© April 2024| IJIRT | Volume 10 Issue 11 | ISSN: 2349-6002

Parkinson's disease detection and monitoring system based on tremors and abnormal gait using Machine Learning

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***Abstract*— This work presents a tremor and aberrant gait analysis-based Parkinson's disease (PD) identification and monitoring system. Using wearable device accelerometer and gyroscope data, the suggested approach uses feature extraction to capture minute movements that are linked to Parkinson's disease. In real-time applications, the K-Nearest Neighbors (KNN), Support-Vector Machine and Logistic regression classifier are implemented due to ease of use and effectiveness. The KNN algorithm demonstrates its effectiveness as a dependable diagnostic tool by achieving outstanding accuracy, having been trained on a dataset containing both PD and non-PD cases. Furthermore, the system serves as an uninterrupted tool that enables us to trace the advancement of a disease in real time. As a result, this makes it easier to modify treatment plans in a timely manner, which greatly enhances patient care thus providing overall health benefits. It serves as a non-invasive yet affordable option for early screening of Parkinson's disease. The lead time due to screening helps in early diagnosis and also provides individualized treatment plan which is a combination of wearable sensor technologies and machine learning.**

***Index Terms*— Parkinson, Gait, ESP8266, Gyroscope, Accelerometer, Machine Learning.**

I. INTRODUCTION

PD is a brain condition that causes problems with movement, internal health, sleep, pain and other health issues. PD gets worse over time. There's no cure, but curatives and drugs that can only reduce symptoms. Common symptoms include tremors, painful muscle condensation and difficulty in speaking. PD complaint results in high rates of disability and the need for care. Numerous people with PD also develop dementia complaint generally occurring in aged people, but younger people can also be affected. The cause of PD is unknown but people with a family history of the complaint have an advanced potential threat. Exposure to pollution, fungicides etc. increase threat.

A. Symptoms

Following are the symptoms of PD:

- Bradykinesia
- Parkinsonian Gait
- Tremors
- Rigidity
- Imbalance

B. Parkinsonian gait

Due to change in posture, slowness in movement and shortened strides, people often experience frozen gait. It's described as a feeling of getting stuck in a place when they start a step or turn.

Parkinsonian gait occurs in the early stages of Parkinson's disease and is characterized by shortened path length, reduced arm movement, rest tremors etc.

C. Parkinsons's Tremor

An involuntary movement, rhythmic shaking or slight movements in the body, tremor is often considered the earliest symptom people notice and is different from other tremors because it's a Resting tremor.

Having tremors doesn't necessarily mean Parkinson's positive case. It's the earliest and fundamental symptom of the disease.

D. Literature survey

Previous studies to predict PD have been implemented on the basic of cardiovascular oscillations [1], force tracking data [2], smell identification data [3]. The author Vojtech Illner [4], used the sawtooth inspired pitch estimator (SWIPE) scheme recorded via smartphone to detect speech disorder and compared it with a healthy person to detect PD. G. Solana Lavalle [5] described a vocal feature-based algorithm that can detect PD early by using Wrappers subset selection methods. The author I. El Maachi [6] finds another method to detect PD by Deep 1D-convnet based on the gait signal. A. Wagner [7] suggests a wavelet method to analyze tremor, bradykinesia, and dyskinesia data collected from patient. T. Arroyo-Gallego [8] worked on the approach to detect PD by touch screen typing. Various machine learning technique have been applied for detection of PD. For the instance, M. A. Little [9] did dysphonia measurements to detect and distinguish patients with PD from healthy people. The author D. Braga [10] used three common machine learning algorithms, namely Random Forest (RF) or Support Vector Machine (SVM) and neural network and applied them to detect Parkinson's disease based on acoustic analysis of speeches.

II. METHODOLOGY

The ESP8266 Node-MCU board is used to interface with two 3-axis gyroscope and accelerometer (MPU6050) with it's different pins.

Two sensors are used to perform two different operations, tremor detection and movement analysis from acceleration and gyro data along the X, Y and Z axis.

One sensor is attached to the arm to detect tremors. Second sensor is attached to the leg to measure the change in acceleration along different axes while walking.

MPU 6050 gives continuous value of acceleration of X-axis, Y-axis, Z-axis. Those data are stored and analyzed. If tremor is not detected, the process will be terminated. If tremor is detected, second MPU6050 will gather the data along the axes.

This whole process will continue for 5 mins. Tremor data and axis data (acceleration and gyro) is stored in an excel sheet.

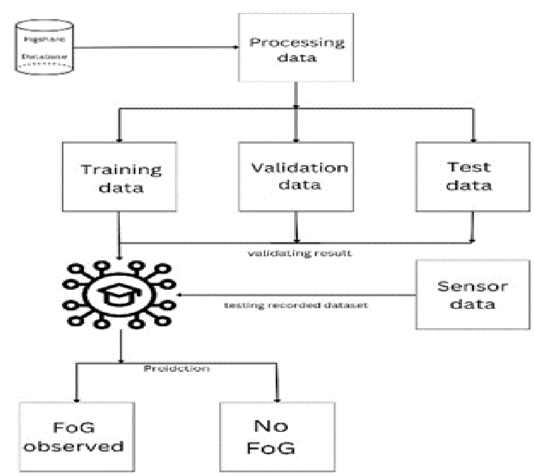
A machine learning model is developed using datasets from figshare [11] and frontier [12]. K nearest neighbors, Support vector machines, logistic regression-based models are implemented for detecting the Freezing of Gait in patients.

According to the results obtained, the K nearest neighbor model stood out to be the most accurate model with an accuracy rate of 98%. The SVM model gave an accuracy of 90%, followed by the logistic regression model with 79% accuracy.

A. Algorithm for approach

- Collect Gait data from the frontiers database.
- Select the required features from the datasets.
- Perform data analysis to detect presence of Null values in the datasets.
- Scale the data in common range using Standard scaler.
- Dividing the data-frame into test, valid and train datasets, where training set is 60% of the total dataset and rest are 20% each.
- Train ML model with logistic regression, KNN, and SVM models.
- Collect the data from the accelerometer.
- The stored data in excel is tested on the trained ML model to predict the instants of Freezing of gait.

B. Proposed architecture

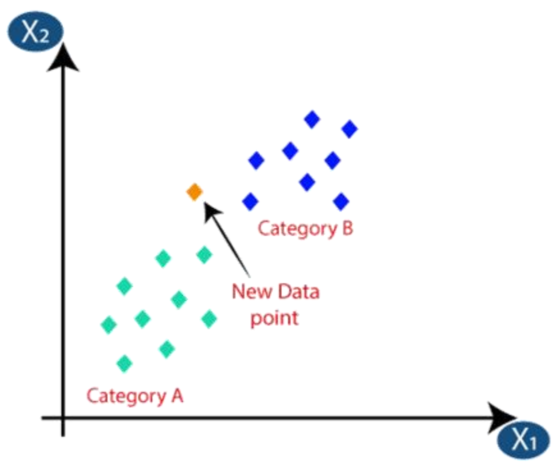


C.1. K-nearest neighbors

KNN is a simple algorithm, based on the local minimum of the target function which is used to learn an unknown function of desired precision and accuracy. The algorithm also finds the neighborhood of an unknown input, its range or distance from it, and other parameters. KNN relies on observable data similarities and sophisticated distance metrics to generate accurate predictions. This technique may seem a bit counterintuitive and not trustworthy at first, but it's actually very reliable. To make predictions, the algorithm calculates the distance between each new data point in the test dataset and all the data points in the training dataset. The Euclidean distance is a commonly used distance metric in K-NN, but other distance metrics, such as Manhattan distance or Minkowski distance, can also be used depending on the problem and data.

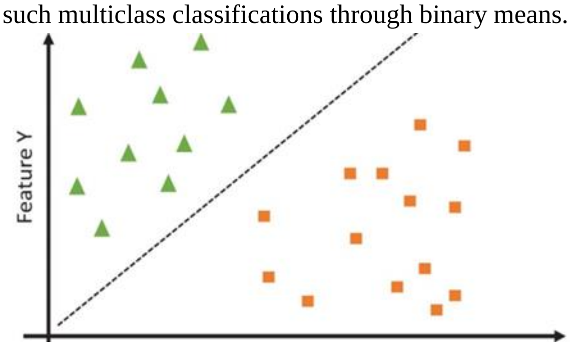
Euclidean distance between two points:

$$\text{distance}(x, X_i) = \sqrt{\sum_{j=1}^{d}(x_j - X_{i_j})^2]}$$



C.2. Support Vector Machines (SVM)

SVM algorithm is to identify a hyperplane that distinguishably segregates the data points of different classes. The hyperplane is localized in such a manner that the largest margin separates the classes under consideration. SVMs are potentially designed for binary classification problems. However, with the rise in computationally intensive multiclass problems, several binary classifiers are constructed and combined to formulate SVMs that can implement such multiclass classifications through binary means.



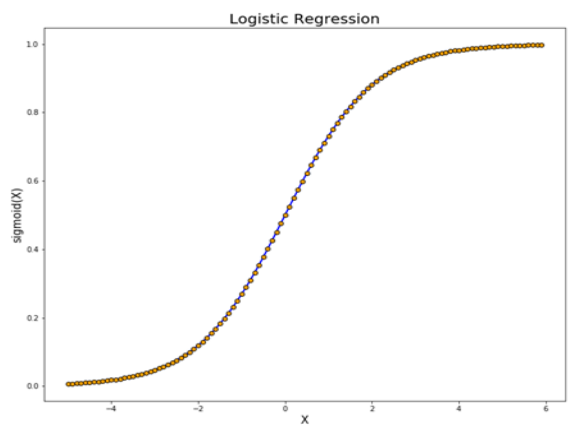
C.3. Logistic Regression

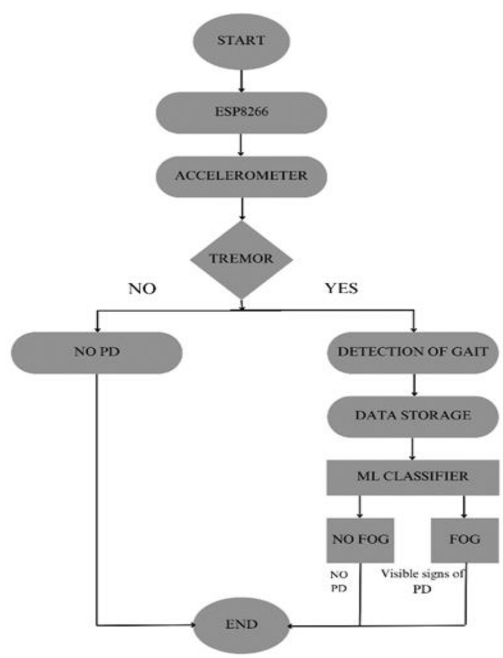
Logistic regression predicts the output of a categorical dependent variable. Therefore, the outcome must be a categorical or discrete value.

It can be either Yes or No, 0 or 1, true or False, etc. but instead of giving the exact value as 0 and 1, it gives the probabilistic values which lie between 0 and 1. Logistic Regression is much similar to the Linear Regression except that how they are used. Linear Regression is used for solving Regression problems, whereas Logistic regression is used for solving the classification problems.

In Logistic regression, instead of fitting a regression line, we fit an "S" shaped logistic function, which predicts two maximum values (0 or 1).

III. FLOWCHART





IV. RESULTS

A. Results for K-Nearest neighbor

	precision	recall	f1-score	support
0	0.50	0.83	0.63	108
1	0.99	0.97	0.98	2964
accuracy			0.97	3072
macro avg	0.75	0.90	0.80	3072
weighted avg	0.98	0.97	0.97	3072

B. Results for Support vector machines

	precision	recall	f1-score	support
0	0.23	0.76	0.36	108
1	0.99	0.91	0.95	2964
accuracy			0.90	3072
macro avg	0.61	0.83	0.65	3072
weighted avg	0.96	0.90	0.93	3072

C. Results for Logistic regression

	precision	recall	f1-score	support
0	0.12	0.75	0.20	108
1	0.99	0.79	0.88	2964
accuracy			0.79	3072
macro avg	0.55	0.77	0.54	3072
weighted avg	0.96	0.79	0.86	3072

V. CONCLUSION

In conclusion, our investigation has helped us to unravel the insights into the application of this project in read world medical industry. The primary goal of this project was to annotate on the Gait of a person using sensor technology.

Summarizing the overall insight, we observed effect of Parkinson's disease on the posture and movement of a person. The postural differences, slowness in movement (Bradykinesia), unable to move (freezing of gait).

Despite the success of our investigation, its is crucial to acknowledge the challenges to manipulate the physical intricacies of sensors and their change in readings due to various factors. This intricacies demands continued exploration, and our project represents a foundational process in this ongoing journey.

VI. ACKNOWLEDGEMENT

We would like to express our sincere gratitude to the professors and coordinators of our esteemed universities.

We would also like to thank our family and well-wishers who have inspired and supported us.

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