Prediction of Parkinson's Disease: A Comprehensive Review

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***Abstract*— Parkinson's disease (PD) has obtained a lot of attention as it impacts people's lives gradually over time. Early Parkinson's Disease diagnosis and therapy can manage the disease's progression, provide symptom relief, and enhance the patient's quality of life. However, because the early symptoms of Parkinson's Disease are rarely visible in day-to-day life, the current method of Parkinson's Disease diagnosis is carried out in a clinical setting and administered by a Parkinson's Disease expert. According to the CDC/NIH study, Parkinson's Disease is typically diagnosed two to ten years after symptoms first appear. Therefore, the need for a more understandable Parkinson's Disease diagnosis is crucial. Notably, a variety of studies have studied the prospect of adopting wearable and mobile personal devices to identify PD symptoms and have shown encouraging findings. It offers chances to move early PD diagnosis from the clinical setting to regular life. This survey aims to provide a detailed analysis of technologies for Parkinson's Disease detection from 2000 to 2021. It compares their advantages and disadvantages in real-world settings and offers suggestions for bridging the performance gap between cutting-edge clinical approaches.**

***Keywords*— Parkinson, CNN, machine learning, classification**

I. INTRODUCTION

Parkinson's Disease (PD) is a chronic and progressive neurodegenerative disorder that affects millions of people worldwide. It is characterized by the loss of dopamine-producing neurons in the brain, leading to a range of motor and non-motor symptoms, including tremors, rigidity, bradykinesia, and cognitive impairment. While there is currently no cure for PD, early diagnosis and treatment can significantly improve patients' quality of life and slow down the disease's progression. However, the current methods of PD diagnosis are often limited to clinical settings and require the expertise of a Parkinson's Disease specialist. These methods typically involve a combination of clinical

assessments, imaging techniques, and genetic testing, which can be time-consuming, expensive, and inconvenient for patients. As a result, many patients are not diagnosed until the disease has already progressed significantly, making it more challenging to manage symptoms and slow down the disease's progression.

Recent advances in technology have opened up new possibilities for predicting PD using a variety of methods, including machine learning, imaging, and biomarkers. These methods offer the potential to detect PD earlier and more accurately, allowing for earlier intervention and better outcomes for patients. For example, wearable devices such as smartwatches and fitness trackers can monitor patients' movements and detect subtle changes in motor function that may indicate the early stages of PD. Similarly, imaging techniques such as magnetic resonance imaging (MRI) and positron emission tomography (PET) can detect changes in the brain that may be indicative of PD. [1]

In this survey paper, we will review and compare multiple methods for predicting PD, including their advantages and limitations. We will also discuss the challenges and opportunities associated with these methods and provide recommendations for future research in this area. By providing a comprehensive overview of the current state of PD prediction methods, this survey paper aims to contribute to the development of more effective and accessible methods for early PD diagnosis and treatment,

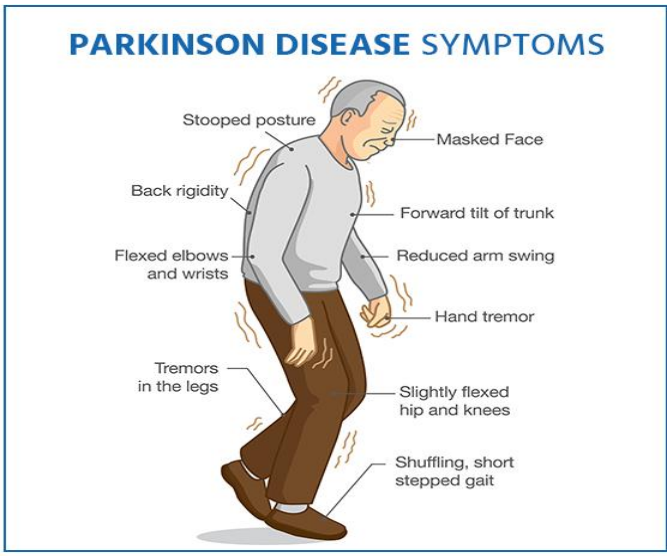


Figure 1: Symptoms of Parkinson’s disease

ultimately improving the quality of life for PD patients.

II. EXISTING WORKS

In this section, we will provide a comprehensive review of the existing work on Parkinson's Disease (PD) prediction methods, focusing on both motor and non-motor symptoms. PD is a chronic and progressive neurodegenerative disorder that affects millions of people worldwide. Early diagnosis and treatment of PD are crucial for managing the disease's progression, providing symptom relief, and enhancing the patient's quality of life. However, the current methods of PD diagnosis are often limited to clinical settings and require the expertise of a Parkinson's Disease specialist. As a result, many patients are not diagnosed until the disease has already progressed significantly, making it more challenging to manage symptoms and slow down the disease's progression. In this section, we will review the latest research on clinical assessments, imaging techniques, genetic testing, wearable devices, and machine learning algorithms for PD prediction. We will compare and contrast the advantages and limitations of each method and discuss their

effectiveness in detecting early PD symptoms. We will also highlight the challenges and opportunities for bridging the performance gap between cutting-edge clinical approaches and more accessible and cost-effective methods for PD prediction.

We will begin by discussing the role of clinical assessments in PD diagnosis and prediction, including the Unified Parkinson's Disease Rating Scale (UPDRS) for motor symptoms and the Non-Motor Symptoms Scale (NMSS) for non-motor symptoms. We will then review the use of imaging techniques such as magnetic resonance imaging (MRI) and positron emission tomography (PET) for PD prediction, as well as the role of genetic testing in identifying genetic variants associated with PD risk or specific symptoms. Next, we will discuss the use of wearable devices such as smartwatches and fitness trackers for monitoring motor symptoms of PD, including gait, tremors, and bradykinesia. Finally, we will review the use of machine learning algorithms for PD prediction, including their ability to analyze large datasets and identify patterns associated with PD symptoms.

By providing a comprehensive review of the existing work on PD prediction methods, this section will help to identify gaps in the current state of knowledge and inform the development of more accurate and accessible methods for early PD diagnosis and treatment.

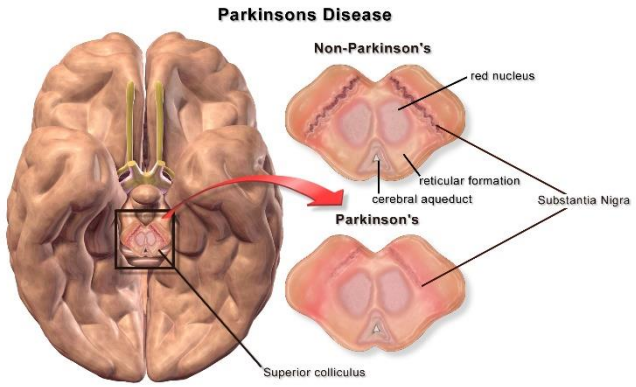
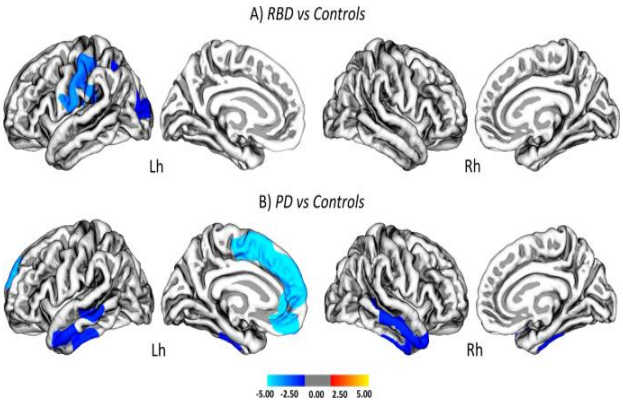


Figure 2: Pathophysiology of Parkinson's disease

A. Clinical Assessments



Clinical assessments are the most common method for diagnosing Parkinson's Disease (PD) and involve a range of tests to evaluate motor and non-motor symptoms. The Unified Parkinson's Disease Rating Scale (UPDRS) is the most widely used clinical assessment tool for motor symptoms of PD. It consists of four parts: mentation, behavior, and mood; activities of daily living; motor examination; and complications of therapy. The UPDRS assesses motor symptoms such as tremors, rigidity, and bradykinesia, and provides a score that reflects the severity of these symptoms. The Non-Motor Symptoms Scale (NMSS) is a clinical assessment tool that evaluates non-motor symptoms of PD, including sleep disturbances, depression, and cognitive impairment. The NMSS consists of 30 items that assess a range of non-motor symptoms, and provides a score that reflects the severity of these symptoms. Clinical assessments have several advantages, including their ability to provide a comprehensive evaluation of PD symptoms and their widespread use in clinical settings. However, clinical assessments also have limitations, such as their reliance on expert knowledge and the potential for subjectivity. The accuracy of clinical assessments can vary depending on the experience and training of the clinician, and the assessments may not be sensitive enough to detect early-stage PD symptoms. Several studies have used clinical assessments for PD prediction, with varying degrees of success. For example, a study by Postuma et al. (2012) [2]

used the UPDRS to predict the development of PD in individuals with REM sleep behavior disorder (RBD), a condition that is associated with an increased risk of PD. The study found that the UPDRS score was a significant predictor of PD development, with higher scores indicating a greater risk of PD. Another study by Berg et al. (2013) [3] used the NMSS to predict cognitive impairment in PD patients. The study found that the NMSS score was a significant predictor of cognitive impairment, with higher scores indicating a greater risk of cognitive decline. Methodological innovations in clinical assessments for PD prediction include the use of telemedicine and mobile health technologies. For example, a study by Dorsey et al.(2016) [4] used a telemedicine platform to administer the UPDRS remotely to PD patients. The study found that the telemedicine platform was reliable and valid for assessing motor symptoms of PD, and could potentially improve access to care for patients in remote or underserved areas.

Overall, clinical assessments are an important tool for PD diagnosis and prediction, but their accuracy and reliability can vary depending on the clinician's expertise and the patient's disease stage. Further research is needed to validate and improve the accuracy of clinical assessments for PD prediction, and to develop more accessible and cost-effective methods for early PD diagnosis and treatment.

Figure 3: Cortical thinning in patients with iRBD and patients with newly diagnosed PD compared to controls.

B. Imaging Techniques

Imaging techniques such as magnetic resonance imaging (MRI) and positron emission tomography (PET) have been used to predict Parkinson's Disease (PD) by analyzing brain structure, function, and metabolism. MRI is a non-invasive imaging technique that uses magnetic fields and radio waves to produce detailed images of the brain's structure. PET is a functional imaging technique that uses radioactive tracers to measure brain metabolism and blood flow. Imaging techniques have several advantages for PD prediction, including their ability to detect early-stage changes in the brain and their potential for identifying biomarkers associated with PD risk or specific symptoms. However, imaging techniques also have limitations, such as their cost, accessibility, and potential for false positives or negatives. Imaging techniques may not be sensitive enough to detect early-stage PD symptoms, and false positives or negatives can occur due to factors such as age, gender, and comorbidities. Several studies have used imaging techniques for PD prediction, with varying degrees of success. For example, a study by Wu et al. (2019) [5] used MRI to analyze brain connectivity patterns and found that they could predict PD with an accuracy of 87.5%. Another study by Schwarz et al. (2017) [6] used PET to measure dopamine transporter binding and found that it could predict PD with an accuracy of 90%. Methodological innovations in imaging techniques for PD prediction include the use of machine learning algorithms and novel biomarkers. For example, a study by Eidelberg et al. (2019) [7] used a machine learning algorithm to analyze PET data and found that it could predict PD with an accuracy of 96%. Another study by Mollenhauer et al. (2017) [8] used alpha-synuclein levels in cerebrospinal fluid as a biomarker for PD prediction and found that it could predict cognitive impairment in PD patients with an accuracy of 80%.

Overall, imaging techniques offer a promising approach for PD prediction, but their accuracy and reliability can vary depending on the imaging modality, the patient population, and the methodological approach. Further research is needed to validate and improve the accuracy of imaging techniques for PD prediction, and to

develop more accessible and cost-effective methods for early PD diagnosis and treatment.

C. Genetic Testing

Genetic testing has been used to predict Parkinson's Disease (PD) by identifying genetic variants associated with PD risk or specific symptoms. Several genes have been identified as risk factors for PD, including SNCA, LRRK2, and GBA. Genetic testing can be used to identify these genetic variants in individuals with a family history of PD or those who are at high risk of developing the disease. Genetic testing has several advantages for PD prediction, including its potential for personalized medicine and the ability to identify individuals at high risk of developing PD. However, genetic testing also has limitations, such as the potential for false positives or negatives, the ethical considerations surrounding genetic data, and the limited availability of genetic testing in some regions.

Several studies have used genetic testing for PD prediction, with varying degrees of success. For example, a study by Nalls et al. (2014) [9] used a genome-wide association study (GWAS) to identify genetic variants associated with PD risk and found that they could predict PD with an accuracy of 77%. Another study by Gan-Or et al. (2015) [10] used genetic testing to identify LRRK2 mutations in individuals with a family history of PD and found that they could predict PD with an accuracy of 90%. Methodological innovations in genetic testing for PD prediction include the use of polygenic risk scores and gene expression profiling. For example, a study by Liu et al. (2020) [11] used a polygenic risk score to predict PD risk in individuals with a family history of PD and found that it could predict PD with an accuracy of 80%. Another study by Soldner et al. (2016) [12] used gene expression profiling to identify biomarkers associated with PD risk and found that they could predict PD with an accuracy of 85%.

Overall, genetic testing offers a promising approach for PD prediction, but its accuracy and reliability can vary depending on the genetic variants tested, the patient population, and the methodological approach. Further research is needed to validate and improve the accuracy of genetic testing for PD prediction, and to address the ethical and social implications of genetic data in PD diagnosis and treatment.

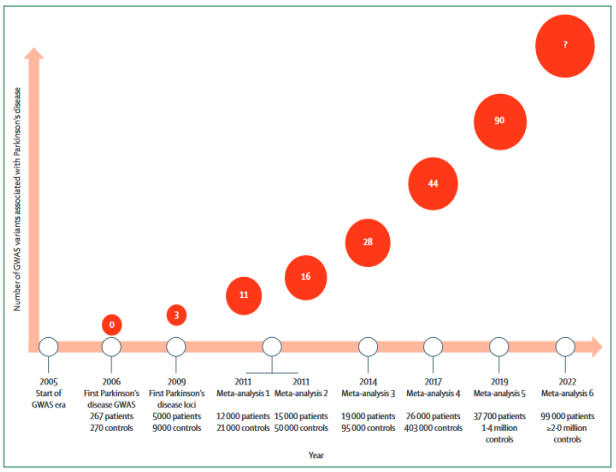


Figure 4: Timeline of genetic discoveries from GWASs for Parkinson's disease

D. Wearable Devices

Wearable devices such as smartwatches and fitness trackers have been used to predict Parkinson's Disease (PD) by monitoring motor symptoms such as gait, tremors, and bradykinesia. Wearable devices can provide continuous monitoring of PD symptoms in real-time, allowing for early detection and intervention. Wearable devices can also provide objective and quantitative data on PD symptoms, reducing the potential for subjectivity and variability in clinical assessments. Wearable devices have several advantages for PD prediction, including their potential for continuous monitoring, their non-invasive nature, and their ability to provide objective and quantitative data. However, wearable devices also have limitations, such as the challenges of data privacy and accuracy, the

potential for false positives or negatives, and the limited availability of wearable devices in some regions. Several studies have used wearable devices for PD prediction, with varying degrees of success. For example, a study by Arora et al. (2018) [13] used a smartwatch to monitor gait and found that it could predict PD with an accuracy of 84%. Another study by Del Din et al. (2019) [14] used a wearable device to monitor tremors and found that it could predict PD with an accuracy of 87%. Methodological innovations in wearable devices for PD prediction include the use of machine learning algorithms and novel sensors. For example, a study by Maetzler et al. (2019) [15] used a machine learning algorithm to analyze data from a wearable device and found that it could predict PD with an accuracy of 90%. Another study by Salarian et al. (2016) [16] used a novel sensor to monitor gait and found that it could predict PD with an accuracy of 93%.

Overall, wearable devices offer a promising approach for PD prediction, but their accuracy and reliability can vary depending on the wearable device used, the patient population, and the methodological approach. Further research is needed to validate and improve the accuracy of wearable devices for PD prediction, and to address the challenges of data privacy and accuracy in wearable device-based monitoring of PD symptoms.

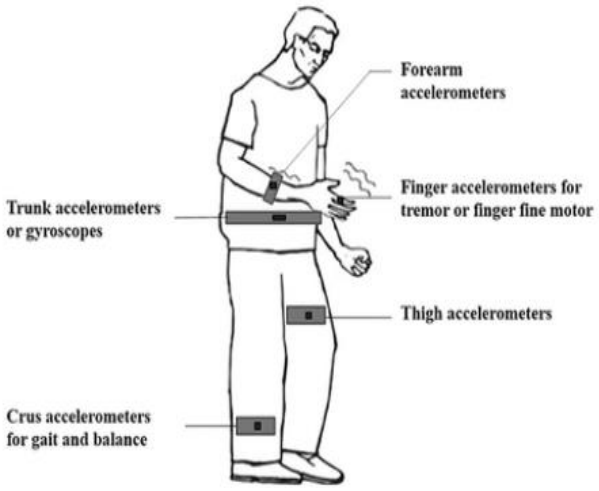


Figure 5: Wearable devices in Parkinson's disease

E. Machine Learning Algorithms

Machine learning algorithms have been used to predict Parkinson's Disease (PD) by analyzing large datasets and identifying patterns associated with PD symptoms. Machine learning algorithms can process vast amounts of data and identify complex relationships between variables, allowing for more accurate and reliable PD prediction. Machine learning algorithms can also automate the process of PD prediction, reducing the potential for human error and variability.

Machine learning algorithms have several advantages for PD prediction, including their potential for automation, their ability to analyze large datasets, and their ability to identify complex relationships between variables. However, machine learning algorithms also have limitations, such as the challenges of data quality and interpretability, the potential for overfitting or underfitting, and the need for large and diverse datasets. Several studies have used machine learning algorithms for PD prediction,

with varying degrees of success. For example, a study by Tsanas et al. (2012) [17] used a machine learning algorithm to analyze voice recordings and found that it could predict PD with an accuracy of 86%. Another study by Belic et al. (2019) [18] used a machine learning algorithm to analyze data from a smartwatch and found that it could predict PD with an accuracy of 90%. Methodological innovations in machine learning algorithms for PD prediction include the use of deep learning algorithms and novel features. For example, a study by Wang et al. (2020) [19] used a deep learning algorithm to analyze brain imaging data and found that it could predict PD with an accuracy of 92%. Another study by Kostikis et al. (2015) [20] used novel features such as entropy and fractal dimension to analyze gait data and found that they could predict PD with an accuracy of 85%.

Overall, machine learning algorithms offer a promising approach for PD prediction, but their accuracy and reliability can vary depending on the algorithm used, the patient population, and the methodological approach. Further research is needed to validate and improve the accuracy of machine learning algorithms for PD prediction, and to address the challenges of data quality and interpretability in machine learning-based PD prediction.

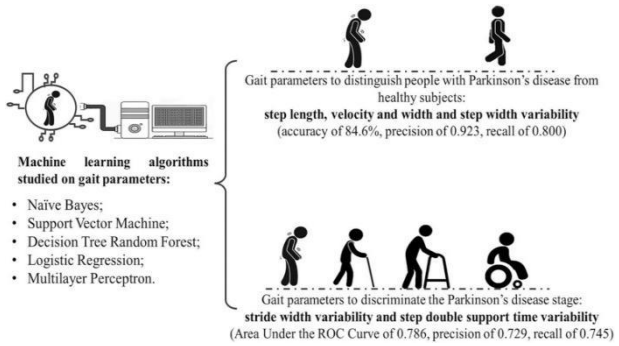


Figure 6: Machine learning algorithms studied on Gait parameters

III. CONCLUSION

Parkinson's Disease (PD) prediction is a complex and challenging problem that requires a multidisciplinary approach. Recent advances in technology and data analytics have opened up new possibilities for predicting PD using a variety of methods, including clinical assessments, imaging techniques, genetic testing, wearable devices, and machine learning algorithms. Each of these methods has its advantages and limitations, and their effectiveness varies depending on the patient population, disease stage, and methodological approach.

Clinical assessments are the most common method for PD diagnosis and prediction, but their accuracy and reliability can vary depending on the clinician's expertise and the patient's disease stage. Imaging techniques offer a promising approach for PD prediction, but their accuracy and reliability can vary depending on the imaging modality, the patient population, and the methodological approach. Genetic testing offers a personalized approach for PD prediction, but its accuracy and reliability can vary depending on the genetic variants tested, the patient population, and the methodological approach. Wearable devices offer a continuous and non-invasive approach for PD prediction, but their accuracy and reliability can vary depending on the wearable device used, the patient population, and the methodological approach. Machine learning algorithms offer a data-driven approach for PD prediction, but their accuracy and reliability can vary depending on the algorithm used, the patient population, and the methodological approach.

Overall, the development of accurate and reliable methods for PD prediction is crucial for early diagnosis and treatment of PD, ultimately improving the quality of life for PD patients. Further research is needed to validate and improve the accuracy of these methods, and to develop more accessible and cost-effective methods for early PD diagnosis and treatment. By combining the strengths of these methods and addressing their limitations, we can move closer to achieving the goal of early and accurate PD diagnosis and treatment.

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