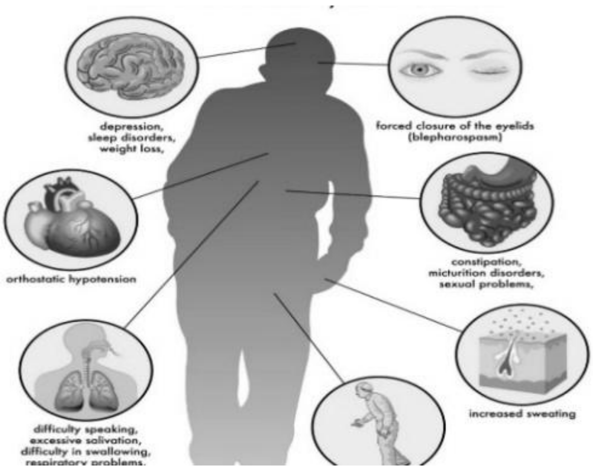

Fig. 1 PD Effected Organs and Symptoms.

C. Complexity in Early Detection

As there is no fixed diagnostic test to identify this illness, the detection of these conditions is only possible through the clinical or observational scenarios [10]. The majority of symptoms that are characteristic of this condition are not easy to detect and may be seen in various other illnesses as well. To determine the harshness of the illness, a doctor is likely to use Unified PD Rating Scale as a way for evaluating the neurologic evaluation. Pre motor stages of the disease can be present for a long time to detect ahead of the more typical clinical motor symptoms. [7]. The most frequent features of the sickness is tremors, which is seen in 41% of the people suffering with disease. The affect of tremor may lead to serious situation at time of identification.

2. Literature Survey

An In [14], Laiba Zahid et al proposed Both Machine learning and artificial intelligence algorithm is used. The author exploited both support vector machine and random forest. The large amount raised 99.7% precision on vowel \ o \ and text is seen using a multi-layer perception. While 99.1% precision saw on vowel\i\ significant components using random forest. The significant part based system performs better when appeared differently in relation to direct acoustic components and be in motion learning moves close. The technique beats the ongoing strategies on the dataset for Parkinson's contamination area.

Liaqat Ali et al [18] said that it manages two critical problems, primary issue biased by unprovoked enlightening assortment for that they used unpredictable under sampling strategy utilizing AI. Additionally, the 2nd matter is low speed of game plan correctness; to further foster it uses streamed learning system method. Moreover, it seen that the proposed streamed structure chips away at the potency of customary Adaboost models by 3.4% and diminishes its complexity. Additionally, the streamed structure achieved precision of 76.4%, awareness of 71% and explicitness of 82%. Limitations are not more precised from various estimations.

In [20], Amato et al separate isolated 60 components from pre-taken care of vocal signals and make them to involve them as commitment to a couple of man-made intelligence models. The systems considered data sets Backing Vector Machine, Unsuspecting Bayes, K-Nearest Neighbor, AdaBoost, Gradient Boosting and Bagging algorithms. And 89% precision in 10-wrinkle cross-endorsement using SVM. Limitations are only the SVM computation works between all the different estimation used in the endeavor. The results demonstrate that the seven elements chosen to be used in SVM is incredibly precise of 83.33 percentage, excellent rates of Parkinson's disease's location at 75% and even the lowest bogus positive effect of 16.67 percentage. It is possible to develop a method that can detect Parkinson's disease using the voices. The voice's redirections are a way to confirm the outcomes from Parkinson's illness. The study proved 73.8 percentage of quality. Our model shows that an enormous amount of data comes from the average people in addition to the more recent the person who is affected by Parkinson's illness. It is possible to model hearing Parkinson's disease using voices. Redirections of the voice can be a sign of the signs of Parkinson's disease. The errand demonstrated 73.8 percent effectiveness. According to our model, the majority of information comes from an ordinary human being, and furthermore from the recently affected people with Parkinson's illness.

In [25], N. P. Narendra et al proposed two approaches to recognize the disease first approach is standard pipeline approach in that they used three methods, they are system structure, baseline features and gif strategies and glottal features. Second approach is beginning to end approach called Pipeline approach. From the ordinary pipeline structures, the most raised grouping accuracy of 68% was given by blend of benchmark what's more, glottal components. From the very outset to complete systems, the raised accuracy of 68.6% was specified by the structure arranged using the QCP-based glottal stream signals. Regardless of the way that gathering exactnesses were honest for all systems, the audit is engaging as the mining of voice source information was seen as most convincing in the two strategies.

In [26], K. Polat proposed the cross variety approach to investigate Parkinson's contamination using talk signals. It combines resounding and time-repeat parts for strong component extraction. Ability of convolutional Mind Associations for voice signal assessment is researched. The author used two strategies they are SMOTE(Synthetic Minority Over-testing Strategy) and sporadic forest area. SMOTE move toward, the amount of tests for minority class in the PD dataset has been falsely extended to change the dataset. Precision of simply irregular backwoods is 87.037%.combination of both Destroyed and irregular timberland precision is 94.89%. The sporadic forest area technique achieved a higher responsiveness than the decision tree model. Subsequently, it is fitting to cultivate a show to helpfully recognize starting stage PDD considering the PD-MCI gauge model made in this survey, to spread out individualized seeing to follow high-risk social occasions.

PD is only recognized when it is in a lower stage of the present system. Therefore, it difficult to prevent the disease and even fatal. Parkinson illness, that is able to be easily identified with 3-seven-t MRI is able to be identified and controlled with the aid of an imaging of the nigral region. With this method, doctors are required to physically assess the patient's signs and symptoms using MRI scans, were describes the neural structures of patients in order to determine the severity of the illness [14] as illustrated in fig.2. Every patient has their own list of illness signs. An overwhelming proportion of wrong diagnosis can occur when the patient is not able to speak up about their condition. Doctors have to wait longer to review the MRI report also, patients invest more in MRI scans to determine if they are affected or not. At present, there are no certain tests to detect this condition. Based on brain conditions and levels of dopamine, experts with a great understanding of cerebrum disorders can identify the disease. MRIs as well as SPECT scans is usually utilized to diagnose the illness by medical professionals [12]. They're also called imaging tests. To create 3D pictures of the brain which allows doctors to decide the condition of the brain, using use of the power of nuclear radio [15]. MRI employs the radio frequency bands, along with magnetic flux to give the image of organs.

Since X-rays are the 3D pictures, they have a great deal of information that is trying to see every which way. The capacity to recognize sicknesses isn't ensured by the ongoing strategy. Inability to convey patient's side effects can leads in a misdiagnosis. Because of this inaccurate check, specialists could suggest some unacceptable prescriptions. To distinguish the situation, these approaches require particular doctors. For this, specific clinical hardware is additionally required [16].

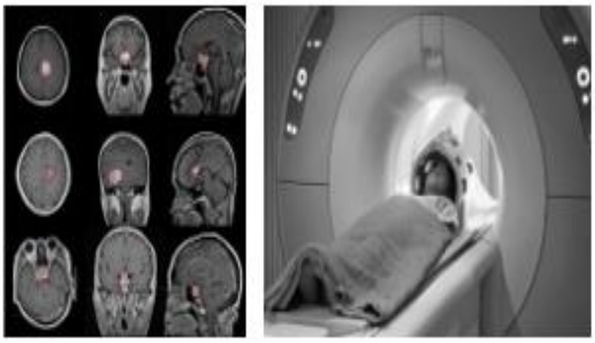

Fig. 2 Brain MRI Image of PD Patient.

3. Proposed Voice and Spiral Drawings on Machine Learning

The speech-datasets and spiral-data are used as inputs for the proposed system enable it to overcome the shortcomings of the earlier models with high accuracy. The speech data is subjected to linear regression and XGBoost in order to quantify the deflection in voice [13]. The Random Forest technique has applied to the spiral handwritten dataset [11]. Slurred speech can also be caused by the other medical problems. The spiral data was used to address the problems with the speech model. Some people aren't able to sketch the spiral shape correctly due to some reasons, including an inability in holding a pen correctly or fear. This speech model fixes problems of the spiral model. As a result, the method is very accurate.

The spiral as well as the voice information was gathered at a high rate from healthy and PD patients as data sets. These datasets were utilized for the development and testing of the model. With the training data set, the system is improved [8], [9]. The test dataset is utilized to determine if the system can produce the results required or not using the suggested model. The spiral and voice models will not deliver exact results when used in conjunction. Therefore, each model has a advantages and disadvantages on each model. One model's limitations can be surpassed by a new model. To identify what is causing the problem this system utilizes the outcomes of the spiral and voice models [19]. The process, that explains the way machine learning algorithms function and the various algorithms for classification are employed to detect diseases is illustrated in fig. 3. To minimize data that may lead to incorrect results, necessary preprocessing needs to be completed prior to applying the algorithms to data. Regression is an element of process of data preparation.

A. Voice-Data Analysis

"XGBoost" stands for "eXtreme Gradient Boosting". The XGBoost algorithm is currently the most widely used ML algorithm. If XGBoost is contrasted against various other algorithms that are different from the model that is in use, it is consistently able to deliver excellent accuracy.

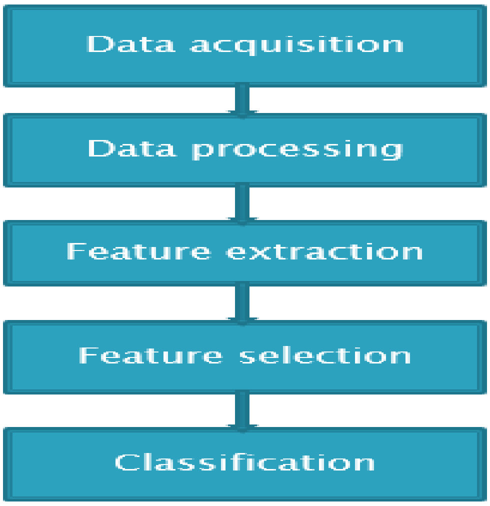

Fig. 3 Methodology of Disease Identification.

Algorithm has an efficiency of 96.7 percent, which is quite inspiring. Based on the findings from the tree the algorithm is able to operate in a way that is. The boosting technique known as XGBoost creates decision trees that are on weights depicted in fig.4 provides the procedure used in the XGBoost classification algorithm.

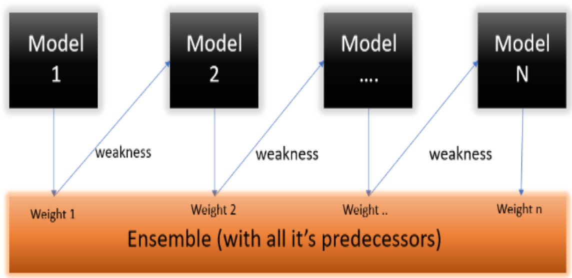

Fig. 4 XGBoost Algorithm.

Because voice deflection is the symptom of Parkinson's disease that has been seen in the most patients, it has been used as a measure to identify the disease [20]. The XGBClassifier () is the machine learning XGBoost classifier used for the predictions from the xgboost package in python by using the command called pip install xgboost. Numpy is used for the linear algebra and the pandas is used for the data processing in the machine learning. For the preprocessing use the MinMaxScalar (). The parameters like accuracy, specificity, sensitivity are all imported from the Sklearn metrics . To determine the illness based on the formulas, various ML algorithms were used to detect the voice's deflection. The data set for these voices were collected from kaggle website [8]. Each column includes a description of a different speech capacity that helps in the diagnosis of PD. A total of 23 different voice characteristics are measured in the collection, which also explains the various characteristics of PD patients.

$$\hat{y}_i = \sum_{k=1}^{k} f_k(x_i), f_k \in F \quad (1)$$

$$\text{obj}(\theta) = \sum_i^n l(y_i, \hat{y}_i) + \sum_{k=1}^{k} \Omega(f_k) \quad (2)$$

Where, F: set of possible CARTs, K: number of trees, f: functional space of F, $\sum_i^n l(y_i, \hat{y}_i)$: failure function, $obj(\theta)$: object function

B. Handwritten Drawings Analysis

One of the most frequently employed ML algorithms can be described as Random Forest (RF). It's used for the classification as well as the regression problem. It is utilized to analyze drawings that are handwritten. This algorithm is based on the notion that the data are divided into subsets according to characteristics [22]. The data for handwritten spiral drawings are retrieved on the Kaggle website [9]. Decision trees are built for each of the features. Random forest's output is determined by the majority vote of the all decision trees. In order to increase the precision in predicting, various sections of the data are utilized, before the mean is determined. This algorithm has a precision of 86.67 percent which is quite a bit in comparison to other utilized algorithmic methods. The methodology described above for this algorithm can be depicted in fig. 5. It blends the yield of several decision trees rather than focusing only on the output from one decision tree. This ensures that it will be more accurate in diagnosis of PD disease [23], [24]. The formula to determine the feature's significance is provided in equations (3) as well as (4).

$$fi_i = \frac{\sum j; nodejsplitsonfeaturei^{ni} j}{\sum k \in allnodes^{ni} k} \quad (3)$$

$$Gini\ Index = 1 - \sum_{i=1}^{n}(p_i)^2 \quad (4)$$

Where fi sub(i) = importance of feature I, ni sub(j) = importance of node

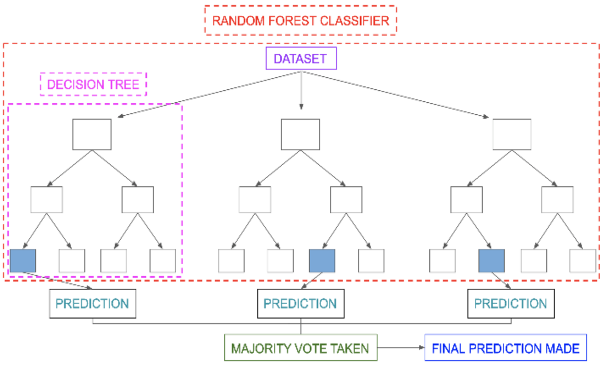

Fig. 5 Random forest algorithm.

The Random Forest Classifier () is the machine learning classifier used for the predictions from the sklearn package in python by using the command called from sklearn.ensemble import Random Forest Classifier. For the preprocessing Label Encoder is used imported from the sklearn package. HOG stands for 'Histogram of Oriented Gradients' used to quantify the image. A structural descriptor called HOG can measure and capture local gradient variations in an image's input. Naturally, HOG will be able to measure the rate at which the directions of spirals and waves change. We will also be able to determine whether these drawings has a more of "shake" to them, as it might anticipate from a Parkinson's patient. The classifier will then be trained using the resultant feature vector.

4. Results and Discussion

A. Results for XGBoost Algorithm

In line with previous study [20], the accuracy is measured using the different machine leaning algorithms with the speech data as input. The comparison among the previously used algorithms and the present algorithm is depicted in Table I. The accuracy of proposed algorithm is shown in the below fig.6.

Model Prediction

```
y_prediction = model.predict(x_test)
print("Accuracy Score is", accuracy_score(y_test, y_prediction) * 100)
print("Sensitivity is",recall_score(y_test,y_prediction)*100)
print("Specificity is",recall_score(y_test,y_prediction,pos_label=0)*100)
cm=confusion_matrix(y_test,y_prediction)
print(classification_report(y_test,y_prediction))
```

```
Accuracy Score is 93.33333333333333
Sensitivity is 95.65217391304348
Specificity is 85.71428571428571
              precision    recall  f1-score   support

           0       0.86      0.86      0.86         7
           1       0.96      0.96      0.96        23

    accuracy                           0.93        30
   macro avg       0.91      0.91      0.91        30
weighted avg       0.93      0.93      0.93        30
```

Fig. 6 Predictions using XGBoost algorithm on speech data.

For ML processes, a classification model's or algorithm's performance is represented using the confusion matrix, this can be either chart or a table. Confusion matrix is the useful tool for formative which tasks a ML system executes correctly and incorrectly . It Includes both the system's predicted and true values when constructing a confusion matrix. Each predicted values has a related row, and each true values has a related column. The confusion matrix for the voice data analysis using the xgboost algorithm is shown in the below fig.7. The individual's face is prepared casing by outline, with the help of Machine Learning concepts. If that individual is wearing the mask and assuming the temperature is distinguished beneath 37C by the temperature sensor, a message will be shown on the screen of the HDMI display as MASK in green colour for wearing the mask, and for the temperature, the Celsius is shown in green colour. In the following stage, the servo motor rotates its hinge 90 degrees, as it addresses the entryway. In the event that any of the above conditions are not met, the buzzer will start to ring, and the servo motor won't rotate the hinge.

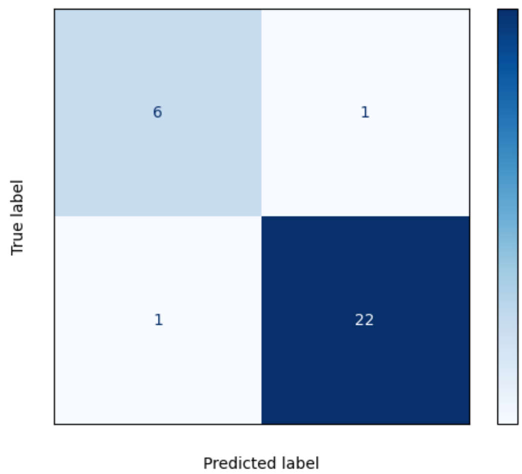

Fig. 7 Confusion Matrix for Speech Data.

Table 1 Comparison of ML Gradient Boosting algorithms.

Model	Accuracy (%)	Precision (%)	Recall (%)	Specificity (%)	F-Score (%)
NB	83	89	82	85	84
KNN	84	87	85	82	85
SVM	86	90	87	86	87
ADA	84	88	85	83	85
GB	76	82	77	75	77
BAG	84	88	85	83	85
RF	83	87	84	82	84
Proposed (XGB)	**93.3**	**91.5**	**91.5**	**85.7**	**91.5**

B. Results for Random Forest Algorithm

In [18], the comparison of the different ML algorithms with the present algorithm to detect the PD based on the handwritten drawings is shown in the below Table-II. Table II contains the different parameters which are used to check the present used machine learning algorithm is better or not. The below fig.8 shows the accuracy and other different parameters result of the Spiral drawings. According to the comparisons made above, the proposed model is having the better accuracy which is 86.67% which is considerable. The below fig.9 is the result of the predictions made by the model. It describes the person is diseased or healthy.

Spiral Drawings

```
print("Random Forest \n")
for metric in ("accuracy", "sensitivity", "specificity","precision","recall","F-measure"):
    print(f"{metric.capitalize()}: ")
    print("Random Forest={:.2f}%".format(
        spiralModels['Rf'][metric]*100))
```

```
Random Forest

Accuracy:
Random Forest=86.67%
Sensitivity:
Random Forest=80.00%
Specificity:
Random Forest=93.33%
Precision:
Random Forest=92.31%
Recall:
Random Forest=80.00%
F-measure:
Random Forest=85.71%
```

Fig. 8 Predictions using random forest algorithm on spiral drawings.

Table 2 Comparison of ML Gradient Boosting Algorithms.

Model	Accuracy (%)	Precision (%)	Recall (%)	Specificity (%)
GNB	65.46	81.94	63.8	48.49
DT	62.03	65.27	70.3	58.78
LDA	68.33	81.94	68.7	54.72
KNN	64.63	70.83	70.6	58.44
SVM(Lin)	51.40	41.66	69.7	61.44
SVM(RBF)	64.54	51.38	81.9	77.70
Proposed (RF)	**86.67**	**93.33**	**85.71**	**80.00**

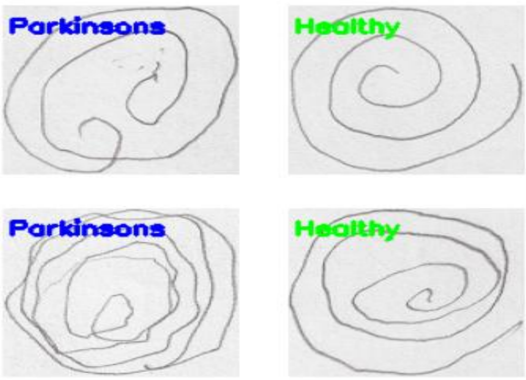

Fig. 9 Model Prediction.

5. Conclusion

According to the above-detailed examination of PD, it is clear that a lot of effort is required for diagnosing this disease. With the use of ML technology, the detection process is made easier and more affordable for humans, allowing patients to receive medical treatment and support as quickly as feasible. Hence, more research into the mechanism for disease detection is required. In the proposed work, the XGBoost algorithm is used to screen for PD using speech data sets, and the Random Forest approach will be used to analyze handwritten drawings. PD can be accurately detected by the analysis of speech and drawing data. The voice data sets and writing drawings are compared with the data sets used in training and testing the model to give accurate information. The accuracy score while studying voice data set is 96.67% and 86.67% for handwritten drawings. Sensitivity is 80% and specificity is 93.33% for handwritten drawings. We created a model which studies the data sets of a person and identify the disease affected people.

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