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DETECTION OF PARKINSON'S DISEASE

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Abstract

Parkinson's disease is a progressive neurodegenerative chronic disorder of the central nervous system that affects movements and induces tremors and stiffness. It has a total of 5 stages and affects more than 1 million individuals in our country every year. Detecting Parkinson's disease at an early stage is essential for slowing down its progress and providing patients the possibility of accessing disease-modifying therapy.

In recent years, speech signal processing has benefited from a lot of attention, because of its widespread application. In this study, we have led a comparative analysis for efficient detection of Parkinson's disease applied to machine learning classifiers from a voice disorder known as dysphonia. To prove robust detection process in our paper, we are trying to use different classifiers such as XGBoost Classifier, Naïve Bayes Classifier, SVM and KNN to detect the disease and thereby analyze which classifier gives the most accurate result.

Keywords*:* Parkinson's disease, XGBoost Classifier, Naïve -Bayes Classifier, SVM and KNN.

1. Introduction

1.1 About Project

Parkinson's disease (PD) is a progressive, neurodegenerative disease that belongs to the group of conditions called motor system disorders. Neurodegenerative disease has human, social and financial impacts, on a personal, professional and social level. It is a progressive pathology that affects the brain and the nervous system, leading to the death of nerve cells. The most known and frequent ones other than Parkinson's disease Alzheimer's. Parkinson's disease is particularly linked to the loss of dopamine-producing neurons in the basic ganglia.

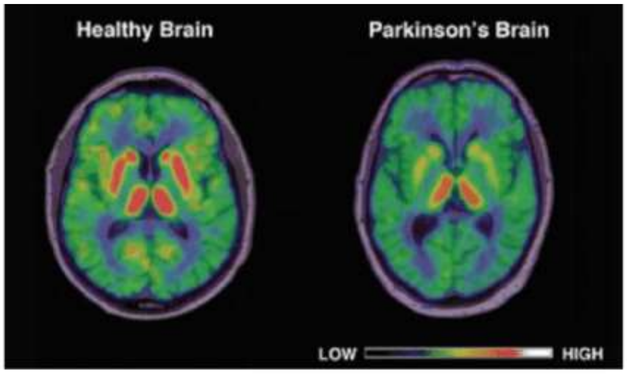

Fig 1. Parkinson's disease symptoms in a human brain

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Parkinson's disease symptoms can be different for everyone. Early signs are mild and go unnoticed. Symptoms usually begin on one side of your body and get worse on that side, afterwards it affects both the sides. Parkinson's symptoms may include

- Tremor
- Slowed movement
- Rigid muscles.
- Impaired posture and balance
- Loss of automatic movements
- Speech changes
- Writing change

The nature of Parkinson's Disease is progressive, meaning that it gets worse over time. There are typical patterns of progression in Parkinson's disease that are defined in stages:

Stage One
Individuals experience mild symptoms that generally do not interfere with daily activities. Tremor and other movement symptoms occur on one side of the body only. They may also experience changes in posture, walking and facial expressions.

Stage Two
Symptoms worsen, including tremor, rigidity and other movement symptoms on both sides of the body. The person is still able to live alone, but daily tasks are more difficult and lengthier.

Stage Three
This is considered mid-stage. Individuals experience loss of balance and slowness of movements. While still fully independent, these symptoms significantly impair activities such as dressing and eating. Falls are also more common by stage three.

Stage Four
Symptoms are severe and limiting. Individuals may stand without help, but movement likely requires a walker. People in stage four require help with daily activities and are unable to live alone.

Stage Five
Stiffness in the legs may make it impossible to stand or walk. The person requires a wheelchair or is bedridden. Around-the-clock nursing care is needed for all activities. The person may experience hallucinations and delusions.

At the moment, no cure has been found. Medication is limited to treatments, at an early stage, to improve the patient's quality of life. Several methods have been used to detect the symptoms of Parkinson's disease, but most of them require motor actions that appear only in an advanced state of the disease. The machine learning techniques are used as an effective way for early detection and diagnosis of the disease.

They can be used to construct predictive or classification models that can learn from past experience and apply in future cases. so there is a need for a more accurate, objective means of early detection, ideally one which can be used by individuals in their home setting.

In this project we have used different classifiers such as KNN, SVM, Naïve-Bayes and XGBoost for the detection of Parkinson's disease and thereby evaluate the performance of these classifiers considering the measures such as precision, sensitivity, specificity and accuracy.

1.2 Objectives

The main objective is to distinguish PD patients from healthy individuals.
• Compare the performance of different classifiers
• Accurate and early detection of PD to slow down the progression of PD

1.3 Scope of the paper

The proposed system will meet the needs of the user by providing following features:
• Detects Parkinson's disease (PD) in the early stage using different classifiers.
• Examines the performance of different classifiers using the measures of specificity, sensitivity, precision and accuracy.

1.4 Advantages

• Helpful in early detection of the disease and to distinguish PD patients from healthy individuals.
• Helps in finding out the classifier which produces most accurate results.
• These models can be effectively used to monitor and diagnose the PD remotely which reduces the need for physical visits of the patients to the clinics

1.5 Disadvantages

• Symptoms vary from person to person and a number of other illnesses have similar symptoms, which means misdiagnoses can occur.
• More time and resources are needed to develop the models.

1.6 Applications

• Used to monitor and diagnose the PD remotely.
• Used to detect neurodegenerative disorders.
• Used for clinical diagnosis for patients above 50 years.
• Improvements to these models can be made such that we can use different types of attributes for the classification of purpose.

2. Literature Survey

2.1 Existing System

In the existing system, PD is detected at the secondary stage only (Dopamine deficiency) which leads to medical challenges. Also, the doctor has to manually examine and suggest medical diagnosis as symptoms might vary from person to person, hence suggesting medication is also a challenge. Thus mental disorders are poorly characterized and have many health complications. There are different techniques that have been developed to detect the disease. Some of which are kmeans, decision trees, random forest, neural networks etc. • A comparison of various classification techniques is done to show the potential of each classifier. The various classification techniques include Support Vector Machine (Linear, Radial Basis Function, Polynomial), Random Forest, Logistic Regression, KNN, Naïve Bayes, and XGBoost. Three different types of feature selection techniques are also explored to reduce the dimensionality of the dataset without affecting the accuracy much. The three different feature selection techniques include mRMR, GA, and PCA. It is observed that the performance of the classifier depends on the type of data under study. If we want to achieve good accuracy with low computation time, then traditional machine learning classifiers like SVM (RBF), KNN, and RF are better choices. It can also be observed that feature selection is an important process if we need to consider both accuracy and computational cost as it reduces the dimensionality of the data. [6] • The Random Forest Classifier was used to classify Parkinson's patients. The primary goal of this system was to improve the model's accuracy while also lowering the computational cost of the classification task. The findings in this paper are promising because they may introduce new methods for assessing patients' health and other neurological diseases using our data. The empirical results show that using feature selection methods for obtaining optimal features is very

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beneficial, particularly when attempting to deal with speech signals containing numerous phonetic features. When compared to other machine learning algorithms for classifying the dependent variable, the result analysis shows that Recursive Feature 7 Elimination with Random Forest classifier produces an accuracy of about 96%. [9] • An automated model for detecting Parkinson's disease in a person with greater accuracy is proposed in this paper. While several models for detecting Parkinson's disease have been established, they are all less reliable and precise. Our model is created using the gradient boosted decision tree, which not only reliably predicts Parkinson's disease in a human, but also predicts it quickly. The feature set contains 22 parameters of the voice signal, which are given to the XGBoost classifier. The developed model predicts Parkinson's disease with 96.6% of accuracy, 95.6% of sensitivity, 100% of specificity, 100% of Precision, and F-Score 97.7%. [7] • The diagnosis method consists of feature selection and classification processes. Classification and Regression Trees, Artificial Neural Networks, and Support Vector Machines were used for classification tasks in the experiments. The primary objective in doing so was to improve the performance and the accuracy of the model and also to reduce the computational cost of the classification task. Accuracies of the classification methods were evaluated with and without Feature Selection and the remarkable effect of Feature Selection was shown. The results indicate that using Feature Selection methods together with classification methods is quite advantageous especially when dealing with speech signals in which hundreds of phonetic features can be obtained. Support Vector Machines with Recursive Feature Elimination were shown to perform better than the other methods. 93.84% accuracy was achieved with the least number of voice features for Parkinson's diagnosis. [10] • It explores the effectiveness of using supervised classification algorithms, such as deep neural networks, to accurately diagnose individuals with the disease. The analysis provides a comparison of the effectiveness of various machine learning classifiers in disease diagnosis with noisy and high-dimensional data. After thorough feature selection, clinical level accuracy is 8 possible. These results are promising because they may introduce novel means to assess patient health and neurological diseases using voice data. Due to the high accuracy performed by the models with these short audio clips, there is reason to believe denser feature sets with spoken word, video, or other modalities would aid in disease prediction and clinical validation of diagnosis in the future. [8] • The machine learning classification algorithms are used to predict if a person has Parkinson's disease or not, comparing different machine learning algorithms such as logistic regression, decision tree, k-nearest neighbor as well as some Ensemble learning techniques where we attempt to improve the accuracy by combining several models. The machine learning model can be implemented to significantly improve the diagnosis method of Parkinson's disease. Involves the application of six classification algorithms on an acquired data set. Algorithms such as Logistic Regression, Support vector machine(SVM), Decision tree, K-Nearest Neighbour (KNN), and XGboost(Extreme gradient boosting) are used to predict the outcome if the person is healthy or affected based on voice input parameters. It indicates that the ensemble techniques XGboost classification (Extreme gradient boosting) algorithm achieved a high test accuracy rate (95%) compared to another classification algorithm. The performance of the methods has been assessed with a reliable dataset from the UCI Machine learning repository. [4] • The main purpose of this paper is to contemplate the survey work of the machine learning techniques and deep learning procedures used for Parkinson's disease classification. Deep learning and machine learning techniques have been used as a part of the discovery for the efficient classification of PD. The various classification models like support vector machines, naive Bayes, deep neural networks, decision trees, and random forests are effectively employed for classification purposes. The analysis of results of different research works showed that both machine learning and deep learning algorithms have shown a promising future and therefore paving a better way for the detection of Parkinson's disease at its earlier stages. It was found that the 9 random forest outperforms the other classifiers in machine learning algorithms which achieved an accuracy of above 99%. Among the deep learning techniques, the neural network classifier also produced a reasonable accuracy of 99.49%. [5] • The proposed predictive analytics framework is a combination of K-means clustering and a Decision Tree which is used to gain insights from patients. By using machine learning techniques, the problem can be solved with a minimal error rate. Voice data sets obtained from the UCI Machine learning repository if given as the input for voice data analysis. It provides accurate results by integrating spiral drawing inputs of normal and Parkinson's affected patients. From these drawings, a Random Forest classification algorithm is used which converts these drawings into pixels for classification and the extracted values are matched with the trained database to extract various features, and results are produced with maximum accuracy. Analyzing spiral drawing using the image processing technique, the predicted output based on Random Forest Classification and confusion matrix is with an accuracy of 83%. [1] • This paper explores the effectiveness of using extreme gradient boosting algorithms, such as XG boost algorithm, to accurately diagnose individuals with the disease. More recently, Learning Machines (MLs) have helped solve computer vision problems, process natural languages, recognize Parkinson's speech using machine learning tools and provide a better understanding of the PD database in the current decade. Parkinson's Voice database is available at UCI machine storage in the center of learning equipment and intelligent programs. The major outcome of this paper is to bring out the result with at most accuracy using the XGBoost Algorithm. The database contains similar links that show high variability in the Parkinson's disease database. We compared our results with various machine learning algorithms such as the Logistic Regression model, Support vector machine model, and Decision Tree Classifier model. MRMR feature selection includes features in terms of layouts and other features and class label compliance. RFE also removes features and builds a model with the remaining features, and tests the 10 performance of the model. Among all the classifiers, it was found that the XGBoost outperforms the other classifiers in machine learning algorithms. An accuracy of 92.76% was reported by using the RFE feature selection technique while the accuracy of 95.39% was reported when using the MRMR feature selection technique on all feature subsets. [3] • In our model, a huge amount of data is collected from the normal person and also previously affected persons by Parkinson’s disease. This data is trained using machine learning algorithms. Of the whole data, 60% is used for training and 40% is used for testing. The data of any person can be entered in db to check whether the person is affected by Parkinson’s disease or not. There are 24 columns in the data set each column will indicate the symptom values of a patient except the status column. The status column has 0s and 1s. These values will decide the person affected with Parkinson’s disease. 1s indicate the person is affected, and 0s indicate normal conditions. The analysis shows a very accurate performance in detecting Parkinson's disease using XGBoost algorithm.

3. Related Work

We are going to compare the performance of different machine learning models which are K-Nearest Neighbour, Support Vector Machine, XGBoost and Naïve-Bayes so as to examine which classifier gives us the most accurate results. For the input, we have considered a Parkinson's Disease dataset where each feature in the dataset is a particular voice measure.

Fig 2.

Voice Dataset Analysis
KNN Naive-Bayes SVM XGBoost

Output Prediction

4. Methods

4.1 Proposed System

This work evaluates the performance of a XGBoost Classifier, Naïve Bayes Classifier, SVM and KNN in the diagnosis of Parkinson’s disease using the Parkinson’s dataset. The dataset has been previously used in testing classification methods in which a relevant classifier identifies healthy and Parkinson’s persons. The main activities that we conduct in this work are data preparation, methods setting, classification, and evaluation.

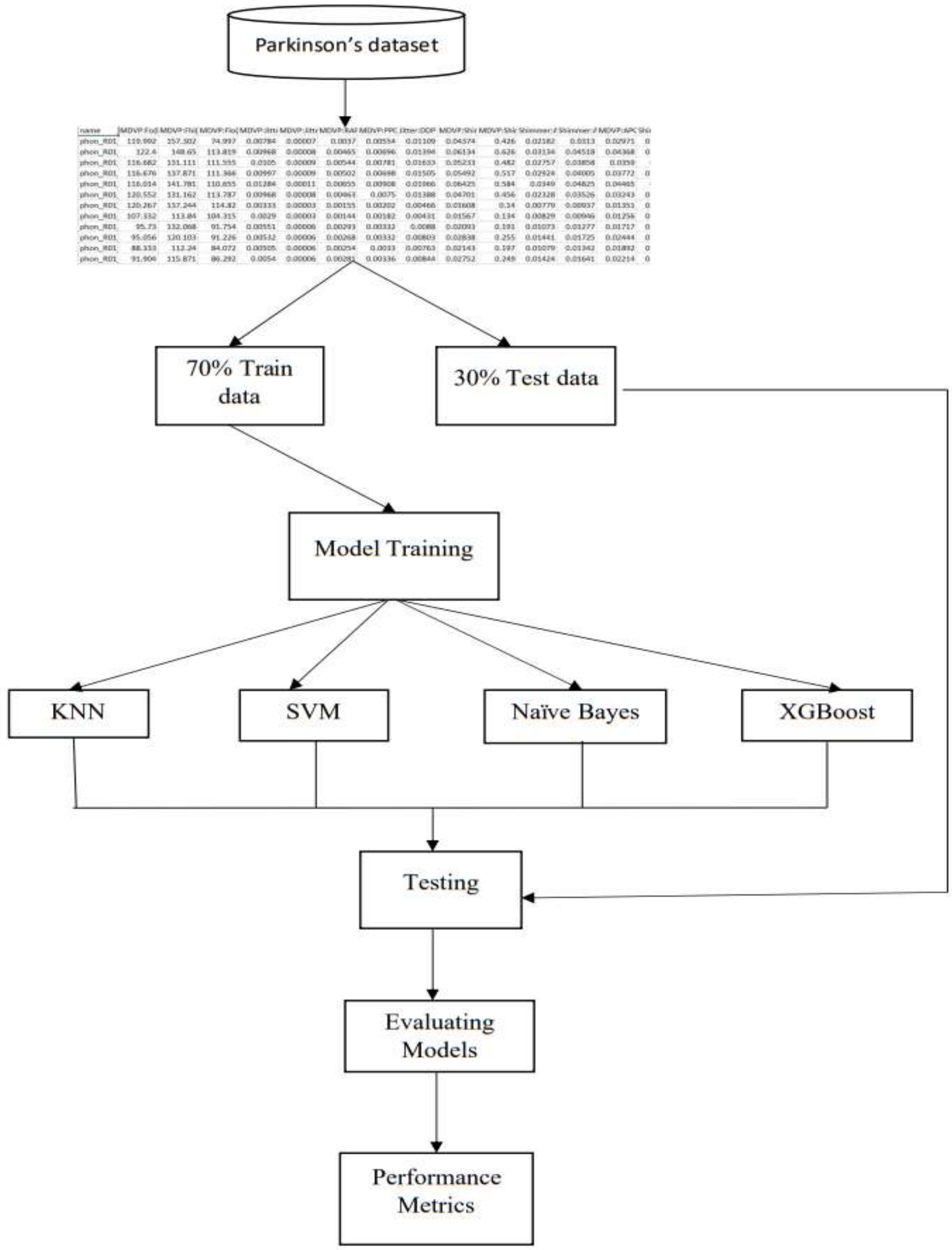

Fig 3. Architecture of the proposed system

4.2 Parkinson's Dataset

Considering the given dataset, we have taken 70% of the data as the training data and the remaining 30% as the testing data. The dataset contains a total of 195 samples, so the testing data consists of 0.33% i.e.,65 samples and the remaining training data which consists of 130 samples . With this data, we have used them in classifiers namely KNN, Naïve-Bayes, SVM and XGBoost to obtain the classifier which gives the most accurate result.

Attribute	Description
MDVP : Fo (Hz)	Average vocal fundamental frequency
MDVP : Fhi (Hz)	Maximum vocal fundamental frequency
MDVP :Flo(Hz)	Minimum vocal fundamental frequency
MDVP: Jitter (%) MDVP:Jitter(Abs) MDVP: RAP MDVP: PPQ	Several measures of variation in fundamental frequency
RPDE D2	Two nonlinear dynamical complexity measures
DFA	Signal fractal scaling exponent
spread1 spread2 PPE	Three nonlinear measures of fundamental frequency variation
NHR HNR	Two measures of ratio of noise to tonal components in the voice
Status	Healthy, Sick

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Fig 4. Feature & Description of dataset

4.3 Classification Methods

A. K-Nearest Neighbor (KNN)

KNN is a supervised ML algorithm that is used for classification as well as regression problems. It is instance-based learning which describes the problem-solving process that is based on solutions for already known similar problems. Instance-based learning methods are a part of lazy learners, which means that there is no computation done on the data until a query is given to the system. The classification of data is done based on different distance metrics. The value of k is considered as the hyper-parameter that varies from problem to problem. The distance metrics used are Manhattan distance, Euclidean distance, and Minkowski distance. However, the distance function is used for continuous variables and hamming distance is used for categorical variables. A new data point is classified by doing the voting of the neighbors, which means that the data point is assigned to the class which has the largest common points among the k nearest neighbors that are measured by some distance function. The Eqs. (1), (2) and (3) define the commonly used distance functions in k-NN.

Minkowski Distance

$$\left(\sum_{i=1}^{n} |x_i - y_i|^p\right)^{1/p} \tag{1}$$

Manhattan Distance

$$d= \sum_{i=1}^{n} |x_i - y_i| \tag{2}$$

Euclidean Distance

$$d(x, y) = \sqrt{\sum_{i=1}^{n}(x_i - y_i)^2} \tag{3}$$

B. SUPPORT VECTOR MACHINES (SVM)

Support Vector Machines belong to the supervised learning algorithms, which require the labeled data for the classification of unseen data. It works on the concept of hyperplanes or decision planes that define the decision boundaries. Hyperplane separates the set of data objects that belong to different classes. The working of SVM is to classify the data by creating a function which split the data points into their corresponding labels with

• the number of errors as least as possible.
• the largest (maximum) possible margin.

It is a powerful learning model which applies to both classification and regression problems and it handles the continuous as well as categorical attributes. In this classification, the function maps the training set into a higher dimensional space. A linear separating hyperplane is found by using a maximum margin. It identifies the best hyperplane that divides the dataset into different classes. The figure below shows an example of SVM, in which a group of instances are separated by the optimal hyperplane and the maximum margin which is on either side of the hyperplane.

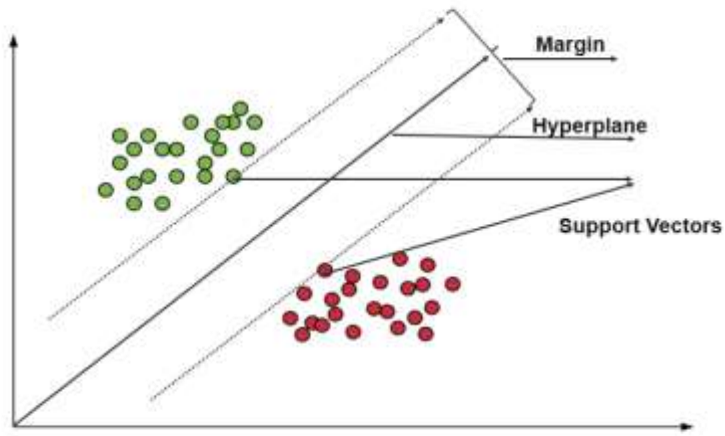

Fig 5. An example of SVM

C. Naïve-Bayes

The Naïve Bayes classifier is used in supervised learning method and it is based on the "probability" concept to classify new entities. It assigns a new observation to the most probable class. The classification process comprises two stages as follows :

1) Training stage: Using the training samples, the method computes the probability distribution of that sample.

2) Prediction stage: For the test sample, the method computes the probability of that unknown instance. The is predicting that the sample belonging to each class according to the largest probability,

D. XGBoost

XGBoost is a decision-tree-based ensemble Machine Learning algorithm that uses a gradient boosting framework.XGBoost is one of the applications of gradient boosting (GB) algorithm, which is based decision tree as a classifier. It has been used due to its fast, efficiency, and scalability. In short, GB and XGBoost can be explained as follows. If we have D = [x,y] represents datasets containing n observation, where x is the feature (independent variables) and y is the dependent variable. In GB, assume there is a k amount of boosting, then we have K function to predict the result using $\hat{y}_i$ as the prediction for the i-th sample at the k-th boost, f_k denoting a tree construction q, with leaf j having a weight score w_j. Then for a given sample, the final prediction can be determined by summing up the scores overall leaves, this is shown in the equation Eq. (4) -

$$\hat{y}_i=\sum_{k=1}^{K} f_k(x_i) \quad (4)$$

4.4 Metrics

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To evaluate the performance of machine methods for discriminating Parkinson's patients, we employ the following criterion:

- Accuracy= TP+TN/TP+FP+TN+FN
- Sensitivity= TP/TP+FN
- Specificity= TN/TN+FP
- Precision=TP/TP+FP

where TP is the number of true positives, FP is the number of false positives, TN is the number of true negatives and FN is the number of false negatives. Accuracy evaluates the proportion of correct predictions. A higher accuracy value means a better overall prediction performance. Sensitivity refers to the ability to correctly detect Parkinson patients. Note that the recall is identical to sensitivity in binary classification. Specificity shows the proportion of actual negatives that are correctly predicted. Specificity refers to the ability to correctly detect normal people. Precision refers to the relevance of the predicted positives.
The PD dataset was divided as follows: 70% for training and 30% for testing. The experiment was performed on the following algorithms:

- KNN
- SVM
- Naïve-Bayes
- XGBoost

Upon testing the dataset on the above classifiers, the Naïve Bayes Algorithm classifies the PD dataset and provides 73.846% accuracy, SVM yields 87.692% accuracy, KNN offers 80.0% accuracy and XGBoost provides 95.384% accuracy.

4.5 Code Implementation

Anaconda is a Python distribution (prebuilt and preconfigured collection of packages) that is commonly used for data science. Anaconda Navigator is a GUI tool that is included in the Anaconda distribution and makes it easy to configure, install, and launch tools such as Jupyter Notebook. The Jupyter Notebook application allows you to create and edit documents that display the input and output of a Python or R language script. Once saved, you can share these files with others. Python and R language are included by default, but with customization, Notebook can run several other kernel environments.

4.6 Packages

Scikit-learn provides a range of supervised and unsupervised learning algorithms via a consistent interface in Python. NumPy, which stands for Numerical Python, is a library consisting of multidimensional array objects and a collection of routines for processing those arrays. Using NumPy, mathematical and logical operations on arrays can be performed. pandas is a software library written for the Python programming language for data manipulation and analysis. In particular, it offers data structures and operations for manipulating numerical tables and time series.

5. Results

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The PD dataset is divided as follows: 70% for training and 30% for testing. The algorithms used for the experiment are KNN, SVM, Naïve-Bayes and XGBoost. Upon testing the dataset on these classifiers, the results are as follows:

Fig 6. Performance measures of the classifiers

	KNN	SVM	XGBoost	Naive Bayes
Accuracy	80.0	87.692	95.384	73.846
Sensitivity	0.705	0.529	0.823	0.823
Specificity	0.833	1.0	1.0	0.708
Precision	0.6	1.0	1.0	0.5

The table below shows the accuracy obtained and the value of TP, TN, FP, and FN for each algorithm.

Fig 7. Confusion results of the classifiers

Classifier	Confusion Results				Accuracy
	TP	FP	FN	TN	
KNN	12	5	8	40	80.0%

SVM	9	8	0	48	87.692%
Naive- Bayes	14	3	14	34	73.846%
XGBoost	14	3	0	48	95.384%

The results show that XGBoost is the most accurate classifier with an accuracy of 95.384%.

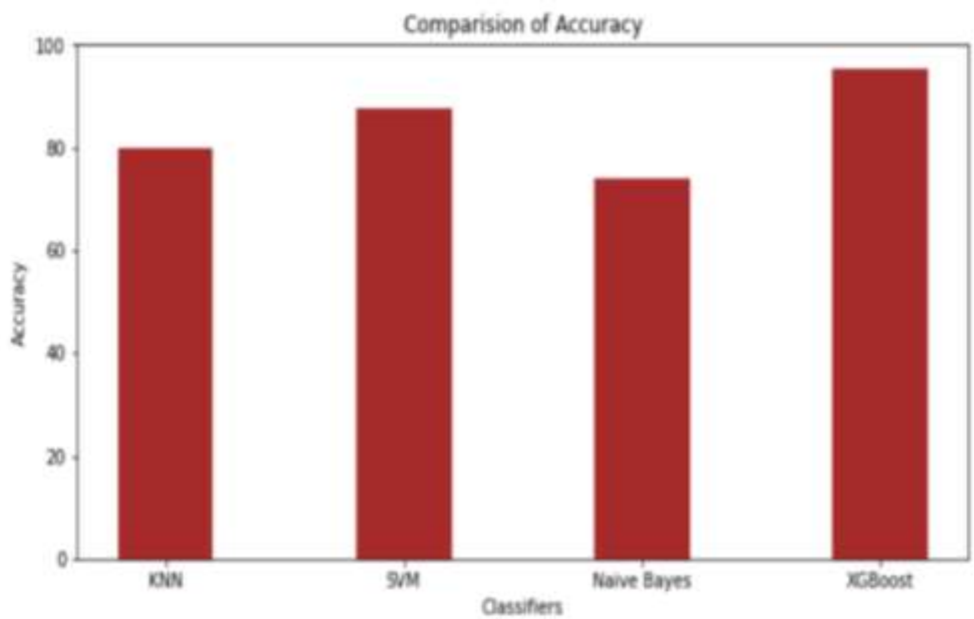

Fig 8. Accuracy of different classifiers

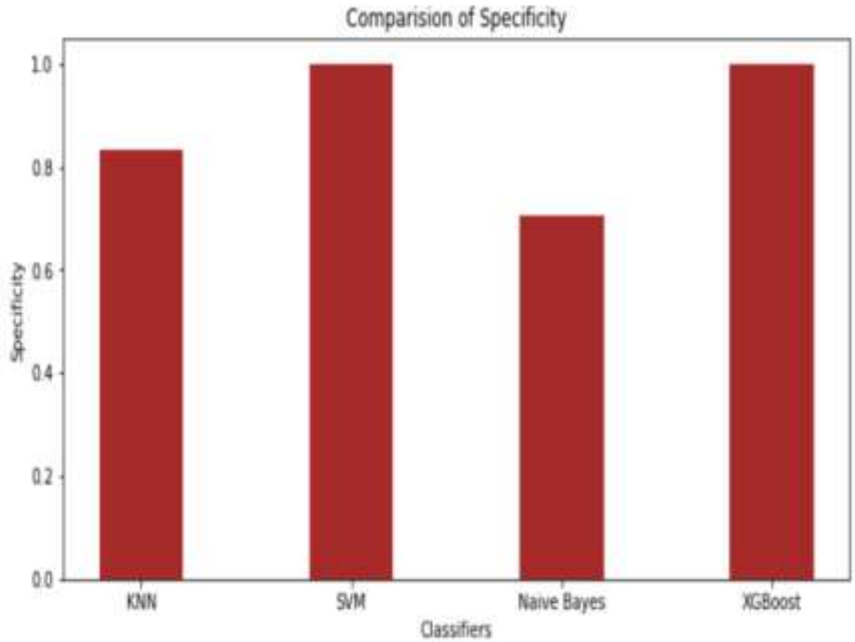

Fig 9. Specificity of different classifiers

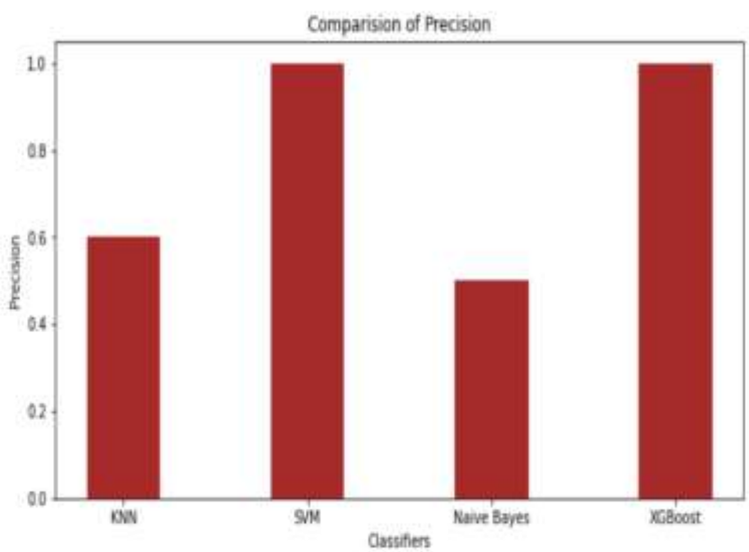

Fig 10. Precision of different classifiers

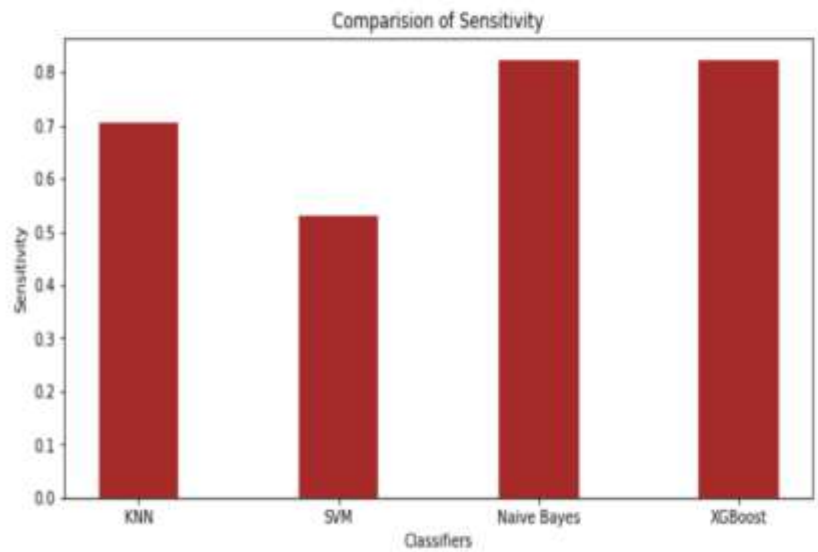

Fig 11. Sensitivity of different classifiers

The results show that XGBoost is the most accurate classifier with an accuracy of 95.384%. The reasons why XGBoost performs better than the other classifiers are as follows:

- It produces smaller trees compared to Random Forest and can fit data better than a single boosted tree.
- It is highly flexible.
- XGBoost improves upon the base GBM (Gradient Boosting Machines) framework through a system's optimization and algorithmic enhancements.

5.1 Future Scope

In future work, we can focus on different techniques to predict Parkinson's disease using different datasets. In this paper, we are using binary attributes (1- diseased patients, 0-non-diseased patients) for patient classification. In the future, we will use different types of attributes for the classification of patients and also identify the different stages of Parkinson's disease.

6. Conclusion

The aim of this study was to recognize how different classifiers would perform when implemented across the PD dataset and to evaluate their performance. These models can be effectively used to monitor and diagnose the PD remotely, which reduces the need for physical visits of the patients to the clinics. A comparative study of Naïve Bayes, SVM, knn, and xgboost classifiers on the PD dataset is performed. From the results we conclude that xgboost proves to be the most accurate classifier among all with 95.384% accuracy. Thus, for the early diagnosis and detection of PD, the techniques of artificial intelligence have been widely employed to produce effective and efficient results. Moreover, we emphasize the importance of early detection and prediction of Parkinson’s disease, such that treatment and support can be provided to patients as soon as possible.

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