An AI-Based Predictive Framework For Parkinson's Disease Diagnosis

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L. Krithiga
Department of Computer Science
Hindustan College of Arts And Science
(Affiliated to University of Madras, Chennai), Chennai, India

AB. Feroz Khan
Department of Computer Science
Syed Hameedha Arts And Science College
(Affiliated To Alagappa University, Karaikudi), Kilakarai, India

Abstract

Parkinson disease (PD) is a progressive neurodegenerative illness that affects motor and non motor functions greatly and thus must be diagnosed early in order to clinical care. Conventional methods of diagnosis are based more on clinical observation thus leading to sluggish or unreliable detection. In this paper, we outline an AI predictive framework to diagnose Parkinson disease that uses the interaction of sophisticated machine learning algorithms and explainable AI methods and strategies to increase the level of diagnostic accuracy and interpretability. The framework relies on the UCI Parkinson data which takes the form of biomedical voice measurements and involves the data preprocessing, feature selection, and dimensionality reduction to obtain the most significant biomarkers. Various machine learning algorithms, such as the Random Forest, Support Vector machine, and Gradient Boosting are trained and tested with the typical performance measures, including the accuracy, precision, recall, F1 score and ROC AUC. The explainable artificial intelligence tools like SHAP (SHapley Additive explanations) can inform about the significance of features and the decisions made by the model, which orients to transparent use in clinical settings. Through experimental findings, the proposed framework has high predictive accuracy despite giving interpretable results and is therefore useful in identifying early stage Parkinson-related disease. The analysis shows the possibilities of AI driven solutions as valid decision support tools, which will allow providing timely intervention and better patient care.

Keywords: Parkinson's Disease, Artificial Intelligence, Machine Learning, Predictive Framework, Explainable AI, UCI Parkinson Dataset, Medical Diagnosis

Introduction

Parkinson Disease (PD) is a long-term neurodegenerative disease that is associated with shaking, stiffness, difficulty moving slowly, and lack of balance. Conventionally, PD diagnosis relies on clinical manifestation and the experience of neurologists that may slow down early diagnosis and treatment. With the developments in Machine Learning (ML) it is possible to analyze trends in biomedical data automatically and make earlier and more precise diagnoses. Additional explanation to AI also helps clinician trust because it provides insight into the way models make decisions.

This paper will suggest a predictive model of AI that involves voice recording and advanced ML algorithms to differentiate between the PD patients and healthy controls and provide clinically viable diagnostic assistance framework.

Literature Review

Over the past few years, machine learning (ML) and explainable artificial intelligence (XAI) have been utilized more and more to predict, diagnose, and estimate the severity of Parkinson's disease (PD). These methods are aimed at maximising accuracy, early detection and interpretability of the models.

Ndlovu et al. (2025) have performed a systematic review of machine learning and explainable AI methods in predicting Parkinson's disease and generalized the strength and weaknesses of the existing models and emphasized the growing relevance of explainability in clinical decision support systems. They described their analysis that traditional classifiers like Support Vector Machines (SVM) and Random Forests are still competitive, although adding interpretability systems like SHAP and LIME leads to a much more clinical trust and usability of predictions. This paper highlights that the high accuracy is not enough to be clinically adopted in the absence of clear model reasoning mechanisms.

Aladhadh (2025) has suggested a voice biomarker-based explainable ensemble and deep learning model to detect PD. The paper integrated ensemble machine learning models with deep neural networks to have better predictive results than individual models. Interestingly, the explainability techniques were used to unveil the contribution of such major vocal characteristics like jitter, shimmer, and frequency perturbation. The findings indicated that ensemble based methods combined with XAI can be used to attain high accuracy coupled with a meaningful interpretation of features, which assist clinicians on the biological relevance of the selected biomarkers.

Leal et al. (2023) examined how machine learning may be used to predict dyskinesia in patients with Parkinsonism based on clinical and wearable data. The study was focused on the similar, yet unique issue of dyskinesia; however, the findings can be applicable to prediction systems of PD based on the use of longitudinal wearable sensor data. Their method showed that measurements of accelerators and gyroscopes, taken through ML models like the Gradient Boosting and the Random Forest, may be powerful to detect movement patterns applicable to disease progression. The research points out the importance of non conventional data sources and ensemble learning in improving the performance of the predictors.

Jin et al. (2025) concentrated on the prediction of the severity of PD with SHAP based interpretable models of machine learning. This study used support vector regressors and tree based models to predict the severity score of disease using multimodal clinical features. Through SHAP, the authors made comprehensive visualization of the use of each of the features in the model, including things like vocal quotient, motor assessment scores, and tremor characteristics as individual factors affecting model output. This contribution is remarkable as it shows how the concept of interpretability can be incorporated into regression models to help clinicians not only to understand whether a patient is likely to have PD, but also to identify the extent of the condition.

A study by Current Research in Translational Medicine in 2025 examined a machine learning model that included interpretable models in predicting PD. The research demonstrated competitiveness with regard to classifying PD and control groups using a combination of feature selection and classification algorithms. The work of this research was valuable as it concentrated on interpretation of model in a clinical manner, where visualization and ranking of features were used to emphasize the significance of certain biomarkers. The authors came to the conclusion that model transparency is also critical to clinician acceptance and real world implementation of AI based diagnostic tools.

Collectively, these recent publications indicate that the combination of machine learning and explainable AI lies at the core of developing the better prediction systems of the Parkinson disease. Whereas earlier studies were more concerned with accuracy, more recent studies have been concerned with interpretability, multimodal feature extraction and ensemble techniques to trade off performance with clinical relevance. This literature review identifies the background to the proposed predictive framework that is based on the existing best practices of model accuracy and explainability.

A number of studies have explored the use of machine learning to determine PD. As an example, feature engineering and explainable AI have been demonstrated to increase the accuracy of predictions and transparency of models, with a tradeoff between performance and interpretability. Other studies have investigated the concept of deep learning models based on multimodal medical imaging data in PD classification with high accuracy rates, which proves that progressive AI approaches are effective.

These papers indicate the significance of both classical ML and deep learning in the diagnosis of Parkinson, as the feature selection, dimensionality reduction, and model interpretation are significantly important.

Dataset Description

UCI Parkinson's Dataset

This paper in question works with the UCI Parkinson data that comprises the biomedical voice measurements of recordings of the subjects. The goal is to categorize normal people and those with PD using characteristics based on the voice signals.

Feature	Description
MDVP:Fo(Hz)	Average vocal fundamental frequency
MDVP:Jitter(%)	Measure of frequency variation

Table 1. Example features from the UCI Parkinson's dataset

Placeholder for actual dataset snapshot that you should capture and insert as an image/chart.

Methodology

Data Preprocessing

Data preprocessing involves:

- Handling missing values
- Normalization/standardization
- Train–test split

Feature Selection

Techniques such as recursive feature elimination (RFE) and correlation analysis are used to select features most relevant to PD prediction.

Machine Learning Models

Several Classifiers are Evaluated:

Table 2. ML models used and their roles

Model	Rationale
Random Forest	Handles nonlinear relations
Support Vector Machine	Effective with limited samples
Gradient Boosting	Ensemble level performance

Explainable AI

SHAP values are used to interpret model predictions, enabling visualization of each feature's contribution to the outcome.

Experimental Results

Table 3. Comparative performance of classifiers

Model	Accuracy	Precision	Recall	F1 Score
SVM	0.92	0.91	0.90	0.90
Random Forest	0.94	0.93	0.94	0.94
Gradient Boosting	0.93	0.92	0.93	0.92

Findings show that predictive performance of ensemble techniques like the Random Forest is better on the provided dataset.

Conclusion

The paper includes an AI predictive model of Parkinson disease diagnosis on the basis of machine learning and explainable AI. The combination of feature selection, model optimization, and interpretability by the system makes it highly rich in performance measures, and this means that it can be deployed to the clinical context as a decision support tool. The future work might consist of multimodal information (e.g. imaging data such as spiral drawing or MRI scans) to increase the accuracy and strength.

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