Jurnal Informatika Universitas Pamulang **ISSN: 2541-1004**
Penerbit: Program Studi Teknik Informatika Universitas Pamulang **e-ISSN: 2622-4615**
Vol. 8, No. 2, Juni 2023 (292-297) **10.32493/informatika.v8i2.32842**

Design and Development Early Detection of Neurodegenerative Disease Using IoT Technology

Safira Faizah[1], Dian Nugraha[2], M. N. Mohammed[3], Muhammad Irsyad Abdullah[4]

[1,2]Department of Informatics Engineering, Jakarta Global University, Depok, Indonesia
[3]Department of Mechanical Engineering, Gulf University, Sanad, Kingdom of Bahrain
[4]Department of Engineering & Technology, Faculty of Information Sciences and Engineering, Management and Science University
e-mail: [1]safirafaizah@jgu.ac.id, [2]dian@jgu.ac.id, [3]dr.mohammed.alshekhly@gulfuniversity.edu.bh, [4]irsyad@msu.edu.my

Submitted Date: June 15th, 2023 Reviewed Date: June 22nd, 2023
Revised Date: June 27th, 2023 Accepted Date: June 30th, 2023

Abstract

Parkinson's disease (PD) stands as one of the most prevalent conditions, impacting approximately 6.3 million individuals globally. This disorder becomes even more complex due to commonly associated non-motor symptoms like depression, cognitive impairments, and disruptions in sleep patterns. The root of PD remains largely unclear as a significant portion of cases lack a specific cause. In the initial phases of the illness, prominent indicators encompass tremors, rigidity, slowed motion, and difficulties in mobility. Presently, patients are obligated to have appointments with their medical practitioner at intervals of six months to a year, typically for brief consultations. The visit to the medical facility offers a limited glimpse into the patient's state, frequently failing to capture the day-to-day obstacles they encounter. The current evaluation methods are insufficient in comprehending this matter. This highlights the significance of promptly identifying PD, as it allows for the early implementation of treatment measures and management tactics. Additionally, this suggested approach contributes to the enhancement of human life within the healthcare framework and holds the potential to identify Parkinson's disease swiftly and precisely.

Keywords: Neurodegenerative disease; Parkinson disease; Internet of thing; Healthcare system

1 Introduction

Parkinson's Disease (PD) arises from the dysfunction of essential neurons situated in the substantia nigra area of the midbrain. This condition significantly impacts patients along with their families, positioning it as the second most prevalent neurodegenerative ailment following Alzheimer's disease. The World Health Organization (WHO) reports a global count of over six million individuals living with and affected by this condition. It's worth noting that most cases are observed in men, with a ratio of 3:2 in comparison to women (Bhat et al., 2018; Max A. Little, 2008; Muliawan et al., 2018; Pastorino et al., 2013; Vidya et al., 2018). The typical motor symptoms of Parkinson's disease encompass postural instability, reduced movement speed, muscle rigidity, tremors, a bent posture, and gait freezing. Additionally, PD is often identified by the absence of regular speech prosody (Darkins et al., 1988; Eskidere et al., 2016; Pastorino et al., 2013). Hughes and Roller noted that there are no particular tests or biomarkers accessible for the diagnosis of PD. Primarily, the existing diagnostic standards derived from motor symptoms rely on clinical criteria reported by patients during stable periods and subsequently assessed by neurologists (a subjective process). Research has indicated an approximate misdiagnosis rate of 25% for PD, with around 40% of cases being mistaken for other neurological conditions. This is largely due to a lack of precise and objective data available to specialists regarding crucial factors such as the frequency and severity of the disease's distinctive features. (Bermeo et al., 2016; Braybrook et al., 2016; Mohammed Abdulrazaq et al., 2020; Perumal & Sankar, 2016).

The term "Internet of Things" (IoT) represents a universe characterized by complete

ISSN: 2541-1004
e-ISSN: 2622-4615
10.32493/informatika.v8i2.32842

interconnectedness, providing advanced technological solutions to elevate healthcare and simultaneously presenting novel and exciting opportunities across nearly every facet of our existence (Poongodi et al., 2019; Strielkina et al., 2017; et al., 2019). IoT in healthcare presents a contemporary perspective that extends services and medical information to even more remote domains. The IoT framework in the medical field has progressed significantly, incorporating a diverse array of components such as intelligent sensors, medical apparatus, substantial data analytics, cloud computing, telemedicine, clinical information systems, and numerous others (Mohammed Abdulrazaq et al., 2020; Strielkina et al., 2017). Intelligent healthcare is a wellbeing administration system that utilizes innovation, for example, wearable gadgets, IoT, and versatile web to progressively get data, associate individuals, materials and foundations identified with healthcare services, and afterward effectively oversee and react to therapeutic environment needs in an insightful way. An intelligent healthcare services system might be operated at the home, inside a network, or even be utilized widely in the world (Mohammed, Desyansah, et al., 2020; Mohammed, Hazairin, et al., 2020).

Given these circumstances, there arises a requirement for a systematic identification approach that encompasses both the extended duration assessment of symptom severity. One such approach involves offering cost-free healthcare services, fostering heightened engagement among all stakeholders within the healthcare domain. This not only ensures that participants receive necessary services, but also aids parties in making informed decisions by facilitating the exchange of information and promoting an equitable allocation of resources. Novel technologies enable the monitoring of disease progression, employing an extensive array of wearable micro-sensors that are user-friendly. Furthermore, the integration of specialized sensors designed for remote health monitoring has become feasible due to advancements in technology. These innovations furnish dependable data for both qualitative and quantitative evaluation of individuals grappling with neurodegenerative conditions, particularly Parkinson's disease. (Pastorino et al., 2013; Tian et al., 2019). The primary objective of this study is to create an early detection mechanism for Parkinson's disease by analyzing movement frequencies during various activities. Therefore, the system is designed to identify different types of Parkinson's symptoms, including resting tremors, postural tremors, bradykinesia, and hypokinesia. This system will be incorporated into smartphones to send notifications when such symptoms are detected.

2 Developed System

This segment outlines the operational workflow of the early detection system devised for Parkinson's disease. The system will utilize an accelerometer sensor to capture movement frequencies. The comprehensive depiction of the program's flow diagram for the sensor node is presented in Figure 1. The procedure commences with the measurement of the accelerometer sensor's axis, followed by signal feature extraction. Subsequently, activities are classified based on the frequencies associated with each motor symptom, namely rest tremor, postural tremor, bradykinesia, and hypokinesia. The frequency ranges for symptom detection are as follows: rest tremor spans from below 3Hz to over 6Hz, postural tremor ranges from under 4Hz to above 12Hz, bradykinesia is around 0.65Hz, and hypokinesia is below 1Hz. If none of these characteristics are detected, it indicates a normal condition. The data gathered from the sensor is exhibited both on the LCD and mobile applications in the form of a graph.

Jurnal Informatika Universitas Pamulang **ISSN: 2541-1004**
Penerbit: Program Studi Teknik Informatika Universitas Pamulang **e-ISSN: 2622-4615**
Vol. 8, No. 2, Juni 2023 (292-297) **10.32493/informatika.v8i2.32842**

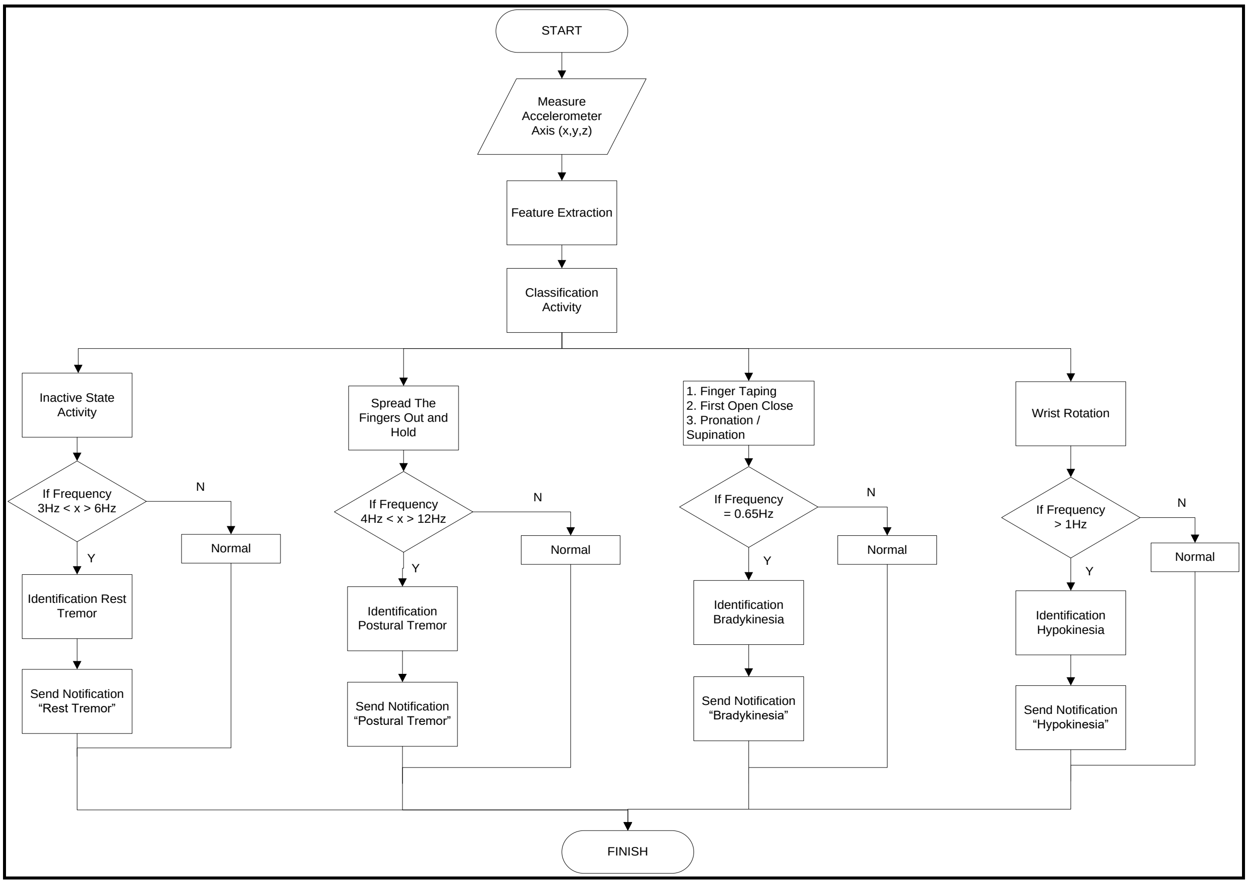


Figure 1. Flowchart diagram system

A foundational prototype of the developed system has been constructed using Proteus software, as illustrated in Figure 2. This software offers an array of robust functionalities suitable for engineering designs spanning mechanical aspects, electrical systems, and possessing a user-friendly development interface. The schematic diagram encompasses a Node MCU ESP8266 functioning as the microcontroller, an ADXL345 accelerometer sensor, and an LCD display for presenting the system's outcomes.

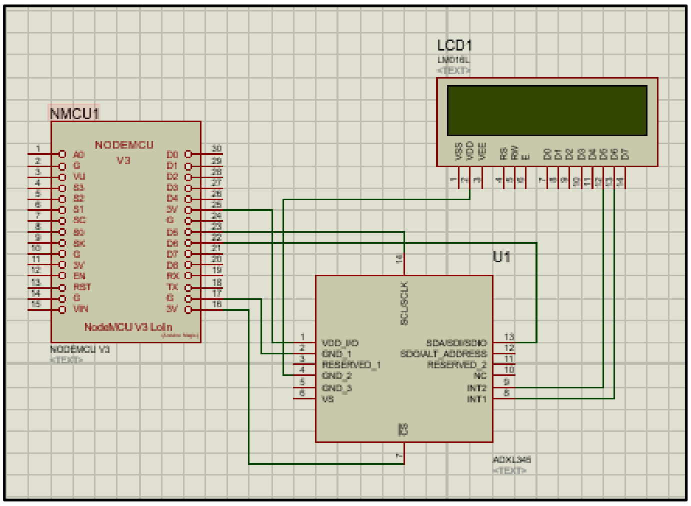


Figure 2. Proposed Circuit Diagram

ISSN: 2541-1004
e-ISSN: 2622-4615
10.32493/informatika.v8i2.32842

Within this project, the Arduino IDE (Integrated Development Environment) is adopted as a versatile application crafted in the Java programming language. Its primary function is to program microcontrollers based on the Arduino platform. Arduino serves as the tool for configuring Node MCU ESP8266 and serves as the interface for inputting code to each sensor node. It encompasses a variety of code editing capabilities including syntax highlighting, brace matching, and automated indentation. Notably, the Arduino IDE supports the application of rules for structuring code, as depicted in Figure 3.

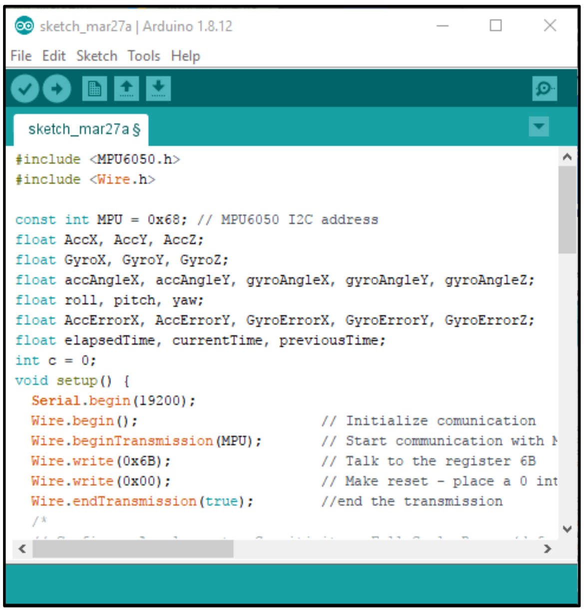


Figure 3. Arduino Coding

3 Result and Discussion

The The proposed design needs to undergo initial simulation to assess its feasibility and ensure the reliability of the mentioned control technique. To validate the system experimentally, the testing phase concentrates on logical intervals within the software to ensure comprehensive coverage of all statements. Functional intervals are executed during testing to pinpoint any errors, while also ensuring that the specified inputs yield corresponding real outcomes aligned with the desired ones. Both program and model level testing are integrated and executed.

The circuit simulation emulates the behavior of the genuine electronic device and circuit within the smartphone-assisted software. This process initiates with the creation of the circuit diagram based on the circuit's principles and structure. Subsequently, the .HEX file is loaded onto the MCU to procure simulation results, as depicted in Figure 4. This procedure commences once the simulation code is verified, and the ensuing results, including frequency and diagnostic state, are displayed on the LCD screen.

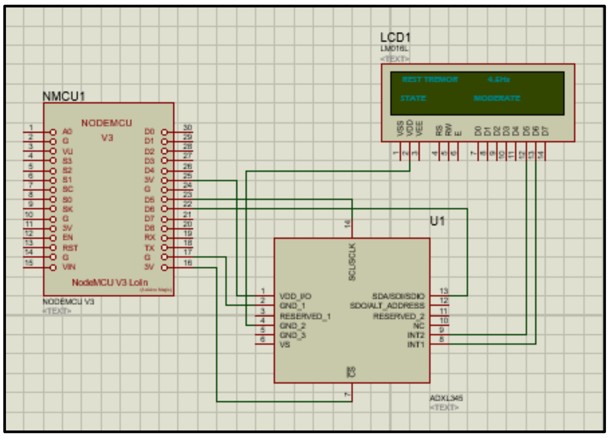


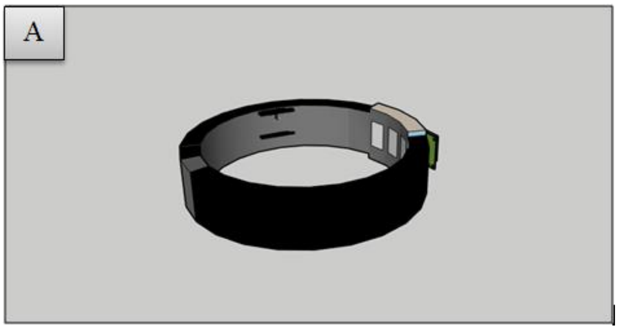
Figure 4. Proteus circuit simulation

Figure 5 illustrates the final design from frontal and isometric perspectives through a 3D representation, a visual generated using SketchUp software. This system is envisioned to facilitate early detection of neurodegenerative diseases by discerning the frequency of various activities in an individual's daily life. Several key functions underpinning this system, as conceptualized in this research, can be further categorized into concrete components:

1. The entire system will be under the control of a microcontroller, specifically the Node MCU ESP8266, which is widely employed in IoT applications.
2. An accelerometer sensor (ADXL345) will be linked to the microcontroller (Node MCU ESP8266), and both will be integrated with an LCD display.

These features collectively contribute to the system's capabilities in detecting neurodegenerative diseases by monitoring activity frequencies in the user's routine activities.

ISSN: 2541-1004
e-ISSN: 2622-4615
10.32493/informatika.v8i2.32842



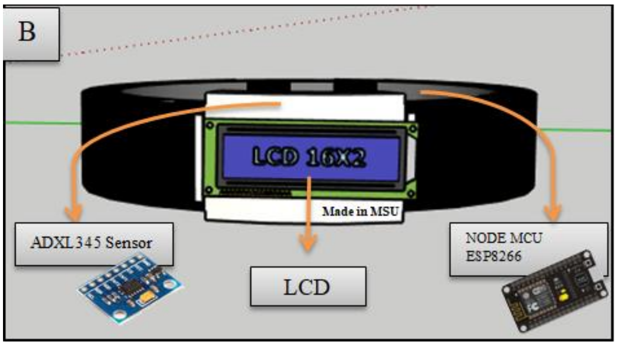


Figure 5. Final Design (a) Top View (b) Detail Component

The system that was developed is depicted in Figure 6. The device undertakes the task of signal acquisition. This device gauges movement activity across six distinct categories, including relaxation, finger spreading followed by raising, wrist rotation, finger tapping, opening and closing the fist, and pronation-supination. Each test is assigned a rating based on the following scale:

0: Normal -> No Tremor
1: Slight
2: Mild
3: Moderate
4: Severe

Upon initiation, the application gathers acceleration data transmitted by the device at a specific sampling frequency designated for each disease. The duration of each test is set at 10 seconds. Following the test, the application stores samples for each axis (x, y, z axes of the accelerometer) and provides real-time graph visualization on the smartphone.

Figure 6. Early Detection System Work

4 Conclusion

An innovative advancement in the field of early neurodegenerative disease detection has been introduced. Evaluating the operational effectiveness of the implemented and tested system, it can be deduced that the proposed approach holds the potential to swiftly and dependably identify and diagnose neurodegenerative disorders, particularly Parkinson's disease. This system showcases rapidity, dependability, minimal dependence on human interpretation, reduced subjectivity, and heightened accuracy, ensuring consistent application of diagnostic benchmarks. Moreover, the system integrates real-time monitoring capabilities, offering portability and user-friendliness, thereby augmenting the overall quality of individuals' everyday lives.

References

Bermeo, A., Bravo, M., Huerta, M., & Soto, A. (2016). A system to monitor tremors in patients with Parkinson's disease. *Proceedings of the Annual International Conference of the IEEE Engineering in Medicine and Biology Society, EMBS*, *2016-Octob*, 5007–5010. https://doi.org/10.1109/EMBC.2016.7591852

Bhat, M., Inamdar, S., Kulkarni, D., Kulkarni, G., & Shriram, R. (2018). Parkinson's disease prediction based on hand tremor analysis. *Proceedings of the 2017 IEEE International Conference on Communication and Signal Processing, ICCSP 2017*, *2018-Janua*, 625–629. https://doi.org/10.1109/ICCSP.2017.8286433

Braybrook, M., O'Connor, S., Churchward, P., Perera, T., Farzanehfar, P., & Horne, M. (2016). An Ambulatory Tremor Score for Parkinson's

Disease. *Journal of Parkinson's Disease*, *6*(4), 723–731. https://doi.org/10.3233/JPD-160898

C, S., B, A. P., & S, L. (2019). Need of Internet of Things for Smart Cities. *International Journal of Trend in Scientific Research and Development*, *Volume-3*(Issue-4), 218–222. https://doi.org/10.31142/ijtsrd23597

Darkins, A. W., Fromkin, V. A., & Benson, D. F. (1988). A characterization of the prosodic loss in Parkinson's disease. *Brain and Language*, *34*(2), 315–327. https://doi.org/10.1016/0093-934X(88)90142-3

Eskidere, O., Karatutlu, A., & Unal, C. (2016). Detection of Parkinson's disease from vocal features using random subspace classifier ensemble. *Proceedings of the 2015 12th International Conference on Electronics Computer and Computation, ICECCO 2015*. https://doi.org/10.1109/ICECCO.2015.7416886

Max A. Little. (2008). Suitability of dysphonia measurements for telemonitoring of Parkinson's disease. *Bone*, *23*(1), 1–7. https://doi.org/10.1109/TBME.2008.2005954.Suitability

Mohammed Abdulrazaq, A. N., Aslamiah Istiqomah, N., Salman Al-Zubaidi Al-Khwarizmi, S., ABDUL Karim, S., Mohammed, M. N., Aslamiah Hazairin, N., Al-Zubaidi, S., Mustapha, S., & Yusuf, E. (2020). Toward a novel design for coronavirus detection and diagnosis system using IoT based drone technology. *Article in International Journal of Psychosocial Rehabilitation*, *24*(March), 2020. https://doi.org/10.37200/IJPR/V24I7/PR270220

Mohammed, M. N., Desyansah, S. F., Al-Zubaidi, S., & Yusuf, E. (2020). An internet of things-based smart homes and healthcare monitoring and management system: Review. *Journal of Physics: Conference Series*, *1450*(1). https://doi.org/10.1088/1742-6596/1450/1/012079

Mohammed, M. N., Hazairin, N. A., Syamsudin, H., Al-Zubaidi, S., Sairah, A. K., Mustapha, S., & Yusuf, E. (2020). 2019 novel coronavirus disease (Covid-19): Detection and diagnosis system using iot based smart glasses. *International Journal of Advanced Science and Technology*, *29*(7 Special Issue), 954–960.

Muliawan, E., Jehosua, S., Tumewah, R., & Kunci, K. (2018). Diagnosis And Therapy Deep Brain Stimulation In Parkinson Disease. *Jurnal Sinaps*, *1*(1), 67–84.

Pastorino, M., Arredondo, M. T., Cancela, J., & Guillen, S. (2013). Wearable sensor network for health monitoring: The case of Parkinson disease. *Journal of Physics: Conference Series*, *450*(1). https://doi.org/10.1088/1742-6596/450/1/012055

Perumal, S. V., & Sankar, R. (2016). Gait and tremor assessment for patients with Parkinson's disease using wearable sensors. *ICT Express*, *2*(4), 168–174. https://doi.org/10.1016/j.icte.2016.10.005

Poongodi, T., Balusamy, B., Sanjeevikumar, P., & Holm-nielsen, J. B. (2019). *Internet of Things (IoT) and E-Healthcare System – A Short Review on Challenges*. *June*.

Strielkina, A., Uzun, D., & Kharchenko, V. (2017). Modelling of healthcare IoT using the queueing theory. *Proceedings of the 2017 IEEE 9th International Conference on Intelligent Data Acquisition and Advanced Computing Systems: Technology and Applications, IDAACS 2017*, *2*(1), 849–852. https://doi.org/10.1109/IDAACS.2017.8095207

Tian, S., Yang, W., Grange, J. M. Le, Wang, P., Huang, W., & Ye, Z. (2019). Smart healthcare: making medical care more intelligent. *Journal of Global Health*, *3*(3), 62–65. https://doi.org/10.1016/j.glohj.2019.07.001

Vidya, V., Poornachandran, P., Sujadevi, V. G., & Dharmana, M. M. (2018). Suppressing Parkinson's diseases induced involuntary movements using wearables. *Proceedings of 2017 IEEE International Conference on Technological Advancements in Power and Energy: Exploring Energy Solutions for an Intelligent Power Grid, TAP Energy 2017*, 1–4. https://doi.org/10.1109/TAPENERGY.2017.8397267