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ACCURATE DETECTION OF NEUROLOGICAL DISORDER

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Abstract

Accurately detecting neurological disorder (ND) at an early stage is certainly indispensable for slowing down its progress and providing patients the possibility of accessing to disease modifying therapy. Towards this end,the premotor stage in ND should be carefully monitored. An innovative machine learning technique is introduced to early uncover whether an individual is affected with ND or not based on premotor features. Specifically, to uncover ND at an early stage, several indicators have been considered in this study, including Rapid Eye Movement and olfactory loss, Cerebrospinal fluid data, and dopaminergic imaging markers. A comparison between twelve machine learning and ensemble learning methods based on relatively small data including 183 healthy individuals and 401 early ND patients shows the superior detection performance of thedesigned model, which achieves the highest accuracy, 96.45% on average. This is mainly due to the desirable characteristics of the machine learning model in learning linear and nonlinear features from ND data without the need for hand-crafted features extraction. Besides detecting the ND, we also provide the feature importance on the ND detection process based on the Boosting method. Accordingly, the outcome of this work can be viewed as a promising first step towards the application of f cutting-edge research for early disease detection.

KEYWORDS: *Machine learning, Premotor Features*

I.INTRODUCTION

The recent report of the World Health Organization shows a visible increase in the number and health burden of neurological disorder patients increases rapidly. Classification algorithms are mainly used in the medical field for classifying data into different categories according to the number of characteristics.

Neurological disorder is the second most dangerous disease that can lead to shaking, shivering, stiffness, anddifficulty walking and balance. It caused mainly due by the breaking down of cells in the nervous system. Neurological disorder can have both motor and non-motor symptoms. The motor symptoms include slownessof movement, rigidity, balance problems, and tremors. If this disease continues, the patients may have difficulty walking and talking. The non-motor symptoms include anxiety, breathing problems, depression, lossof smell, and change in speech. If the above-mentioned symptoms are present in the person, then the details are stored in the records. In this paper, the author considers the speech features of the patient, and this data is used for predicting whether the patient has Neurological disorder or not.

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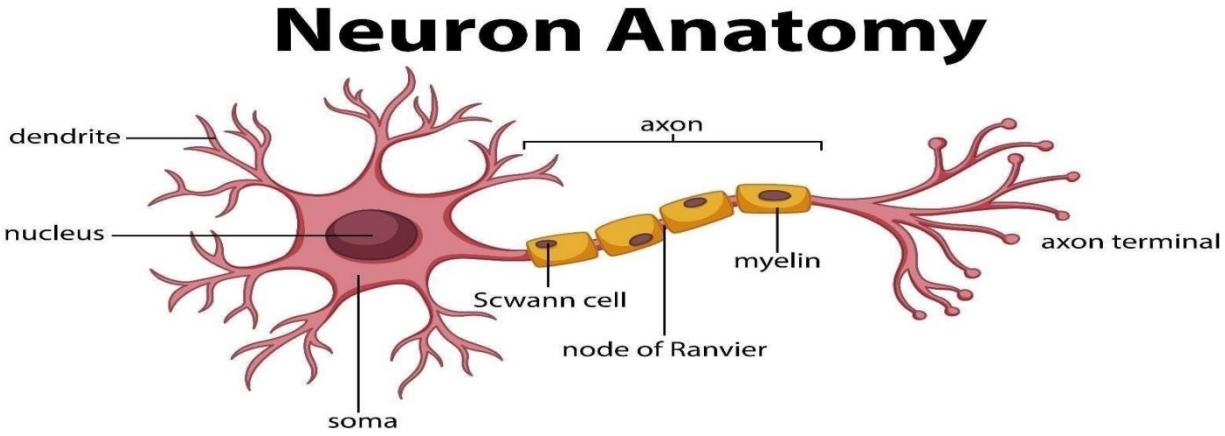
Neurodegenerative disorders are the results of progressive tearing and neuron loss in different areas of the nervous system. Neurons are functional units of the brain. They are contiguous rather than continuous. A good healthy-looking neuron as shown in fig1 has extensions called dendrites or axons, a cell body, and a nucleus that contains our DNA. DNA is our genome and a hundred billion neurons contain our entire genome which is packaged into it. When a neuron gets sick, it loses its extension and hence its ability to communicate which is not good for it and its metabolism becomes low so it starts to accumulate junk and it tries to contain the junk in the little packages in little pockets. When things become worse and if the neuronis a cell culture it completely loses its extension, becomes round and full of vacuoles.



Structure of Neuron

This work deals with the prediction of Neurological disorder which is now a day is tremendously increasing incurable disease. Neurological disorder is a most spreading disease which gets its name from James Parkinson who earlier described it as a paralysis agitans and later gave his surname was known as PD. It generally affects the neurons which are responsible for overall body movements. The main chemicals are dopamine and acetylcholine which affect the human brain. There is a various environmental factor which has been implicatedin PD below are the listed factor which caused Neurological disorder in an individual.

- **Environmental factors**: Environment is defined as the surroundings or the place in which an individual lives. So, the environment is the major factor that will not only affects the human's brain but also affects all the living organism who lives in the vicinity of it. Many types of research and evidence have proved that the environment has a big hand in the development of neurodegenerative disorders mainly Alzheimer's and Neurological disorder. There are certain environmental factors that are influencing neurodegenerativedisorder with high pace are: -

    - Exposure to heavy metals (like lead and aluminum) and pesticides.
    - Air Quality: Pollution results in respiratory diseases.
    - Water quality: Biotic and Abiotic contaminants present in water lead to water pollution.
- Unhealthy lifestyle: It leads to obesity and a sedentary lifestyle.

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- Brain injuries or Biochemical Factors: The brain is the control center of our complete body. Due to certain trauma, people have brain injuries which leads some biochemical enzymes to come intothe picture which provides neurons stability and provides support to some chromosomes and genes in maintenance.
- Aging Factor: Aging is one of the reasons for the development of Neurological disorder. According tothe author in India, 11,747,102 people out of 1, 065, 070, 6072 are affected by Neurological disorder.
- Genetic factors: Genetic factor is considered as the main molecular physiological cause which leadsto neurodegenerative disorders. The size, depth, and effect of actions of different genes define the statusor level of neurodegenerative disease which increases itself gradually over time. Mainly the genetic factors which lead to Neurodegenerative disorders are categorized into pharmacodynamics and pharmacokinetics.
- Speech Articulation factors: Due to the condition associated with Neurological disorder (rigidity and bradykinesia), some speech-language pathology such as voice, articulation and swallowing alterations arefound. There are various ways in which Neurological disorder (PD) might affect the individual.

    - The voice get breathy and softer.
    - Speech may be smeared.
    - The person finds difficulty in finding the right words due to which

II LITERATURE SURVEY

Speech or voice data is assumed to be 90% helpful to diagnose a person for identifying the presence of disease.It is one of the most important problems that have to be detected in the early stages so that the progression rateof the disease is reduced. Many of the researchers work on different datasets to predict the disease more efficiently. In general, Persons with PD suffer from speech problems, which can be categorized into two: hypophonia and dysarthria. Hypophonia indicates a very soft and weak voice from a person and dysarthria indicates slow speech or voice, that can hardly be understood at one time and this causes damage to the central nervous system. So, most of the clinicians who treat PD patients observe dysarthria and check out to rehabilitate with specific treatments to improvise vocal intensity. Lots of researchers did work on the pre- processing dataand feature selection in the past.

Anila M and Dr G Pradeepini proposed the paper titled “Diagnosis of Neurological disorder using Artificial Neural network” [2]. The main objective of this paper is that the detection of the disease is performed by usingthe voice analysis of the people affected with Neurological disorder. For this purpose, various machine learning techniques like ANN, Random Forest, KNN, SVM, XG Boost are used to classify the best model, error rates are calculated, and the performance metrics are evaluated for all the models used. The main drawback of this paper is that it is limited to ANN with only two hidden layers. And this type of neural networks with two hidden layers are sufficient and efficient for simple datasets. They used only one technique for feature selection which reduces the number of features.

Arvind Kumar Tiwari Proposed the paper titled “Machine Learning-based Approaches for Prediction of Neurological disorder” [3]. Inthis paper, minimum redundancy maximum relevance feature selection algorithms were used to select the most important feature

among all the features to predict Parkinson diseases. Here, it was observed that the random forest with 20 number of features selected by minimum redundancy maximum relevance feature selection algorithms provide the overall accuracy 90.3%, precision 90.2%, Mathews 12 correlation coefficient values of 0.73 and ROC values 0.96 which is better in comparison to all other machine learning based approaches such as bagging, boosting, random forest, rotation forest, random subspace, support vector machine, multilayer perceptron, and decision tree based methods.

Mohamad Alissa Proposed the paper titled "Neurological disorder Diagnosis Using Deep Learning" [14]. Thisproject mainly aims to automate the PD diagnosis process using deep learning, Recursive Neural Networks (RNN) and Convolutional Neural Networks (CNN), to differentiate between healthy and PD patients. Besides that, since different datasets may capture different aspects of this disease, this project aims to explore which PDtest is more effective in the discrimination process by analyzing different imaging and movement datasets (notably cube and spiral pentagon datasets). In general, the main aim of this paper is to automate the PD diagnosis process in order to discover this disease as early as possible. If we discover this disease earlier, then the treatments are more likely to improve the quality of life of the patients and their families.
There are some limitations to this paper namely:

- They used the validation set only to investigate the model performance during the training and this reduced the number of samples in the training set.
- RNN training is too slow and this is not flexible in practice work.
- Disconnecting and resource exhaustion: working with cloud services like Google Collaboratory causesmany problems like disconnecting suddenly. And because it is shareable service by the world zones, this leads to resource exhaustion error many times.

Afzal Hussain Shahid and Maheshwari Prasad Singh proposed the paper titled "A deep learning approach for prediction of Neurological disorder progression" [19]. This paper proposed a deep neural network (DNN) model using the reduced input feature space of Neurological disorder telemonitoring dataset to predict Neurological disorder (PD)progression and also proposed a PCA based DNN model for the prediction of Motor-UPDRS and Total- UPDRS in Neurological disorder progression. The DNN model was evaluated on a real-world PD dataset takenfrom UCI. Being a DNN model, the performance of the proposed model may improve with the addition of more data points in the datasets.

T. J. Wroge, Y. Özkanca, C. Demiroglu, D. Si, D. C. Atkins and R. H. Ghomi, proposed the paper titled "Neurological disorder Diagnosis Using Machine Learning and Voice" [24] is that it explores the effectivenessof using supervised classification algorithms, such as deep neural networks, to accurately diagnose individualswith the disease. Historically, PD has been difficult to quantify and doctors have tended to focus on some symptoms while ignoring others, relying primarily on subjective rating scales. The analysis of this paper provides a comparison of the effectiveness of various machine learning classifiers in disease diagnosis with noisy and high dimensional data. Their peak accuracy of 85% provided by the machine learning models exceeds the average clinical diagnosis accuracy of non-experts (73.8%) and average accuracy of movement disorder specialists (79.6% without follow-up, 83.9% after follow-up) with pathological post-mortem examination as ground truth.

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Siva Sankara Reddy Donthi Reddy and Udaya Kumar Ramanadham proposed the paper "Prediction of Neurological disorder at Early Stage using Big Data Analytics" [21]. This paper describes mainly various BigData Analytical techniques that may be used in diagnosing of right disease in the right time. The main intentionis to verify the accuracy of prediction algorithms. Their future study aims to propose an efficient method to diagnose this type of neurological disorder by some symptoms at the early stage with better accuracy using different Big Data Analytical techniques like Hadoop, Hive, R Programming MapReduce, PIG, Zookeeper, HBase, Cassandra, Mahout etc…

Daiga Heisters proposed the paper titled "Neurological disorder: symptoms, treatments and research" [9]. This paper initially says that Current treatments can help to ease the symptoms but none can repair the damage in the brainor slow the progress of the condition; now, Neurological disorder UK researchers are working to developnew treatmentsthat can and finally worked together to build on existing discoveries and explore these innovative areas of research, it is hoped that a cure for Neurological disorder will be found. Neurological disorder UK offers support for everyone affected,, including people with the condition, their family, friends and careers, researchers and professionals working in this area.

III EXISTING SYSTEM

- In existing system, Neurological disorder is detected at the secondary stage only (Dopamine deficiency), which leads to medical challenges. Thus, the mental disorders are been poorly characterized and have many health complications.
- This type of disorder is generally diagnosed with the following clinical methods as:

➢ MRI or CT scan - Conventional MRI cannot detect early signs of Neurological disorder disease

➢ PET scan - is used to assess activity and function of brain regions involved in movement

➢ SPECT scan - can reveal changes in brain chemistry, such as a decrease in dopamine. This results ina high misdiagnosis rate (up to 25% by non-specialists) and many years before diagnosis, people canhave the disease.

Thus, existing system is not effective in early prediction and accurate medicinal diagnosis to the affected people.

LIMITATIONS OF EXISTING SYSTEM

- Dopamine deficiency can be detected at the secondary stage only which leads to medical challenges.
- Suggesting medicine is also a challenge.
- Inaccurate results of the tests can occur sometimes.
- It not effective in early prediction.

IV PROBLEM STATEMENT

The main aim is to predict the prediction efficiency that would be beneficial for the patients who are sufferingfrom Parkinson and the percentage of the disease will be reduced. Generally, in the first stage, Neurological disorder can be cured by the proper treatment. So it's important to identify the PD at the early stage for the betterment of the patients. The main purpose of this research work is to find the best prediction model i.e.the best machine learning technique which will distinguish the Neurological

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disorder patient from the healthy person. The techniques used in this problem are KNN, Naïve Bayes, and Logistic Regression. The experimental study is performed on the voice dataset of Neurological disorder patients which is downloaded from the Kaggle. The prediction is evaluated using evaluation metrics like confusion matrix, precision, recall accuracy, and f1- score. The author used feature selection where the important features are taken into consideration to detect Neurological disorder.

NEUROLOGICAL DISORDER SYMPTOMS

The symptoms of Neurological disorder broadly divided into two categories.

- **Motor symptoms:** This is a symptom where any voluntary action involved. It indicates the movement-related disorders like tremors, rigidity, freezing, Bradykinesia, or any voluntary muscle movement.
- **Non-Motor symptoms:** Non motor symptoms include disorders of mood and affect with apathy, cognitive dysfunction as well as complex behavioral disorders. There are two other categories of PD which are divided by doctors: Primary symptom and Secondary symptom.
- **Primary symptoms:** It is the most important symptom. Primary symptoms are rigidity, tremor and slowness of movement.
- **Secondary symptoms:** It is a symptom that directly impacts the life of an individual. These can be either motor or non-motor. Its effect depends on person to person. A very wide range of symptoms is associated with Parkinson 's, Besides these symptoms, there are some other symptoms found that lead to Neurological disorder. These symptoms are micrographic, decreased olfaction & postural instability, slowing of the digestive system, constipation, fatigue, weakness, and Hypotension. Speech difficulties i.e., dysphonia (impaired speech production) and dysarthria (speech articulation difficulties) are found in patients with Neurological disorder. 1.3 Introduction to Machine Learning Machine Learning may be a sub-area of AI, whereby theterm refers to the power of IT systems to independently find solutions

MOTIVATION

Many of the people aged 65 or more do have a neurodegenerative disease, which has no cure. If we detect the disease in the early stages, then we can control it. Almost 30% of the patients are facing this incurable disease.Current treatment is available for patients who have minor symptoms. If these symptoms cannot be found at the early stages, it leads to death. The main cause for Neurological disorder is the accumulation of protein molecules in the neuron which gets misfolded and hence causing Neurological disorder. So till now, researchers got the symptoms and the root causes i.e. from where this disease had evolved. But very few symptoms have come to their cure and there are many symptoms that have no solution. So in this era where Neurological disorder is increasing, it is very important to find the solution.

V PROPOSED SYSTEM

- By using machine learning techniques, the problem can be solved with minimal error rate.
- The voice dataset of Neurological disorder disease from a dataset is used as input. Also, our proposed system provides accurate results by integrating voice detection inputs of normal and the disease affected patients.
- Thus, by these results, the doctor can conclude normality or abnormality and prescribe the medicine based on the

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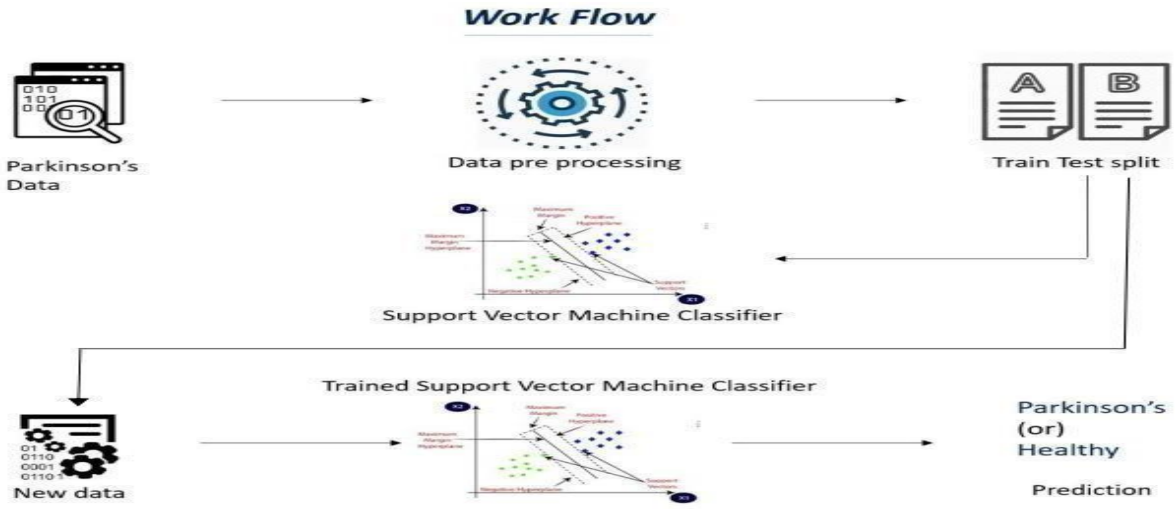
affected stage.

- The algorithm will be trained on 80% of the entries in the data set, while the remaining 20% will beused to test its accuracy.
- Furthermore, several steps will be taken to improve the accuracy of the algorithms by optimizingthem. Cleaning the dataset and preprocessing the data are two of these stages.

ADVANTAGES

- It will give accurate result
- It gives minimal error rate
- It is less expensive
- It consumes less time to exam

VI ARCHITECTURE



Technical Architecture

VII IMPLEMENTATION

Let us discuss about the various modules in our proposed system and what each module contributes inachieving our goal.

Speech Dataset

Pre-processing data

Training data

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Apply Machine Learning Algorithms

KNN

Naïve Bayes

Logistic Regression

Testing Data

Speech Dataset:

The main aim of this step is to spot and acquire all data-related problems. during thisstep, we'd like to spot the various data sources, as data are often collected from various sources like files and databases. The number and quality of the collected data will determine the efficiency of the output. The moreare going to be the info, the more accurate are going to be the prediction. We've collected our data from theKaggle website.

	MDVP:Fo(Hz)	MDVP:Fhi(Hz)	MDVP:Flo(Hz)	MDVP:Jitter(Abs)	MDVP:PPQ	MDVP:APQ	NHR	HNR	RPDE	DFA	spread2	D2	PPE
count	195.000000	195.000000	195.000000	195.000000	195.000000	195.000000	195.000000	195.000000	195.000000	195.000000	195.000000	195.000000	195.000000
mean	154.228641	197.104918	116.324631	0.000044	0.003446	0.024081	0.024847	21.885974	0.498536	0.718099	0.226510	2.381826	0.206552
std	41.390065	91.491548	43.521413	0.000035	0.002759	0.016947	0.040418	4.425764	0.103942	0.055336	0.083406	0.382799	0.090119
min	88.333000	102.145000	65.476000	0.000007	0.000920	0.007190	0.000650	8.441000	0.256570	0.574282	0.006274	1.423287	0.044539
25%	117.572000	134.862500	84.291000	0.000020	0.001860	0.013080	0.005925	19.198000	0.421306	0.674758	0.174351	2.099125	0.137451
50%	148.790000	175.829000	104.315000	0.000030	0.002690	0.018260	0.011660	22.085000	0.495954	0.722254	0.218885	2.361532	0.194052
75%	182.769000	224.205500	140.018500	0.000060	0.003955	0.029400	0.025640	25.075500	0.587562	0.761881	0.279234	2.636456	0.252980
max	260.105000	592.030000	239.170000	0.000260	0.019580	0.137780	0.314820	33.047000	0.685151	0.825288	0.450493	3.671155	0.527367

Speech data set

we can see the speech dataset that has collected from kaggle website. This acquireddataset has around 756 patient's data and each row has 755 different voice features. But in this project, we have chosen 10 main features that required to find the prediction. The features are listed below:

- Status
- Gender
- Jitter
- Shimmer
- NHR
- HNR
- Spread1
- Spread2
- D2
- PPE
- Frequency

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Importing the Dependencies

In [109]:
```
import numpy as np
import pandas as pd
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler
from sklearn import svm
from sklearn.metrics import accuracy_score
```

Data Collection & Analysis

In [111]:
```
# loading the data from excel file to a Pandas DataFrame

nd_data = pd.read_excel("mini_dataset.xlsx")
```

Data collection and analysis

The dataset we chose is in the form of CSV (Comma Separated Value) file. After acquiring the data our nextstep is to read the data from the CSV file into the Google colab also called a Python notebook. Python

notebook is used in our project for data preprocessing, features selection, and for model comparison. In the fig-3.3, we have shown how to read data from CSV files using the inbuilt python functions that are part ofthe pandas library.

When compared in genders the Neurological disorder is mostly found in the male rather than female. As thisdataset consists of more male persons we chose. In Fig-3.4, we have shown the male people are more thanfemale.

Standard distribution of Python comes with a **REPL (Read-Evaluate-Print Loop)** environment in the form of Python shell with >>> prompt. IPython (stands for Interactive Python) is an enhanced interactive environment for Python with many functionalities compared to the standard Python shell.

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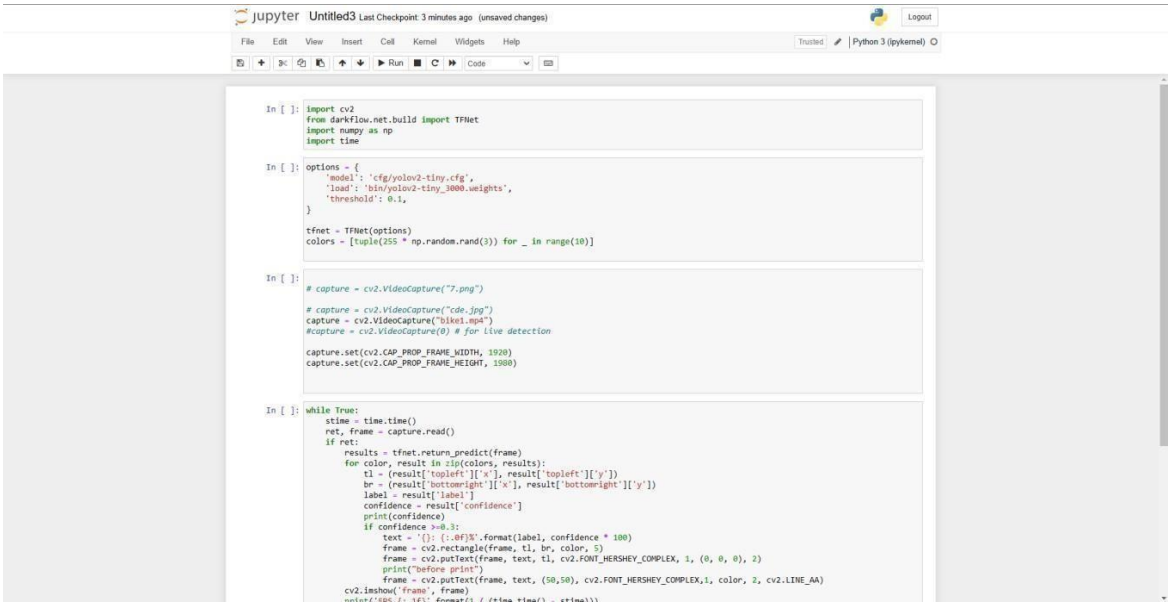

Jupyter notebook

RESULTS

```
import numpy as np
import pandas as pd
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler
from sklearn import svm
from sklearn.metrics import accuracy_score
```

```
# loading the data from csv file to a Pandas DataFrame
nd_data = pd.read_excel('mini_dataset.xlsx')
```

```
# printing the first 5 rows of the dataframe
nd_data.head()
```

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Out[112]:

	name	MDVP:Fo(Hz)	MDVP:Fhi(Hz)	MDVP:Flo(Hz)	MDVP:Jitter(%)	MDVP:Jitter(Abs)	MDVP:RAP	MDVP:PPQ	Jitter:DDP	MDVP:Shimmer	...	Shim
0	phon_R01_S01_1	119.992	157.302	74.997	0.00784	0.00007	0.00370	0.00554	0.01109	0.04374	...	
1	phon_R01_S01_2	122.400	148.650	113.819	0.00968	0.00008	0.00465	0.00696	0.01394	0.06134	...	
2	phon_R01_S01_3	116.682	131.111	111.555	0.01050	0.00009	0.00544	0.00781	0.01633	0.05233	...	
3	phon_R01_S01_4	116.676	137.871	111.366	0.00997	0.00009	0.00502	0.00698	0.01505	0.05492	...	
4	phon_R01_S01_5	116.014	141.781	110.655	0.01284	0.00011	0.00655	0.00908	0.01966	0.06425	...	

5 rows × 24 columns

Data analysis output

```
X = nd_data.drop(columns=['name','status'], axis=1)
Y = nd data['status']
```

```
print(X)
```

```
MDVP:Fo(Hz)  MDVP:Fhi(Hz)  MDVP:Flo(Hz)  ...  spread2                 D2       PPE
0     119.992      157.302       74.997  ...  0.266482  2.301442  0.284654
1     122.400      148.650      113.819  ...  0.335590  2.486855  0.368674
2     116.682      131.111      111.555  ...  0.311173  2.342259  0.332634
3     116.676      137.871      111.366  ...  0.334147  2.405554  0.368975
4     116.014      141.781      110.655  ...  0.234513  2.332180  0.410335
..        ...          ...          ...  ...       ...       ...       ...
190   174.188      230.978       94.261  ...  0.121952  2.657476  0.133050
191   209.516      253.017       89.488  ...  0.129303  2.784312  0.168895
192   174.688      240.005       74.287  ...  0.158453  2.679772  0.131728
193   198.764      396.961       74.904  ...  0.207454  2.138608  0.123306
194   214.289      260.277       77.973  ...  0.190667  2.555477  0.148569

[195 rows x 22 columns]
```

```
print(Y)
```

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```
4    1
     ..
190  0
191  0
192  0
193  0
194  0
Name: status, Length: 195, dtype: int64
```

```
X_train, X_test, Y_train, Y_test = train_test_split(X, Y, test_size=0.2
, random_state=2)
print(X.shape, X_train.shape, X_test.shape)
```

(195, 22) (156, 22) (39, 22)

:

```
# accuracy score on training data
X_train_prediction = model.predict(X_train)
training_data_accuracy = accuracy_score(Y_train, X_train_prediction)
print('Accuracy score of training data : ', training_data_accuracy)
```

Accuracy score of training data : 0.8846153846153846

```
# accuracy score on training data
X_test_prediction = model.predict(X_test)
test_data_accuracy = accuracy_score(Y_test, X_test_prediction)
print('Accuracy score of test data : ', test_data_accuracy)
```

Accuracy score of test data : 0.8717948717948718

Building a Predictive system

Finally, this system predicts whether a person have neurological disorder or not. Here numpyarray,scaler transform functions are used.

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```
input_data = (197.07600,206.89600,192.05500,0.00289,0.00001,0.00166,0.0
0168,0.00498,0.01098,0.09700,0.00563,0.00680,0.00802,0.01689,0.00339,26
.77500,0.422229,0.741367,-7.348300,0.177551,1.743867,0.085569)

# changing input data to a numpy array
input_data_as_numpy_array = np.asarray(input_data)

# reshape the numpy array
input_data_reshaped = input_data_as_numpy_array.reshape(1,-1)

# standardize the data
std_data = scaler.transform(input_data_reshaped)

prediction = model.predict(std_data)
print(prediction)
```

[0] The Person does not have neurological disorder

CONCLUSION

The diagnosis of Neurological disorder is not directed which means that one particular test like blood testor ECG cannot determine whether a person is suffering from PD or not. Doctors go through the medicalhistory of a patient, followed by a thorough neurological examination. They find out at least two cardinal symptoms among the subjects and then predict whether the subject is suffering from PD.Themisdiagnosis rate of PD is significant due to a no definitive test. In such case it will be helpful forus to aid the doctor by providing a machine learning model. The prediction models are developed using machine learning techniques of boosted logistic regression, classification trees, Bayes Net and multilayer perceptron based on these significant features. It is observed that the performance is better.It is demonstrated that Boosted Logistic Regression produce superior results. These results encourage us to try other ensemble learning techniques. The present work employs different machine learning algorithms which are not used in [3]. This study plays an important role in having a comparative analysis of various machine learning algorithms. In conclusion, this model can provide the nuclear experts an assistance that can aid them in better and accurate decision making and clinical diagnosis. It is also found that the proposed method is fully automated and provides improved performance and hence can be recommended for real life applications.

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