



(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)



Impact Factor: 8.699

Volume 14, Issue 6, June 2025

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www.ijirset.com |A Monthly, Peer Reviewed & Refereed Journal| e-ISSN: 2319-8753| p-ISSN: 2347-6710|

Volume 14, Issue 6, June 2025

|DOI: 10.15680/IJIRSET.2025.1406166|

Parkinson's Disease Detection

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ABSTRACT: Parkinson's disease is a neurodegenerative disorder that affects quality of life extensively, and timely detection is very important for successful intervention. Conventional diagnostic approaches are based on subjective evaluations, which may result in misdiagnosis and delayed treatment. With the advent of artificial intelligence, machine learning (ML) models have emerged as potential tools to enhance diagnostic accuracy. This project provides a machine learning system for Parkinson's disease detection based on multi-modal data, such as gait, brain images, and spiral drawings, as well as speech recordings. A combination of Random Forest classifiers, Convolutional Neural Networks (CNN), and other deep models are utilized to learn features from and classify the data. The system combines pre-processed features like gait dynamics, spiral drawing traits, and acoustic patterns from voice recordings. Data augmentation techniques are also utilized to improve the stability of the models . The solution being proposed here offers an explainable diagnosis, classifying patients as "Parkinson's Detected" or "Healthy" based By providing an appropriate , medical conditions the system provides the best clinical health care with speed and efficient on the part of health , leading ultimately to better patient outcomes by allowing intervention early on.

KEYWORDS: MFCCs

I. INTRODUCTION

Neurological disorders such as Parkinson's Disease (PD) affect millions worldwide, leading to progressive motor and cognitive impairments. Early and accurate diagnosis is crucial for effective management, but traditional methods relying on clinical assessments and patient history can be subjective and inconsistent. With advancements in machine learning (ML) and deep learning (DL), automated diagnostic tools have emerged as a promising solution.

Parkinson's disease shows unique biomarkers, such as hand-drawn spiral traces, gait pathology, brain imaging, and voice alteration, which can be inspected through AI models. This project employs Convolutional Neural Networks (CNNs), and Machine Learning algorithms to learn important features from these sources of data, enhancing diagnostic accuracy and giving a reliable, objective, and early detection mechanism for Parkinson's Disease.

The system is deployed as a web application in Flask with defined access roles for doctors, patients, and labs.. Lab provides patient medical records to diagnose, doctors sanction the system diagnoses before inputting a diagnosis, and patients log in to see their diagnostic output and be provided with medical recommendations via the platform.

II. LITERATURE SURVEY

Parkinson's disease detection offers different machine learning and deep learning techniques on clinical data such as brain imaging, spiral drawing, walk, and speech. One research article entitled "Detection of Parkinson's Disease from 3T T1 Weighted MRI Scans Using 3D Convolutional Neural Network"[1] (2021) handled brain imaging analysis.It established that a 3D CNN-based model had a detection rate of 92.4% for diagnosing Parkinson's from MRI scans, which proves the importance of deep learning. In the paper "Hand-drawn Spiral Analysis Using Deep Learning for Early Parkinson's Disease Detection"[2] (2022), the authors used EfficientNet-B3 to distinguish spiral drawings of Parkinson's patients from healthy subjects. The model was accurate at 88.7%, proving the potential of deep learning in movement disorder analysis. The research "Automated Gait Analysis for Parkinson's Disease Diagnosis Using Machine Learning"[3] (2023) explored gait analysis from accelerometer signals and Random Forest classification. The accuracy





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of the model was 85.2%, highlighting the significance of gait disturbances in detecting Parkinson's. In "Parkinson's Disease Classification Using Voice Analysis and Machine Learning" [4] (2023), the researchers used MFCC feature extraction and SVM classification from voice recordings with 89.6% accuracy. The study emphasized the role of voice disorders in the diagnosis of Parkinson's. The research "Hybrid Deep Learning Approach for Parkinson's Disease Diagnosis Using Multimodal Data" [5] (2024) fused brain imaging, gait, voice, and spiral drawings with a hybrid CNN model. The approach had 91.3% accuracy, indicating the advantages of multimodal fusion. "Explainable AI in Parkinson's Disease Diagnosis" [6] (2024) emphasized interpretability through the utilization of SHAP values to interpret deep learning model predictions. The research revealed that brain scan features contributed most to model predictions. In the paper "Feature Extraction from Gait Videos for Parkinson's Disease Prediction" [7] (2023), a feature extraction model based on CNN was presented to analyze gait video data. The model achieved 83.5% accuracy, further establishing the viability of video-based analysis. "Comparative Analysis of Machine Learning Models for Parkinson's Disease Detection" [8] (2024) compared a range of classifiers, including SVM, Decision Trees, and Neural Networks. The research revealed that neural networks performed better than conventional ML models, with an accuracy of 87.2%. The research "Deep Learning-Based Parkinson's Disease Prediction Using Spiral Drawings" [9] (2024) compared convolutional networks for extracting features from spiral drawings. The proposed ResNet model achieved 90.1% accuracy, superior to traditional methods. "Multi-Modal Learning for Parkinson's Disease Diagnosis" [10] (2024) demonstrated that combining different types of data significantly improves diagnostic accuracy. The study reached 92.7% accuracy using a Transformer-based model that combined voice, gait, and image data.

III. METHODOLOGY

The dataset used in the detection of Parkinson's within this project amalgamates different data sources including spiral drawing images, audio records, and brain scans to enhance diagnostic performance. The spiral drawing dataset includes 1,600 images annotated in Pascal VOC format and resized to 640x640 pixels, which assists CNN-based models in identifying motor impairments. The voice dataset, which is stored in CSV format with 195 samples, contains acoustic features like jitter, shimmer, HNR, F0, and MFCCs, investigated on machine learning algorithms. The project entails the utilization of NTUA Parkinson Dataset, comprising MRI scans and DaT scans of 78 subjects (55 patients with Parkinson's disease and 23 controls), with more than 42,000 brain images. In particular, the dataset consists of 590 Parkinson's DaT scans, 330 control DaT scans, 32,706 Parkinson's MRI scans, and 10,381 control MRI scans, which go into deep learning models for neuroimaging analysis. Through this multimodal dataset, the system improves early detection of Parkinson's, enabling more accurate diagnosis and clinical decision-making.

Data preprocessing is a critical step in developing deep learning models for the detection of Parkinson's disease, making data consistent, improving model performance, and preventing overfitting.Spiral drawing analysis resizes the images to 640x640 pixels, grayscale, and normalizes to improve feature extraction. In voice analysis, raw audio signals are transformed into MFCCs, and jitter, shimmer, and HNR features are extracted to describe Parkinsonian speech defects. The brain imaging data is preprocessed using operations like skull stripping, intensity normalization, and resizing to homogeneous MRI and DaT scans.. Data augmentation methods like rotation, flipping, and noise addition are also used to enhance model generalization. These preprocessing operations make the input data deep learningmodel optimized so that efficient classification of Parkinson's disease across modalities is possible.

. Each model examines its respective data type to identify Parkinson's disease markers. The system's performance is gauged on accuracy, precision, recall, and F1-score, ensuring that it can be used reliably in real-world applications. Designed as a web application based on Flask, the platform allows for direct communication between laboratories, physicians, and patients. Physicians assess AI-made predictions, verify results, and make medical suggestions, while patients securely view their diagnosis reports. With the combination of multimodal analysis and AI-powered detection, the system boosts early diagnosis and patient outcomes.





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(a) Fig. 1. Shows the system architecture of Parkinson's Disease Detection

IV. EXPERIMENTAL RESULTS

Our framework integrates four robust machine learning models to identify Parkinson's Disease (PD)—EfficientNet-B3 for brain MRI, CNN for spiral drawing analysis, XGBoost for voice, and Random Forest for gait. By leveraging these diverse approaches, we achieved an overall accuracy of 87%, proving that a multimodal analysis is a strong and reliable way to detect PD. Each model plays a crucial role: EfficientNet-B3 accurately identifies changes in brain scans, CNN detects tremors in hand-drawn spirals, XGBoost picks up subtle variations in voice, and Random Forest assesses gait abnormalities. While the system performed well overall, some misclassifications occurred, particularly in gait and voice assessments, where symptoms tend to overlap. In spite of these limitations, this hybrid system offers a better integrated and understandable means of assisting early detection of Parkinson's, enabling physicians to make more informed decisions. Different models have different performances Hybrid CNN with a precision of 0.88, recall of 0.80, and an F1- score of 0.90. EfficientNet-B3 with a precision of 0.90, recall of 0.80, and an F1- score of 0.80.Random Forest with a precision of 1.00, recall of 1.00, and an F1- score of 0.90.XGBoost with a precision of 1.00, recall of 0.50, and an F1- score of 0.66. The Random Forest and Xgboost models have higher accuracy, recall, and precision. This models perform well using their datasets and provide much higher performance.





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Fig. 2. Shows the result of result of Parkinson's Disease Detection (a)Lab dashboard, (b)Lab dashboard-Medical Records, (c)Lab dashboard-Prediction Table,(d)Lab dashboard-Report generation,(e)Doctor dashboard,(f) Patient dashboard

V. CONCLUSION

This project presents a unified digital platform for the early detection of Parkinson's Disease by processing diverse patient data—ranging from brain scans and hand-drawn spirals to voice patterns and gait movements. The system integrates machine learning models tailored to each data type, ensuring precise and reliable predictions. By combining insights from multiple diagnostic channels, the platform improves overall accuracy while reducing the chance of misdiagnosis. One of the core innovations is the decision logic that confirms Parkinson's only when all input models agree, thereby enhancing diagnostic certainty. This approach streamlines the medical evaluation process and allows labs, physicians, and patients to interact through a single, user-friendly system. Looking forward, increasing data diversity will help the system adapt better to real-world cases across different populations. The integration of advanced architectures—such as vision transformers and attention mechanisms—can boost performance on complex data like motion and audio. Additionally, adding capabilities like real-time analysis, mobile accessibility, and wearable device integration can bring the solution closer to everyday use. With continued upgrades, this system has the potential to become a powerful support tool in neurological diagnostics and long-term patient monitoring.

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