ISSN No:-2456-2165

# Survey on Parkinson's Disease Detection Using Multi-Modal Approach

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**Abstract:- This paper investigates using machine learning to help diagnose Parkinson's disease early on. It specifically looks at two aspects - hand movements and vocal features. Unique datasets for both the symptoms are explored. Specialized techniques extract the most distinguishing hand motions and speech characteristics as biomarkers. Unlike traditional methods relying on one feature only, this multimodal approach combines both hand movement and voice biomarkers into one computational model. Overall, the study illustrates promise for machine learning tools enabling earlier intervention for medical purposes, not individual diagnosis. The focus remains on aiding clinicians rather than replacing specialized assessments.**

***Keywords:-*** *Deep Learning, Feature Extraction, Neural Networks, Pattern Recognition, Multimodal Approach, Computational Models.*

## I. INTRODUCTION

Parkinson's disease (PD) is a complex neurodegenerative disorder impairing motor control and cognitive capacity. Pathology is characterized by degradation of dopamine neurons and intracellular Lewy body accumulations. PD elicits an array of non-motor manifestations as well spanning sensory, autonomous, and neuropsychiatric domains. Parkinson's disease profoundly impacts quality of life for millions, necessitating early intervention. Technology - driven solutions aim to transform detection through automation and quantification. An emerging approach taps into two cardinal realms disrupted in Parkinson's - handwriting and speech. This survey consolidates existing techniques assessing kinetic tremor and dysarthria. It synthesizes current knowledge regarding the application of these modalities for enhanced diagnosis. The study further pioneers a predictive framework fusing representations learned from each domain. This computational architecture contrasts traditional methods grounded solely in single symptoms. By mimicking interconnected disease manifestations, the integrated approach indicates potential for improved performance over isolated metrics. Yet real-world validation across diverse, large-scale cohorts remains imperative before clinical adoption. Overall, the survey signifies promising headway at the intersection of digital health and machine learning for detecting Parkinson's disease.

## II. LITERATURE SURVEY

**[1]** This "Deep Transfer Learning Based Parkinson's Disease Detection Using Optimized Feature Selection "Early detection of Parkinson's Disease (PD), a chronic neurological condition with symptoms resembling other diseases, is crucial for timely treatment and improved patient lives. Handwritten records play a significant role in PD detection, with various machine learning methods explored. However, conventional feature extraction techniques often exhibit low accuracy. To address this, a novel deep learning model is proposed, emphasizing efficient feature selection through a genetic algorithm coupled with K-Nearest Neighbour technique. The model achieves a detection accuracy exceeding 95%, precision of 98%, an area under the curve of 0.90, and a minimal loss of 0.12. Comparative analysis with state-of-the-art approaches highlights the superior detection capability of the proposed model for early Parkinson's disease identification.

**[2]** This" Machine Learning Techniques for Voice-based Early Detection of Parkinson's Disease" Parkinson's disease (PD), a neurodegenerative condition marked by diverse motor and non-motor symptoms, prominently manifests early-stage speech and vocal impairments. In the realm of biomedical signal processing, there is a burgeoning focus on utilizing vocal analysis as a pivotal component in diagnostic systems for the timely identification of PD. Early detection not only enhances the accuracy of diagnosis and treatment but also empowers caregivers to provide more effective support. Additionally, it aids hospital management centers in optimizing resource allocation. This study delves into machine learning methodologies for predicting the early onset of PD, utilizing the UCI Machine Learning repository dataset. Various machine learning techniques are applied, revealing that a stacked model approach yields the highest efficacy, achieving an impressive 93% accuracy in detecting PD at an early stage.

**[3]** This "Early Identification of Parkinson's Disease from Hand-drawn Images using Histogram of Oriented Gradients and Machine Learning Techniques" Parkinson's disease, a significant neurodegenerative challenge, lacks specific clinical tests for accurate detection. Early identification is crucial to mitigate further damage in affected individuals. Handwriting and hand-drawn images have emerged as potential indicators of PD. This study proposes a novel approach utilizing computer vision and machine learning to predict Parkinson's disease from hand-

drawn wave and spiral images. Various classification algorithms, including Decision Tree, Gradient Boosting, K-Nearest Neighbor, and Random Forest, are applied with the HOG feature descriptor algorithm. The proposed strategy, particularly with Gradient Boosting and K-Nearest Neighbors, demonstrates superior performance in accuracy, sensitivity, and specificity, reaching 86.67%, 93.33%, 80.33% and 89.33%, 91.67%, respectively. This innovative method enhances system design flexibility for effective Parkinson's disease prediction from hand-drawn images.

**[4]** This "Deep Learning-Based Parkinson's Disease Classification Using Vocal Feature Sets" Parkinson's Disease (PD), a progressive neurodegenerative disorder, often manifests vocal impairments in its early stages. This study introduces two Convolutional Neural Network (CNN) frameworks for PD classification using vocal features. The first framework combines diverse feature sets before inputting them into a 9-layered CNN, while the second employs parallel input layers directly connected to convolution layers, allowing simultaneous extraction of deep features from each branch. Trained on a UCI Machine Learning repository dataset, both models are validated using Leave-One-Person-Out Cross Validation. Focusing on imbalanced class distribution, assessment metrics include F-Measure, Matthews Correlation Coefficient, and accuracy. Experimental results highlight the second framework's promise, leveraging parallel convolution layers to learn deep features effectively. These features not only distinguish PD patients from healthy individuals but also enhance classifier discriminative power.

**[5]** This" Feature Selection Based on L1-Norm Support Vector Machine and Effective Recognition System for Parkinson's Disease Using Voice Recordings" Efficient and early prediction of Parkinson's disease (PD) is crucial for enhancing patient quality of life. Recognizing the complexity and time-consuming nature of PD diagnosis, a machine-learning-based prediction system is proposed. Leveraging support vector machine (SVM) as a predictive model, the system incorporates L1-norm SVM for feature selection, ensuring accurate classification of PD and healthy individuals. The selected features, derived from the PD dataset, undergo validation using K-fold cross-validation. Performance metrics such as accuracy, sensitivity, specificity, precision, F1 score, and execution time are computed, showcasing the system's effectiveness. The optimal accuracy achieved underscores the significance of selected features in PD prediction. The experimental results suggest the proposed method's viability for accurate PD prediction, offering potential integration into healthcare for diagnostic purposes. This computer-assisted predictive system addresses feature selection and classification gaps in utilizing voice recordings data, contributing to PD recognition and enhancing the diagnostic process.

**[6]** This "Using Machine Learning to Diagnose Parkinson's Disease from Voice Recordings" Parkinson's Disease (PD), a neurodegenerative condition lacking standardized blood tests for diagnosis, necessitates a swift and cost-effective diagnostic approach. This study advocates employing machine learning algorithms for analyzing voice pattern variations as a unique method for predicting PD. The proposed predictive model utilizes a dataset derived from extrapolated voice recordings of both PD patients and unaffected subjects, achieving maximum accuracy. Experimental testing identified a Boosted Decision Tree, an ensemble model of gradient boosted regression trees, as the most effective, yielding an accuracy score of 91-95%. Filter-based feature detection revealed that nonlinear measures—spread1, spread2, and PPE—were the most influential features in assessing fundamental frequency variation in voice recordings. These findings have broader applications in PD, other motor disorders, and even vocal biometrics

**[7]** This "Multi-Source Ensemble Learning for the Remote Prediction of Parkinson's Disease in the Presence of Source-Wise Missing Data" In the era of widespread mobile health data collection, the challenge of missing data significantly impedes the analysis of datasets, especially in remotely diagnosing and monitoring Parkinson's disease (PD) via smartphones. This study introduces a novel approach, multi-source ensemble learning, which combines dataset deconstruction with ensemble learning to include participants with incomplete data, ensuring a 100% retention rate. Tested on a cohort of 1513 participants, where 91.2% had incomplete data in tapping, gait, voice, and/or memory tests, the method utilizes convolutional neural networks (CNNs) to capitalize on available data, boosting PD classification accuracy from 73.1% to 82.0% compared to traditional techniques. The improvement is attributed to multi-channel CNNs and the development of models with a large participant cohort. Bootstrap sampling reveals superior feature selection with a larger cohort of participants with incomplete data. This method is applicable to various wearable/remote monitoring datasets with missing data, enhancing the ability to remotely monitor PD by addressing symptom heterogeneity.

**[8]** This "The Parkinson's Disease Detection using Machine Learning Techniques." Parkinson's disease is a progressive neurodegenerative disorder that significantly impacts the quality of life, primarily affecting motor functions. Termed "parkinsonism" or "parkinsonian syndrome," its symptoms, including shaking, rigidity, slowness of movement, difficulty walking, and behavioral changes, manifest gradually. Depression and anxiety are common as well. This project introduces a voice-based model for Parkinson's detection, showcasing 73.8% efficiency. The model is trained on a substantial dataset comprising information from both normal individuals and those previously affected by Parkinson's. Utilizing machine learning algorithms, 60% of the data is employed for training, and 40% for testing. With 24 columns representing symptom values and a status column indicating the presence (1) or absence (0) of Parkinson's, the model proves effective in determining the disease status based on voice characteristics.

ISSN No:-2456-2165

## III. SYSTEM ARCHITECTURE

This innovative machine learning solution introduces a pioneering multimodal approach for the early detection of Parkinson's disease (PD). By concurrently analyzing hand movements and speech—key physical manifestations of PD—a comprehensive dataset is compiled, encompassing diverse PD severities to capture the disease's dynamic nature. Rigorous data pre-processing, including normalization and segmentation, ensures a standardized and discrete data structure, setting the stage for specialized feature engineering.

The kinematic attributes extracted from hand-drawn images, considering factors like velocity, strokes, and pressure, offer valuable insights into the degradation of fine motor control associated with PD. Simultaneously, metrics derived from speech, such as timing, articulation, and vocal frequency, unveil patterns indicative of early PD-related speech impairments. Advanced feature selection methods are employed to identify the most discriminative subsets from both modalities, facilitating a more nuanced understanding of the disease compared to approaches focusing solely on a single domain.

The integration of these complementary biomarkers holds significant promise, providing a holistic perspective on PD's early detection. By combining information from hand movements and speech, this multimodal strategy enhances the accuracy and depth of insights, potentially revolutionizing approaches to PD diagnosis and intervention.

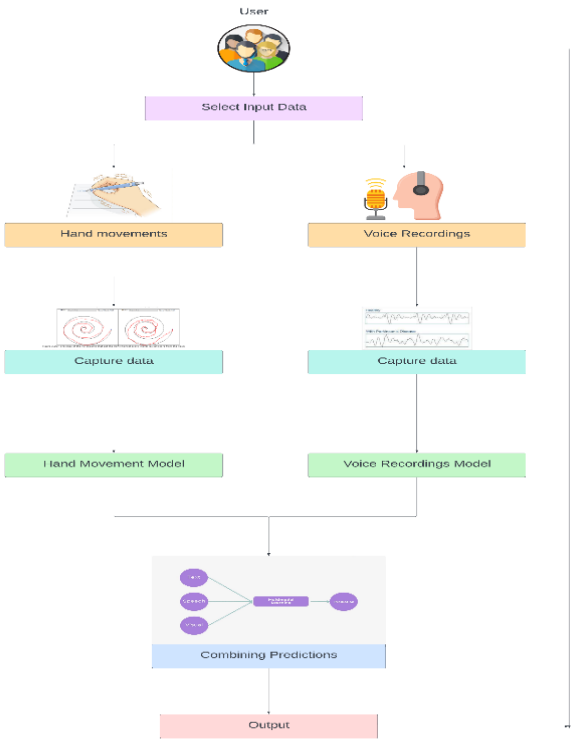


Fig 1: System architecture

## IV. APPLICATIONS

Kinematic sensors meticulously track intricate hand movements during specific tasks, compiling spatiotemporal signatures of motor impairment for subsequent computational analysis. Simultaneously, vocal recordings obtained from sustained phonations and conversational speech contribute to datasets encoding abnormalities in prosody, articulation, and phonation. Employing advanced neural architectures, the system learns latent representations within multimodal data, unveiling interactions between vocal and movement symptoms that might be imperceptible through isolated analyses. Rigorous validation procedures utilize geographically and demographically diverse datasets to assess the generalizability of the system across variable populations and diverse data collection protocols. The modular design of the system facilitates the incremental integration of emerging data modalities as ongoing research reveals new motor and non-motor indicators of disease progression. Positioned as a cost-effective screening tool, the system enables large-scale testing to identify high-risk patients who may warrant further clinical evaluation, facilitating early intervention. In adherence to ethical considerations, extensive testing for algorithmic bias and continuous model updates are implemented to prevent inaccurate or discriminatory predictions across diverse patient groups.

## V. CONCLUSIONS

This research illuminates early biomarkers of Parkinson's Disease (PD) progression through meticulous tracking of both motor and non-motor impairments preceding clinical diagnosis. Its modular architecture and extensive validation pave the way for seamless adaptation to incorporate emerging modalities like gait, sleep, and sensor-based assessments as additional indicators of early neurodegeneration. The system's capability to detect the initial emergence of symptoms allows for the optimization of treatment plans and lifestyle interventions to potentially slow the progression towards disability. Positioned as an inexpensive and non-invasive screening tool, it holds promise for enhancing access and equality in PD detection within community healthcare settings. Overall, this methodology may catalyse a paradigm shift towards preventative medicine, providing a quantitative and scalable platform for revealing the earliest physical manifestations of neurological disease.

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