International Journal of Medical and Pharmaceutical Research
Website: https://ijmpr.in/ | Print ISSN: 2958-3675 | Online ISSN: 2958-3683
NLM ID: 9918523075206676
Volume: 4 Issue:5 (Sep-Oct 2023); Page No: 393-397

Original Article

IJMPR

Copyright@IJMPR

Role of Ai in the Diagnosis and Management of Parkinsonism

Anuj Gautam[1], Dr. Sharadendu Bali[2*]

[1] Bsc, MBA (Hospital administration), Maharishi Markandeshwar University, Mullana, Ambala, Haryana, India
[2] Professor General Surgery, TMU, Moradabad, UP, India

ABSTRACT

Parkinson's Disease (PD) is an age-related progressive neurodegenerative disease that poses significant challenges for both patients and healthcare providers. One of the crucial challenges in PD diagnosis and management is the absence of reliable diagnostic biomarkers and variability in PD symptoms, leading to potential misdiagnoses. Artificial Intelligence (AI) solutions and quantum computing techniques can be utilized to enhance PD diagnosis, monitoring, and treatment. Several AI-based tools and systems have been developed that facilitate early diagnosis, continuous monitoring, data integration, and medication optimization. Quantum computing algorithms can further be developed to analyze medical data and make predictions regarding PD presence and progression. The accurate diagnosis of Parkinson's disease can be achieved through AI, and there is need for a strong collaboration between Artificial Intelligence (AI) and healthcare systems that can adapt to evolving needs. This will lead to a significant contribution to advancing AI in healthcare and improving patient well-being.

Key Words: *Parkinson's Disease,*

***Corresponding Author**
Dr. Sharadendu Bali*
Professor General Surgery, TMU, Moradabad, UP, India

INTRODUCTION

Parkinson's Disease (PD) is a complex and challenging neurological disorder that primarily affects movement but can also involve cognitive symptoms [1]. One of the critical challenges in Parkinson's disease management is the lack of reliable diagnostic biomarkers [2]. Diagnosing Parkinson's disease can be challenging, especially in its early stages. The similarity of its symptoms to other conditions like essential tremors or normal aging can lead to misdiagnosis. Neurologists often rely on a combination of clinical assessments, medical history, and sometimes neuroimaging (like brain scans) to help make an accurate diagnosis and rule out other conditions.

The slow and gradual progression of Parkinson's disease can make it difficult for current monitoring methods to detect subtle changes in the disease's progression [3]. Cerebrospinal fluid, neuroimaging techniques, and blood biochemical tests have demonstrated promising accuracy as potential biomarkers for Parkinson's disease [4]. These biomarkers come with high costs, entail invasiveness, and require specialized medical facilities. Thus, they are not an appropriate option for frequent assessment, which is essential for early diagnosis and continuous monitoring of disease progression.

Machine learning models have been applied to various data types in PD diagnosis, such as Handwriting patterns [5], Voice analysis [6], Movement data [7], Neuroimaging data [8], Cerebrospinal fluid (CSF) analysis [9], Optical coherence tomography (OCT) and Serum glycosylation [10]. The integration of wearable technology and AI in Parkinson's Disease diagnosis and management can help improve early diagnosis, symptom monitoring, and personalized treatment plans. It can provide valuable information to healthcare professionals and researchers, leading to more effective management of PD.

UTILIZATION OF AI IN THE MANAGEMENT OF PARKINSONISM

Symptomatology of PD

Symptoms of PD can vary significantly from person to person. This variability can lead to challenges in accurately diagnosing the disease, particularly in its early stages [11]. Therefore, it is crucial to follow an individualized approach to diagnosis, treatment, and management. Parkinson's disease can manifest with a diverse range of clinical symptoms and prognoses among patients, taking years to develop. While the risk of developing PD does increase with age, it can also affect individuals who are younger than 50, although it is less common in this age group. There is no known cure for Parkinson's disease. Based on early diagnosis, several treatment options can be utilized to help manage the symptoms such as tremors and postural instability, and improve the quality of life for patients with Parkinson's disease.

DIFFERENT MODALITIES OF AI USE IN PD

Machine learning algorithms can be used to predict the severity of PD symptoms with high accuracy [12]. Motor symptoms, such as tremors and bradykinesia, can be monitored using ***wearable sensors,*** where algorithms can provide accurate predictions of symptom severity. Wearable sensors can monitor gait patterns such as shuffling or freezing of gait and provide data for analysis to assess the severity of these symptoms [7]. Wearable devices with sensors can also capture handwriting data for analysis and provide indications of motor function impairment [13].

Yang et al. designed an AI model to detect Parkinson's disease (PD) and monitor its progression using ***nocturnal breathing patterns*** [14]. Study findings indicated the effectiveness of a novel digital biomarker, using Artificial intelligence (AI) to assist in recognizing individuals with Parkinson's disease based on their nocturnal breathing patterns while providing precise assessments of the severity and progression of the disease. This biomarker for PD possesses several characteristics. It can serve as both a diagnostic tool and a progression biomarker. It functions objectively, eliminating the subjectivity associated with assessments carried out by patients or clinicians.

Additionally, it is non-invasive and can be easily measured within the comfort of a person's own home. The utilization of wireless signals to monitor breathing patterns allows for collecting measurements in a contactless manner. The AI-based biomarker also exhibited heightened sensitivity to progressive changes in Parkinson's disease. This technique can thus yield positive results, streamlining clinical trials, lower expenses, and accelerate advancements in the field, reducing the burden on patients.

Alshammri et al. [15] carried out a PD detection project using different types of **Deep Learning** (DL) and Machine Learning (ML) models including Support Vector Machine (SVM), Decision Tree (DT), Multi-Layer Perceptron (MLP), Random Forest (RF), and K-Nearest Neighbor (KNN) applied to voice signal features to identify healthy and PD patients. Support Vector Machine (SVM) and a Multi-Layer Perceptron (MLP) method showed high accuracy in PD diagnosis. These results imply that it is easy to incorporate machine learning approaches in PD diagnosis and management. Machine learning techniques to identify PD are reliable and effective, reducing treatment costs by providing early diagnostics.

Bayestehtashk et al. [16] developed a system that applied regression analysis to determine the severity of Parkinson's disease (PD) based on ***sustained phonations***. Assessing PD severity through voice analysis during sustained phonation is a non-invasive and cost-effective approach. This model can be particularly useful in remote monitoring or telemedicine settings.

Research by Cantürk and Karabiber [17] also developed a machine learning system to detect and diagnose Parkinson's disease by analyzing ***speech patterns.*** The researcher used four different feature selection algorithms (LASSO, LLBS, mRMR, and Relief) to identify the most relevant and informative features within the speech signals that are important for diagnosing PD. The study utilized six different classifiers, including Adaboost, Support Vector Machine (SVM), Multilayer Perceptron (MLP), k-Nearest Neighbor (k-NN) and Naive Bayes (NB) and two validation methods, k-fold cross-validation and Leave-One-Subject-Out (LOSO) to assess the performance of the machine learning system, ensuring that it can effectively diagnose PD in different individuals. The feature selection (FS) algorithms consider the features of jitter (rap) and mean period, median pitch, jitter (local, absolute), AC, shimmer (apq11), jitter (ppq5), and degree of voice breaks crucial for discriminating between individuals with Parkinson's disease and healthy individuals when analyzing speech signals. The application of feature selection (FS) algorithms to a diverse dataset of speech recordings with a limited set of features resulted in a significant improvement in classification accuracy.

Neural networks promise high accuracy due to their superior optimization facilitated by activation functions. These activation functions within neural networks enable researchers to assess whether a patient with a particular feature set is affected by Parkinson's disease or not. A quantum computing system with a ***multi-layer perceptron*** was designed and predicted PD with 82% accuracy. The MLP classifier was implemented in phase 1 and different layers were generated with different rules. The MLP achieved an accuracy of 92%, while K-NN delivered an accuracy of 83% in PD recognition [18].

Vanegas et al. [19] introduced three machine-learning frameworks for the identification of **EEG biomarkers** associated with Parkinson's disease. The initial model with an extra tree classifier, achieved an impressive 99.4% Area Under the Curve (AUC) in the Receiver Operating Characteristic (ROC) analysis. These findings were based on EEG spectral amplitudes recorded from the posterior occipital region of the brain during visual stimulation in a sample of 30 control participants and 29 PD patients. The logistic regression model and decision tree model, achieved AUC values of 94.9% and 86.2% in the ROC analysis, respectively. The weights derived from the logistic regression and the decision nodes in the decision tree served to identify the specific frequency bins that had the strongest impact on distinguishing between individuals with Parkinson's disease and control subjects. The influential frequency bins spanned across the theta, alpha, and beta frequency ranges.

Another project utilized an Internet of Things (IoT)-based approach and created a series of standardized tasks and exercises and collected movement data using wearable sensors from patients diagnosed with Parkinson's disease (PD) as well as other neurological conditions. The study exhibited an integrated data analysis process for categorizing different types of tremors using machine learning techniques, focusing on the improvement of the accuracy of PD diagnosis [20].

41 PD patients and 15 patients with various neurodegenerative diseases took part in the study. The findings indicate that using machine learning techniques for data analysis and categorization of tremor types, including feature extraction, dimensionality reduction, and classification, contributes significantly to enhancing the precision of Parkinson's disease (PD) diagnosis. Considering both bradykinesia and tremor, the accuracy of distinguishing PD from similar conditions is significantly increased, resulting in an improved f1 score of 0.88 (F1 score is a machine learning evaluation metric that measures a model's accuracy).

Evans et al. [21] put into operation an innovative idea known as the **PD virtual clinic (VC)** for 61 patients diagnosed with Parkinson's disease (PD). This idea aimed to create a streamlined system that integrates home-based telemedicine solutions and digital wearable technology. Healthcare providers employed the Parkinson's Kineti Graph, a wrist-worn device designed for an objective motor assessment, to facilitate medication management and optimization. The results demonstrated the safety and efficiency of the Parkinson's VC template, with a large number of remote consultations achieving treatment outcomes similar to those observed in traditional face-to-face clinics.

With the onset of the **COVID-19 pandemic** in December 2019, there was anotion that individuals with pre-existing neurodegenerative conditions and COVID-19 may experience worsening of their neurological symptoms and even develop severe and potentially life-threatening COVID-19 pneumonia. Both during and after lockdowns, home-based telemedicine systems emerged as a reliable and cost-effective solution for healthcare professionals, including physicians and nurses, as well as patients and healthcare systems.

A study was carried out by Cilia et al in 2020, in Italy, with a two-pronged model to optimize the care of Parkinson's disease (PD) patients, exhibiting their successful experience with **telemedicine** during the COVID-19 crisis in Italy. This model progressed in two distinctive phases. The first phase introduced a novel telemedicine platform for nursing assistance services called "Parkinson Care". This telemedicine service was provided free of charge to all patients. Data analysis revealed that the telemedicine system managed 2,021 interactions (telephone calls) between nurses and 525 patients. Among the 194 video consultations conducted by a neurologist using the Zoom® platform, only 18 were unsuccessful due to patient software issues. The second phase of the model was implemented using the Microsoft Teams® platform to allow video consultations with experienced neurologists. Similar to the first phase, video consultations greatly increased between March 30 and May 14, 2020, eventually comprising over two-thirds of all outpatient assessments. Only 21.8% of patients needed in-person hospital visits. Questionnaire feedback from patients revealed that more than two-thirds of them had positive feedback, with no comments given in 28% of cases, and only 2% of PD patients with negative feedback. These results concluded that, in the future, a multidisciplinary medical team could effectively address the challenges of managing the non-motor complications of PD by utilizing home-based telemedicine applications [22].

A study in 2016 involved performing a quantitative comparison of the impact of **Robot-Assisted Gait Training** (RAGT) and treadmill training in PD patients, focusing on assessing ***gait kinematics and spatiotemporal parameters.*** The findings showed significant improvements in gait kinematics, especially in the frontal plane at the pelvic and hip joint levels among patients who followed RAGT [23]. Further research explored this comparative analysis between the two treatment models. The study aimed to evaluate the effects of RAGT using the Walkbot-S™ system on gait speed as compared to treadmill training. The research also focused on identifying the mechanisms responsible for these effects by monitoring changes in gait automaticity and brain functional networks [24]. Robot-assisted gait Training (RAGT) and treadmill training were further compared based on various parameters including walking endurance, speed, gait freezing episodes, and the overall attitude. The group utilizing RAGT experienced a significant reduction in the daily occurrences of gait-freezing episodes [25].

Medication non-adherence is another area in healthcare of patients having neurodegenerative disorders, where AI can play a role. Non-compliance with medication schedules can result in high health risks and increased medical expenses. Adherence to medication schedules can be monitored by analyzing movement patterns in the case of many neurological disorders. Healthcare providers typically rely on visual assessments of movement, primarily constrained to clinical evaluations. Thus, monitoring medication adherence becomes particularly challenging when patients are outside the clinical settings.

Tucker et al. [26] evaluated ***non-wearable sensors*** to create a model for predicting drug treatment adherence, away from the hospital setting. Gait variations and data mining techniques were utilized for analysis. The study employed seven PD patients who were assessed both when they were off their dopaminergic drugs (after more than 12 hours without medication) and when they were under therapy (at least 1 hour following drug administration). During each assessment, the patients underwent a walking trial. The Microsoft Kinect, an off-the-shelf sensor capable of capturing 3D skeletal images was used. The recorded data was processed and demonstrated a strong relation between identifying adherence and non-adherence and patterns of whole-body movement. The study identified evaluation methods to offer healthcare providers the opportunity to receive real-time and concise feedback on patient adherence. Most importantly, this assessment can take place in non-clinical settings and be transmitted remotely to healthcare professionals. The study outcomes align with the observed motor function impairments caused by non-adherence and indicate that skeletal data mining is a useful tool for detecting adherence issues. This methodology presents a practical and cost-effective way to remotely identify medication adherence. It is also valuable for patients, as they can receive self-reminders if instances of non-adherence are identified.

DISCUSSION

One of the critical challenges in the management of Parkinson's disease is the lack of reliable diagnostic biomarkers [2]. Diagnosing Parkinson's disease can be challenging, especially in its early stages. The similarity of its symptoms to other conditions like essential tremors or normal aging can lead to misdiagnosis. Neurologists often rely on a combination of clinical assessments, medical history, and sometimes neuroimaging (like brain scans) to help make an accurate diagnosis and rule out other conditions. The challenge of accurate diagnoses can be met with a strong collaboration between Artificial intelligence (AI) and the routine methodology employed by healthcare systems. Addressing these challenges through AI-based solutions is imperative and timely. AI algorithms can offer cost-efficient alternatives to conventional diagnostic and treatment methods. Also, it is crucial to further explore the potential impact of complete autonomous management on the quality of life (QoL) of PD patients.

Research into Parkinson's disease continues to advance, with efforts aimed at better understanding of its causes, identifying less expensive diagnostic tools, developing more effective treatments, and potentially finding ways to slow or halt disease progression at an early stage. Machine learning techniques are playing a crucial role in the healthcare sector. Machine learning enables computer programs to learn and extract meaningful insights from data. Further research should be carried out to leverage AI solutions to enhance PD diagnosis, monitoring, and treatment. This is highly relevant, given the global increase in PD prevalence, the impact of the COVID-19 pandemic, and the existing shortages of healthcare professionals.

CONCLUSION AND FUTURE PERSPECTIVES

This paper has emphasized on the effective utilization of AI and quantum computing for PD diagnosis and management, addressing a critical global need. Products that utilize AI and Quantum Computing for PD diagnosis and digital presentation are currently in the early stages of development. Therefore, it is a unique and innovative perspective to assess the feasibility of utilizing AI-based and quantum technologies for the early and cost-effective diagnosis and automated management of various stages of Parkinson's disease. Various research groups are actively involved in developing such diagnostic products. The cost-efficiency of AI algorithms as compared to conventional diagnostic and treatment methods is a key consideration for healthcare providers and patients. Furthermore, this innovative approach can help to achieve complete autonomous management of PD, thus improving patients' quality of life. The expected outcomes of AI in the management of Parkinsonism include improved early PD diagnosis, enhanced symptom tracking, personalized treatment, efficient utilization of healthcare resources, and an improved quality of life for PD patients.

REFERENCES

1. Srivastava, S. (2021). Genetic Algorithm Optimized Deep Learning Model for Parkinson Disease Severity Detection. Ph.D. Thesis, National College of Ireland, Dublin, Ireland.
2. Delenclos, M., Jones, D. R., McLean, P. J. &Uitti, R. J. (2016). Biomarkers in Parkinson’s disease: advances and strategies. Parkinsonism Relat. Disord. 22, S106–S110.
3. Evers, L. J. W., Krijthe, J. H., Meinders, M. J., Bloem, B. R. & Heskes, T. M. (2019). Measuring Parkinson’s disease over time: the real-world within-subject reliability of the MDS-UPDRS. Mov. Disord. 34, 1480–1487.
4. Tang, Y. et al. (2017). Identifying the presence of Parkinson’s disease using low-frequency fluctuations in BOLD signals. Neurosci. Lett. 645, 1–6.
5. Pereira C. R., Pereira D. R., Rosa G. H., Albuquerque V. H. C., Weber S. A. T., Hook C., et al.. (2018). Handwritten dynamics assessment through convolutional neural networks: An application to Parkinson's disease identification. Artif. Intell. Med. 87, 67–77. 10.1016/j.artmed.2018.04.001
6. Sakar B. E., Isenkul M. E., Sakar C. O., Sertbas A., Gurgen F., Delil S., et al.. (2013). Collection and analysis of a Parkinson speech dataset with multiple types of sound recordings. *IEEE J. Biomed. Health Inform*. 17, 828–834. 10.1109/JBHI.2013.2245674
7. Pham TD, Yan H. (2018). Tensor Decomposition of Gait Dynamics in Parkinson's Disease. *IEEE Trans Biomed Eng*. 65(8):1820–1827. doi: 10.1109/TBME.2017.2779884.
8. Segovia F., Górriz J. M., Ramírez J., Martínez-Murcia F. J., Castillo-Barnes D. (2019). Assisted diagnosis of Parkinsonism based on the striatal morphology. *Int. J. Neural Syst*. 29:1950011. 10.1142/S0129065719500114
9. Maass F., Michalke B., Willkommen D., Leha A., Schulte C., Tönges L., et al.. (2020). Elemental fingerprint: reassessment of a cerebrospinal fluid biomarker for Parkinson's disease. Neurobiol. Dis. 134:104677.

10.1016/j.nbd.2019.104677
10. Váradi C., Nehéz K., Hornyák O., Viskolcz B., Bones J. (2019). Serum N-glycosylation in Parkinson's disease: a novel approach for potential alterations. Molecules 24:2220. 10.3390/molecules24122220
11. Adler, C. H., Beach, T. G., Hentz, J. G., Shill, H. A., Caviness, J. N., Driver-Dunckley, E., ... & Dugger, B. N. (2014). Low clinical diagnostic accuracy of early vs advanced Parkinson disease: *clinicopathologic study. Neurology*, 83(5), 406-412.
12. Belić M, Bobić V, Badža M, Šolaja N, Đurić-Jovičić M, Kostić VS. (2019). Artificial intelligence for assisting diagnostics and assessment of Parkinson's disease-A review. *Clin Neurol Neurosurg*. 184:105442. doi: 10.1016/j.clineuro.2019.105442. http://paperpile.com/b/L0Ug4Q/5EkR
13. Drotár P, Mekyska J, Rektorová I, Masarová L, Smékal Z, Faundez-Zanuy M. (2015). Decision support framework for Parkinson's disease based on novel handwriting markers. *IEEE Trans Neural Syst Rehabil Eng*. 23(3):508–16. doi: 10.1109/TNSRE.2014.2359997.
14. Yang, Y., Yuan, Y., Zhang, G. et al. (2022). Artificial intelligence-enabled detection and assessment of Parkinson's disease using nocturnal breathing signals. Nat Med 28, 2207–2215. https://doi.org/10.1038/s41591-022-01932-x
15. Alshammri R, Alharbi G, Alharbi E, Almubark I. (2023). Machine learning approaches to identify Parkinson's disease using voice signal features. Front ArtifIntell. 6:1084001. doi: 10.3389/frai.2023.1084001. PMID: 37056913; PMCID: PMC10086231.
16. Bayestehtashk A., Asgari M., Shafran I., McNames J. (2015). Fully automated assessment of the severity of Parkinson's disease from speech. Comput. Speech Lang. 29:172–185. doi: 10.1016/j.csl.2013.12.001.
17. Cantürk, İ., &Karabiber, F. (2016). A Machine Learning System for the Diagnosis of Parkinson's Disease from Speech Signals and Its Application to Multiple Speech Signal Types. Arabian Journal for Science and Engineering, 41(12), 5049–5059. doi:10.1007/s13369-016-2206-3
18. Swarna, S. R., Kumar, A., Dixit, P., & Sairam, T. V. M. (2021). Parkinson's Disease Prediction using Adaptive Quantum Computing. 2021 Third International Conference on Intelligent Communication Technologies and Virtual Mobile Networks (ICICV). doi:10.1109/icicv50876.2021.9388628
19. Vanegas, M.I.; Ghilardi, M.F.; Kelly, S.P.; Blangero, A. (2018). Machine learning for EEG-based biomarkers in Parkinson's disease. In Proceedings of the 2018 *IEEE International Conference on Bioinformatics and Biomedicine (BIBM*), Madrid, Spain, pp. 2661–2665.
20. Talitckii, Aleksandr & Kovalenko, Ekaterina & Anikina, Anna & Zimniakova, Olga & Semenov, Maxim & Bril, Ekaterina & Shcherbak, Aleksei & Dylov, Dmitry & Somov, Andrey. (2020). Avoiding Misdiagnosis of Parkinson's Disease with the Use of Wearable Sensors and Artificial Intelligence. IEEE Sensors Journal. 21. 1-1. 10.1109/JSEN.2020.3027564.
21. Evans L, Mohamed B, Thomas EC. (2020). Using telemedicine and wearable technology to establish a virtual clinic for people with Parkinson's disease. *BMJ Open Qual.* 9(e001000) doi: 10.1136/bmjoq-2020-001000
22. Cilia R, Mancini F, Bloem BR, Eleopra R. (2020). Telemedicine for parkinsonism: A two-step model based on the COVID-19 experience in Milan, Italy. Parkinsonism Relat Disord. 75:130-132. doi: 10.1016/j.parkreldis.2020.05.038. Epub 2020 Jun 10. PMID: 32723588; PMCID: PMC7286232.
23. Galli M, Cimolin V, De Pandis MF, Le Pera D, Sova I, Albertini G, Stocchi F, Franceschini M. (2016). Robot-assisted gait training versus treadmill training in patients with Parkinson's disease: A kinematic evaluation with gait profile score. *Funct Neurol*. 31:163–170. doi: 10.11138/fneur/2016.31.3.163.
24. Kang MG, Yun SJ, Shin HI, Kim E, Lee HH, Oh BM, Seo HG. (2019). Effects of robot-assisted gait training in patients with Parkinson's disease: Study protocol for a randomized controlled trial. Trials. 20(15) doi: 10.1186/s13063-018-3123-4.
25. Capecci M, Pournajaf S, Galafate D, Sale P, Le Pera D, Goffredo M, De Pandis MF, Andrenelli E, Pennacchioni M, Ceravolo MG, Franceschini M. (2019). Clinical effects of robot-assisted gait training and treadmill training for Parkinson's disease. A randomized controlled trial. *Ann Phys Rehabil Med*. 62:303–312. doi: 10.1016/j.rehab.2019.06.016.
26. Tucker CS, Behoora I, Nembhard HB, Lewis M, Sterling NW, Huang X. (2015). Machine learning classification of medication adherence in patients with movement disorders using non-wearable sensors. *Comput Biol Med*. 66:120–134. doi: 10.1016/j.compbiomed.2015.08.012.