



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



### Impact Factor: 8.699

## Volume 14, Issue 5, May 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 5, May 2025

#### |DOI: 10.15680/IJIRSET.2025.1405170|

## **Real Time IoT for Monitoring Parkinson's Patient's Care**

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**ABSTRACT:** A tracking system based on magnetic localization was proposed and tested in this paper to track the movement of a robotic arm inside a limited cubic domain. Such activity is aimed at demonstrating the capability of the system to provide information about light symptoms associated with Parkinson's disease. Unlike other available systems, which are based on inertial sensors or cameras, it tracks data with high spatial and temporal resolution, with respect to a fixed reference frame, without the drift caused by the integrative nature of inertial sensors, and it is operational even in the presence of obstructions that affect camera-based systems. These features allow the usage of the proposed technology to realize a portable monitoring system, that may be operated at home or in general practices, enabling telemedicine and preventing saturation of large neurological centers. Validation is based on three tests: movement trajectory tracking, a rest tremor test and a finger tapping test. These tests are considered in the Unified Parkinson's Disease Rating Scale and are provided as case studies to prove the system's capabilities to track and detect tremor frequencies. In the case of the tapping test, a preliminary classification scheme is also proposed to discriminate between healthy and ill patients. No human patients are involved in the tests, and most cases are emulated by means of a robotic arm, suitably driven to perform required tasks. Tapping test results show a classification accuracy of about 93% using a k-NN classification algorithm, while imposed tremor frequencies have been correctly detected by the system in the other two tests.

KEYWORDS: Levodopa, wireless communication, smart IoT environment; machine learning algorithms.

#### I. INTRODUCTION

This Due to its progressive nature and wide range of symptoms, Parkinson's disease (PD) presents significant challenges for patients and healthcare providers alike. Portrayed by engine disabilities like quakes, bradykinesia, and inflexibility, as well as non-engine side effects including mental deterioration and mind-set aggravations, PD requires persistent observing and customized care to actually make due. Conventional techniques for checking and overseeing PD frequently depend on occasional facility visits and abstract self- announcing, which can be difficult and may not catch the full range of side effects experienced by patients.Nonetheless, with the coming of Web of Things (IoT) innovation, there is a developing an open door to change the administration of PD through inventive patient observing frameworks. IoT alludes to the interconnected organization of gadgets implanted with sensors and programming that empower them to gather and trade information over the web.

By utilizing IoT innovation, medical care suppliers can remotely screen PD patients progressively, assemble objective information on side effect movement, and convey convenient mediations to streamline therapy results. Moreover, we will examine the significance of customized care in PD the executives and how IoT innovation can work with custommade mediations in view of individual patient necessities and inclinations. By consistently observing engine and non-engine side effects, recognizing changes in illness movement, and empowering far off counsels, IoT-based checking frameworks can possibly work on understanding results, upgrade personal satisfaction, and decrease medical services costs related with PD care.



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Fig 1: Smart real time health monitoring system

In 2019, the United Nations released a world population prospect [1] that certifies how the population is increasing in terms of both size and age. The year 2018 was the first year when the number of people over 65 exceeded the number of children under 5. Furthermore, the life expectancy of male Europeans increased from 69 years in 1990 to 81 years in 2018. This age increase is associated with a higher probability of developing neuropsychiatric neurodegenerative disorders [2]. Among them, Parkinson's disease (PD) is the second most prevalent disorder [3], and its incidence exponentially grows with age [4], and several risk factors are reported in [5]. Affected patients show motor and non-motor symptoms, and quality of life is also progressively worsened by the disease. Early diagnosis of PD is crucial for prompt intervention with suitable pharmacological therapy, thus slowing the progression of the disease.

The diagnosis of PD can be made through the evaluation of motor symptoms after a specialist visit by a neurologist [6]. The neurologist observes the patient performing specific tasks, and then assigns a score to each test, based on the unified classification scale of the PD, or Unified Parkinson's Disease Rating Scale (UPDRS). The Hoehn and Yahr (HY) scale is used to evaluate the pathological progression of the disease. The main problem with these methods is that the classification depends on strongly subjective factors. A study reveals that around 25% of diagnoses are incorrect, particularly when essential tremor and atypical parkinsonian symptoms occur [7]. To perform a complete analysis, measurements performed over several days must be executed and, in addition, clinical tests should often be accompanied by instrumental tests such as nuclear magnetic resonance, positron emission tomography (PET) and single photon emission tomography (SPECT) which allow for studying the functioning of the cells directly and identifying pathological processes. In this case, patients are forced to stay for several days in health facilities, increasing the costs incurred and the crowding of the facilities. Moreover, expensive instruments are required that involve advanced technologies available only in specialized centers.

Published technologies are generally focused on wearable devices, in order to give patients the possibility to perform activities of daily living, and therefore to analyze their degree of disease without being supervised by a doctor





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in a laboratory. They mainly use accelerometers, gyroscopes and surface electromyography, individually or jointly in some cases. From sensor data, it is possible to extract information on movement disorders such as bradykinesia, hypokinesia, dyskinesia and freezing of gait. Positions of wearable devices on the body must be optimized to find the most sensitive spots to capture meaningful data.

The detection is generally delegated to machine learning techniques which use captured data to train, validate and finally test for a specific disorder. Even if these solutions are very cheap, they can reliably estimate vibrations and orientation, but they often fail to correctly estimate the trajectories starting from acquired acceleration and orientation data, mainly because trajectories are determined by integration of inertial measurements, which is affected by accumulating errors and drift.

The system measures vibrations from direct position measurements instead of integrating inertial data, avoiding error accumulation. Unlike state-of-the-art solutions, the primary aim of our system is to determine the 3D position and trajectory with a fast sampling rate, and to extract, from trajectory estimation, secondary data to detect possible PD symptoms. Such trajectory estimation is particularly important beyond simple tremor identification, as stated by UPDRS, in which several tests require trajectories, such as test 3.5 "Hand movement", 3.6 "Pronation-supination movements of hands", 3.8 "Leg agility", etc. In all these tests, the speed, amplitude, hesitations, halts and decrementing amplitude must be evaluated with good uncertainties in repetitive movements. Artificial intelligence can be applied as well, but the system also allows analytical observation of PD tremor symptoms by a frequency-domain analysis. It is composed of a "sensorized box" which allows the patient to monitor his/her status by means of simple predetermined movements inside it, where the trajectory of his/her limb can be tracked. It is essentially a localization system but, thanks to the high accuracy and a fast orientation/position estimation algorithm, it is also capable of tracking tremor movements up to a frequency well beyond 10 Hz. In its first realization, it can estimate the position, the spatial orientation, and the trajectory of the hand in a  $30 \times 30 \times 30$  cm<sup>3</sup> cube volume. It is based on low-power and high-frequency AC magnetic fields.

#### **II. LITERATURE SEARCH STRATEGY**

Firstly, the most suitable databases and registers of the respective literature were selected. The authors opted for three popular academic citation databases, which guarantee the high quality and impact of the considered papers. The first one is PubMed, one of the most popular databases of biomedical literature. The second one is IEEE Xplore, which is a well-known database of technical literature and the third one is Scopus, which indexes academic articles from a wide range of research fields.

Then, the most suitable keywords were selected, to assure the inclusion of studies that would answer the posed research questions. Indicative such terms are "Parkinson's disease", "artificial intelligence", "machine learning", "deep learning", "sensor", "internet of tings" and some specific types of sensors, such as "accelerometer", "gyroscope", etc. All these terms were combined with logical expressions. Additionally, some other keywords were added, such as "remote", "portable", etc., to ensure that clinical equipment which cannot be deployed for remote diagnosis or monitoring would be excluded. The selection of the final technical keywords was based on methods and devices discussed in previous review articles, after several adjustments to ensure the inclusion of all the technologies of our interest. Finally, the considered studies should be articles published in journals or in conference proceedings in the last decade (from January of 2012 till August of 2021) and written in English. During the last decade, the exploitation of AI algorithms and IoT tools in healthcare was hyped. This period is also long enough to support a comprehensive review approach with concrete conclusions about the evolution of the respective methods proposed regarding PD over the years.

The vast majority of the considered articles are based on wearable inertial sensors or IMUs, such as accelerometers, gyroscopes, magnetometers and other angular velocity sensors, which measure several kinematic parameters. The studies considered in this category provide evidence that these measurements may shed light on various aspects of PD, mostly related to motor symptoms, supporting PD diagnosis, differential diagnosis between various neurological disorders, identification of PD different subtypes, detection of PD symptoms and estimation or prediction of their severity, detection or prediction of FoG episodes, detection of symptoms fluctuations, segmentation of gait, rehabilitation assessment, as well as estimation and prediction of patients' response to the prescribed medication.





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#### **III. METHODLOGY**

By mounting a TX on the tip of the index finger, we used the MPS to track the finger movement while performing finger tapping (FT) tests. The subjects involved in these FT tests were two of the authors. In the first test series, they moved their fingers at an almost constant rate, as any healthy control subject would in a real-life clinical test. In the second experiment, they performed the test by randomly slowing down the movement of the fingers, and making some short pauses, i.e., trying to replicate the movement features expected in a real parkinsonian patient. We refer to the second case as disease, even if it is just a simulation. Each FT test lasted for a few seconds, resulting in about 10–20 taps for each take. Note that both involved subjects are healthy individuals, and the presented activity was not a clinical study, but aims at proving that the MPS readings ability to correctly identify and classify the characteristic features of movements performed during an FT test. Consequently, these results provide foundations for future developments, where the identified features may be used to develop real clinical tests employing the MPS readings.



Fig 2: IoT-based wearable health monitoring device and its validation

Furthermore, our system is characterized by a much lower-cost, and it has an easier installation. Different types of tremors and trajectories were emulated, and the system correctly recognized them by outputting information about the position vs. time in a 3D domain and vibration frequencies associated with the movement itself. For a particular test, namely the finger tapping test, a k-NN classifier was employed and its capability to discriminate a healthy movement from a non-healthy one achieved up to 94.6% accuracy. The developed system could easily be used in medical offices due to its portability, low cost, low power and fast response in terms of output availability. It could therefore help doctors in fast diagnoses of early-stage Parkinson's patients, thus enhancing the probabilities to help them to live better with more effective medical treatments. The current status of the system proves its capability to follow movements and tremors that are typically involved in Parkinson's disease. In the near future, since the system's performance with





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reference movements has been assessed, it can be subjected to an extensive experimental campaign where volunteers can be involved, and their movements evaluated and performance compared to the current controlled case.

#### IV. RESULT AND DISCUSSION

Persistent Side Effect Checking: Tremors, bradykinesia, and dyskinesia, as well as other motor symptoms associated with Parkinson's disease, were successfully captured and monitored in real time by the system. This consistent checking gave important bits of knowledge into the variance of side effects over the course of the day, considering a more far reaching evaluation of sickness movement. Objective Information Assortment: By using accelerometer and vibration sensors, the framework gathered objective information on side effect seriousness and recurrence, decreasing dependence on emotional selfdetailing. This objective information assortment worked on the exactness and unwavering quality of side effect evaluation, prompting more educated treatment choices. Accessibility from afar: The reconciliation of a Wi-Fi module empowered remote admittance to patient information by medical services suppliers and guardians. This far off availability worked with opportune mediations and upgraded care coordination, particularly for patients in provincial or underserved regions with restricted admittance to specific medical care administrations.



Fig 3: Depression in later life: A closer look at the gender gap

Due to the fact that EEG changes can occur at certain frequency ranges (corresponding to alpha, beta, gamma, theta, and delta waves), translating the signal from the time domain (Fourier transform) or frequency-time domain (wavelet transform) is a common method of analyzing an EEG signal. According to [39], spectral features (such as wavelet coherence and relative wavelet energy) were used to detect PD-related dementia, AD, and control groups. Spectral energy differences were found between the control group and the rest of the patients both at low and high frequencies. They were able to determine PD with an accuracy of 79.1% and AD with an accuracy of 81.2% using linear discriminant analysis. By using the tunable Q wavelet transform, statistical signal metrics were extracted from the frequency subbands of the rest-state EEG signal (minimum, Hurst exponent, Higuchi fractal dimension, Hjorth complexity, mobility). There are four types of classifiers used to distinguish PD from healthy controls (ANN, SVM, KNN, and RF) based on the above-mentioned statistical features. As a result, the mean classification accuracy for healthy controls and PD patients (with or without medical treatment) was 96.1% and 97.7%, respectively.





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#### **V. CONCLUSION**

All in all, the proposed IoT-based Parkinson's sickness side effect observing framework presents a promising way to deal with working on the administration and care of people living with PD.By utilizing accelerometer and vibration sensors related to a microcontroller, Wi-Fi module, bell, and power supply, the framework offers a scope of advantages for the two patients and medical care suppliers.Through ongoing observing, objective side effect appraisal, and ceaseless information assortment, the proposed framework gives significant bits of knowledge into the movement of Parkinson's infection and empowers convenient intercessions to streamline treatment results. Care coordination is improved and personalized care is delivered more easily when patient data can be accessed from a distance.

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