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REVIEW ARTICLE

Artificial Intelligence in the Diagnosis of Parkinson's Disease

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Abstract: Parkinson's Disease (PD) is a progressive neurodegenerative disorder where the loss of neurons and synaptic dysfunction can be seen. The alpha-synuclein present in the filament of Lewy body gets mutated where it is connected to familial PD. The gait position, tremors, tone, Stiffness and handwriting will be seen as symptoms. Based on these, biomarkers have been used but those are late and costly in clinical practice to identify quickly weather symptoms related to PD. AI, identifies risk assessment before clinical diagnosis by the help of radio waves, breath belt data set in the natural breathing signals. Nanorobots are also introduced in the identification with help of AI and ML. This gives accurate results. The signal transmission curve will be obtained then the range in between 0.8 to 0.9 indicates the diagnosis as PD. The integration of AI algorithms in PD research has particularly shown promise in enhancing diagnostic accuracy, predicting disease progression, and personalizing treatment plans based on individual patient profiles. There are some disadvantages like data privacy and security, algorithm bias, Integration with clinical practice, cost and accessibility. However, there are several advantages like early diagnosis, Research and drug development, personalized treatment, monitoring and management. Artificial intelligence holds and plays a vital role in the future, such as Early diagnosis personalized treatment plan, continue monitoring, Remote case telemedicine, predictive analytics, integration with other technologies are capabilities of artificial intelligence improve the outcome and quality of the life for individual living with better treatment strategies.

Keywords: Neurodegenerative disorder; Parkinson's Disease; Synaptic dysfunction; Alpha-synuclein; Machine learning.

1. Introduction

Parkinson's disease has a rich and complex history that spans countries. In 1817 James Parkinson described PD as a neurological syndrome for the first time. Before James Parkinson the symptoms resembling PD were found in the ancient India Chinese and Egyptian texts. This was recognized by British physician Dr. James Parkinson. Later he provides a detailed account on Parkinson's disease describing its symptoms, progression and impact on individuals. Throughout the 19th century and early 20th century researchers made significant studies in understanding PD. French neurologist Jean marthin Charcot worked on the disease clinical features and neuropathology greatly advanced the field. He coined the term Parkinson's disease to honor Dr.parkinson's contribution. The mid 20th century saw further progress with the discovery of dopamine's re in PD by Swedish scientists Arvid Carlson and Oleh horneykiewicz. This breakthrough led to the development of levodopa. A medication that remains a cornerstone of PD treatment. Advances in neuroimaging, genetics and molecular biology have deepened our understanding of PD underlying mechanisms. Today ongoing research focuses on explaining the complex interplay of genetic environmental and neurochemical factors involved in diseases. Emerging technologies like artificial intelligence are more personalized and effective approaches to Parkinson's disease management.[1]

Parkinson's disease is differentiated into three main types namely:

Vascular parkinsonism: This type of Parkinson's disease is caused by multiple small strokes or reduced blood supply to the brain leading to the symptoms such as gait disturbances, rigidity and bradykinesia. It typically has a more abrupt onset than other forms of Parkinson's common symptoms including problems with memory, mood change, movements and sleep. [2]

Drug induced parkinsonism: Some medications particularly antipsychotic drugs and certain anti-nausea medications can induce PD symptoms as a side effect. This affects a very small number of people, and most will recover within a few days or months. The psychotic drugs which block the action of chemical dopamine in the brain are the biggest cause of drug influence. [3]

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Idiopathic parkinsonism: The exact cause of idiopathic PD is not known. The term idiopathic means an unknown origin. It involves a combination of genetic environment and lifestyle factors. The diagnosis of idiopathic PD is primarily based on clinical symptoms although neuroimaging and other tests may be used for other neurological disorders. The medication used is mainly symptoms based.[4]

Parkinson's disease (PD) affects almost 0.3% of the population. The synaptic dysfunction caused by neuronal cells leads to Parkinson's disease. The patients suffering from PD suffer with tremors, stiffness, impaired balance, difficulty in movements etc. Detection of PD in the early stage is crucial but challenging. In the beginning stages segregation of people with PD from healthy individuals is tricky.[3] The traditional method of diagnosing PD relies heavily on clinical assessment leading to challenges in early detection. Artificial intelligence (AI) has emerged as a groundbreaking technology with vast potential to revolutionize various aspects of healthcare. The AI makes significant studies in the diagnosis and management of PD. The integration of AI into PD research and clinical practice is offering promising solutions for diagnosis and treatment. AI powered algorithms can Analyze vast amounts of medical data including image scans, genetic information, improving diagnosis accuracy, predicting disease progression and patient care. It also detects subtle patterns and biomarkers associated with PD, to make more accurate and timely diagnosis and to track disease progression. The AI is driving innovation in wearable devices and sensors that can continuously monitor symptoms in real-time providing valuable insights into patient daily activities and medication response to these technological advancements and power both patients and health care providers by facilitating proactive disease management and optimizing therapeutic outcomes. In this article we will explore the intersection of artificial intelligence and PD diagnosis into the transformative impact of AI. Driven approaches on diagnosis, treatment and management strategies. [5]

2. Pathophysiology

Parkinson's disease [PD] is a progressive disorder where degeneration of neurons occurs, and progress of complexity can be seen the dopaminergic neuron and Lewy bodies are interlinking with [PD]. These neurons get degenerated which are present in substantia nigra. The intrinsic features are directly related to the mutated protein that is Alpha- synuclein which is in cytoplasm. Usually, it is a random coil that repeats itself. However, in pathological conditions it aggregates and forms Lewy bodies. Locus coeruleus and parlor of substantia nigra under microscopic examination during the pathological state catecholaminergic neurons which are pigmented get degenerated. This is interlinked with gliosis in remaining neurons the Lewy bodies can be identified. These are covered with pale halo and in the form of single/multiple and inclusion in form of round or elongated. Lewis bodies contain thin filaments which are densely packed but loose at the rim. The Alpha-synuclein is present in the filament and the gene relates to familial [PD]. This degeneration is due to exposure of [1-methyl 4- phenyl- 1,2,3,6- tetrahydropyridine], MPTP this with synthesis [the monoamine oxidase A] meperidine analogues. MAO B is essential for toxicity. Due to the exposure of pesticides the [PD] increases the risk. Alpha-synuclein is mutated due to autosomal dominant [PD].[6]

2.1. Symptoms

Parkinson's disease Symptoms starts very slowly the first Symptom are formation of tremors on single hand during this condition. Stiffness and slow movements can be identified. During the starting phase of disease, facial expressions will be diminished, or little can be observed. Movement of hands may stop, walking tone may change. Limbs get usually shaken in a rhythm due to formation of tremors and during rest the hand may tremble. During tasks shaking decreases. Bradykinesia can be observed when the movement is slowed. Things become harder and complex to perform and time consuming. While walking the movement gets slowed down. The feet may get dragged while walking during this condition. The muscle gets stiff and causes painful motion. Due to the stooped posture the balance may get disturbed. Handwriting may change and the person may feel hard to write. Due to Parkinson's disease the person may face thinking difficulty, depression and emotional changes, swallowing problems, chewing and eating problems, sleep problems, complications can be identified. [7, 8]

2.2. Diagnosis

Current diagnosis of PD is based on the clinical features from the history, examination and clinical evaluations which may or may not be sufficient for early-stage detection. The Parkinson's disease diagnosis with AI has been integrated into various scales to enhance accuracy. United Parkinson's disease rating scale (UPDRS) compromises the motor evaluation activities of daily life and complications in therapy. Movement disorder society unified Parkinson's disease rating scale (MDS-UPDRS) incorporates advancement in understanding PD and includes a broader assessment of motor and non-motor symptoms. Hoehn and Yahr scale categories PD stages based on symptom severity, ranging from mild to severe. AI models can analyze patient data to predict disease progression.[9]

3. Implementation of AI and ML models

Bioactive lipids are essential for signaling regulators even though they are part of cellular membranes. These lipids play an important role in immunological control, inflammation and homeostasis maintenance. The brain is a lipid rich organ. It regulates unique lipid flux because of blood brain barrier and high concentration of glycerophospholipid, sphingolipid and cholesterol. The dysregulation

in them can result in neuro degenerative disorder. There is no methodology for diagnosis of PD, it has become challenging and for this the biomarkers are used in the investigation of PD in the indication of beginning stages and later stages. AI is predominantly growing in the health sector especially in medical imaging and ML has the capacity to diagnose different symptoms very effectively. Nanorobots have been introduced in neuroscientific research as a brain augmentation device. Due to its small size more members are needed for microscopic and macroscopic tasks. Due to advancement in technology, digitization of healthcare and emergency of big data analysis they have provided structured and unstructured neuroimaging data in large amounts. This has become convenient for surgeons and clinicians for diagnosis of PD. These AI and ML methods help in reducing time and cost of drug discovery and development process of drugs for PD (Table 1). This helps for getting a perfect decision-making process and minimize the data errors. [10]

Table 1. Comparison of AI-based Diagnostic Methods for Parkinson's Disease

AI Method	Data Used	Accuracy	Advantages	Limitations
Nocturnal Breathing Signals	Breathing patterns during sleep	0.90-0.85 (AUC)	Non-invasive, can be done at home	Requires multiple nights of data
Support Vector Machine (SVM)	Brain imaging data	0.988 (AUC)	High accuracy, uses multiple characteristics	Requires specialized imaging equipment
Machine Learning with Bioactive Lipids	Lipid profiles	Not specified	Potential for early diagnosis	Still in research phase
AI-enhanced UPDRS	Clinical symptoms and patient history	Varies	Improves on traditional clinical scales	Depends on accurate clinical assessment

3.1. Nocturnal Breathing Signals

AI has been developed for tracking the progress of nocturnal breathing signals. This has been done on 7671 individuals by using datasets. The AI model identifies the PD curve ranges from 0.90 and 0.85 and by external test. By using disease rating scale severity and progression of PD can be estimated with respect to sleep and electroencephalogram. This can be done in a touchless manner with the help of radio waves produced during breathing at the time of sleep. PD biomarkers in cerebrospinal fluid, blood biochemical and neuroimaging have accurate predictions, but these are costly and need specialized medical Center and not suitable for early diagnosis and frequent testing. The disease progression also cannot be tracked. PD is associated with degeneration of nerves in the brainstem that controls breathing. This leads to abnormal respiratory muscle function and breathing disorders.

3.2. Radiowave transmission

This can be detected by input of night breathing signals by transmitting a low power radio signal. In this task quantitative electroencephalogram from nocturnal breathing predicts prevention of overfitting and helps in interpreting the output model. This will be low cost and measured repeatedly at home. This comes under a contactless manner. The radio sensor in sleeping room analyze the radio reflections from surroundings to obtain the breathing signals.

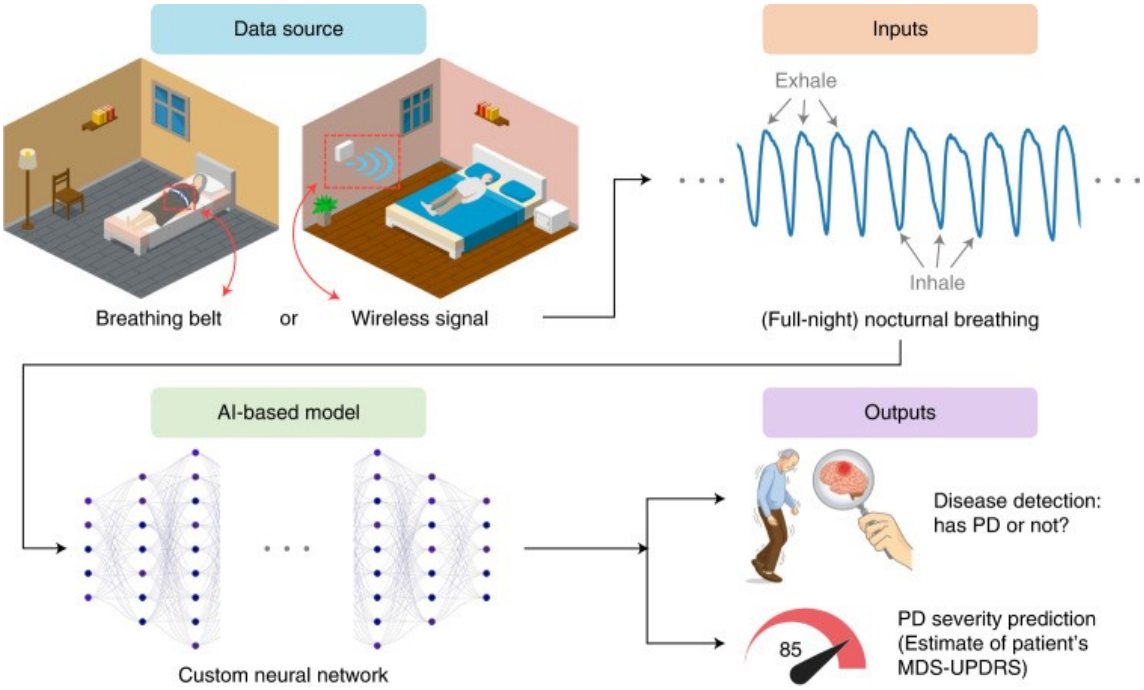

Figure 1. Implementation of AI and ML models for early diagnosis of PD

3.3. Breath belt dataset

This comes under polysomnography sleep studies. Breathing belts are used to record breathing overnight. The breathing belt achieves ROC (Receivers operating characteristic curve) of 0.884. While wireless signals achieve AUC (Area under curve) of 0.906, these values predict the PD. To achieve high test-retest reliability several nights combined from the same individual with both belt and radio waves. By this both sensitivity and specificity of PD are increased to 100%. This is computed and obtained in 12 nights. This gives highly accurate results. [5,11-15]

3.4. Diagnosis of PD with Support Vector Machine (SVM) Model

PD diagnosis is done automatically in the healthy controls by the radiomic techniques. The sub regions of the brain were identified. This is done with the help of visual basic (VB) net automatically and with the help of radiomics. The characteristics of bilateral thalamus, putamen, pallidum and caudatum have been isolated by using stochastic gradient descent, quadratic discriminant analysis and random forest of ML. It shows the best performance due to multiple characteristics. The curve identifies at 0.988 this gives much benefit for the line graph models. High accuracy for PD diagnosis will be obtained with the SVM model due to its combined characters. [16]

Table 2. Advantages and Challenges of use of AI and ML methods in the diagnosis of PD

Advantages	**Challenges**
Early detection of subtle symptoms	Data privacy and security concerns
Improved accuracy in diagnosis	Need for large, diverse datasets for training
Potential for personalized treatment plans	Integration with existing clinical workflows
Continuous monitoring of disease progression	Potential for algorithmic bias
Cost-effective and accessible (for some methods)	Regulatory approval for clinical use
Assists in drug discovery and development	Interpretation of AI results by healthcare providers

4. Conclusion

In conclusion, studies investigating various aspects of PD, from genetic predispositions to novel therapeutic interventions, have contributed significantly to our knowledge and treatment strategies. One of the key themes across these studies is the growing role of multidisciplinary approaches, combining neurology, genetics, imaging, and artificial intelligence (AI). The integration of AI algorithms in PD research has particularly shown promise in enhancing diagnostic accuracy, predicting disease progression, and personalizing treatment plans based on individual patient profiles. Moreover, the studies tracking disease trajectories and exploring biomarkers have provided valuable insights into the heterogeneous nature of PD. They emphasize the need for tailored interventions that address diverse clinical presentations and symptom severities

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Author's short biography

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Sree Mahalakshmi Pasumarthy is an Assistant Professor in the Department of Pharmacology at Narayana Pharmacy College, Nellore, Andhra Pradesh, India. Her research interests encompass in silico studies using tools such as AutoDock Vina, PyRX, and QSAR toolbox, as well as in vitro and in vivo experimental work. She completed her M.Pharm in Pharmacology from Sri Padmavathi Mahila Viswavidyalayam, Tirupathi, and subsequently undertook an internship at Pharma Deep Remedies, Hyderabad. She holds a certification in Clinical SAS and has also earned a diploma in Food & Nutrition from IGNOU, Vishakhapatnam. Her expertise extends to various aspects of pharmacology and drug delivery. Dr. Pasumarthy has presented her research on "Therapeutic Drug Monitoring" at a seminar titled "Current Achievements, Challenges and Future Prospects of Drug Delivery" held at Gokula Krishna College of Pharmacy, Sullurpet

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Deepika Katam is currently pursuing her Bachelor of Pharmacy (B.Pharm) degree at Narayana Pharmacy College. She has a keen interest in research, particularly in the fields of pharmacology and pharmacognosy. Deepika's academic focus and passion for these subjects drive her to explore innovative approaches in pharmaceutical sciences.

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Keerthika Neella is an undergraduate student in the B.Pharm program at Narayana Pharmacy College. Her academic interests lie in the research domains of pharmacology and pharmacognosy. Keerthika is enthusiastic about contributing to advancements in these fields through her studies and research endeavors.

Sowmya Gayathri Mylavarapu

Sowmya Gayathri Mylavarapu is enrolled in the B.Pharm program at Narayana Pharmacy College. She demonstrates a strong inclination towards research in pharmacology and pharmacognosy. Sowmya's dedication to these subjects reflects her commitment to expanding her knowledge and skills in pharmaceutical research.