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Early Detection of Huntington Diseases by Using Wearable Sensor

Nivedha A.K[*1], Madhupriya R[*2], Padmapriya R[*3], Priyasakthi M[*4], Tamilzhkani K[*5],

[*1] Assistant professor, Dhanalakshmi Srinivasan Engineering College (Autonomous) Perambalur, India.

*[2,3,4,5] B.E Bio Medical Engineering, Dhanalakshmi Srinivasan Engineering College (Autonomous) Perambalur, India.

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***Abstract* -** Huntington's Disease (HD) is a hereditary neurodegenerative condition characterized by the gradual degeneration of neurons, particularly in the cerebral cortex and basal ganglia. This degeneration results in motor dysfunction, cognitive impairment, and behavioral abnormalities. Among the earliest and most impactful symptoms are gait disturbances, including reduced stride length, irregular gait rhythm, and balance issues, which significantly impair mobility and quality of life. Traditional gait analysis requires expensive lab setups and lacks portability. Recent advancements in wearable sensor technology offer low-cost, real-time alternatives suitable for both clinical and home environments. This study presents a wearable monitoring system built on the Node MCU microcontroller, integrating a tri-axial accelerometer for gait analysis and sensors for Physiological monitoring—temperature, humidity (DHT11), heart rate, SpO2, and galvanic skin response (GSR). Data is transmitted wirelessly to the Thing Speak cloud for real-time visualization and remote analysis. Preliminary findings indicate that integrating gait and physiological data enhances the ability to monitor disease progression, support early intervention, and personalize therapeutic strategies. The system demonstrates promise as an accessible, non-invasive tool for continuous HD monitoring.

***Keywords*-**wearable sensor, gait analysis, physiological monitoring, real time monitoring

1. Introduction

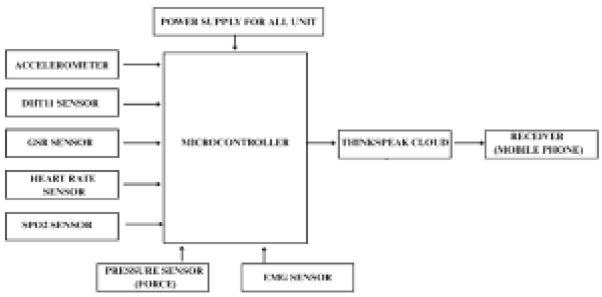
Huntington's Disease (HD) is a progressive, autosomal dominant disorder caused by expanded CAG repeats in the HTT gene, resulting in toxic huntingtin protein accumulation and subsequent neuronal degeneration. The disease commonly presents between the ages of 30 and 50, progressing over two to three decades. Clinical features include involuntary movements (chorea), dystonia, bradykinesia, cognitive decline, emotional disturbances, and eventual loss of functional independence.

Gait impairments are among the earliest motor symptoms and include slowed walking speed, decreased stride length, increased variability, and compromised balance, which contribute to falls and reduced mobility. Beyond movement, HD patients often face cognitive dysfunction (e.g., impaired decision-making, memory deficits) and psychiatric symptoms (e.g., depression, irritability, psychosis), further complicating care and diagnosis.Traditional assessments of HD progression rely heavily on clinical observation and episodic evaluations, which are subjective and may fail to capture the full scope of functional decline. These limitations highlight the need for objective, continuous, and real-world data collection. Wearable technology offers an innovative approach to address these gaps.

Devices equipped with inertial and biosensors can unobtrusively monitor both motor and physiological parameters in daily environments. Gait data extracted from tri-axial accelerometers can reveal changes in stride, cadence, and gait phases, serving as early indicators of motor decline. When paired with physiological metrics like heart rate variability, oxygen saturation, and stress indicators (via GSR), a more comprehensive understanding of patient health is possible.

This research introduces a compact, cost-effective wearable solution for continuous, multi-modal monitoring in HD patients. The system leverages the Node MCU platform and various sensors to collect and transmit physiological and gait data to a cloud server (Thing Speak), enabling real-time remote access for clinicians and caregivers. The proposed system not only aids in tracking disease progression but also offers the potential for data-driven, personalized treatment plans.

2. System Methodology



2.1 Limitations of Existing Systems

Current gait monitoring systems primarily focus on analyzing motion-related data, often neglecting concurrent physiological signals crucial for comprehensive health assessment in Huntington's Disease (HD) patients. Many existing wearables utilize a minimal number of sensors—sometimes only one—typically positioned on a single limb, leading to reduced measurement fidelity. Additionally, real-time data processing is frequently absent, limiting the systems' utility in fast-paced clinical environments or home-based care. The inconsistency in sensor placement and the lack of intelligent data integration frameworks further affect the reliability and reproducibility of the collected data.

2.2 Proposed System

The proposed system introduces an integrated, wearable platform designed to simultaneously monitor both gait and physiological parameters in individuals with HD.

This cost-effective solution employs a suite of sensors including an MPU6050 accelerometer for motion capture, a DHT11 sensor for environmental temperature and humidity, pulse oximeter and heart rate modules, and a GSR sensor for electrodermal activity indicative of stress. These components interface with a Wi-Fi-enabled Node MCU microcontroller, enabling wireless data transmission to the Thing Speak cloud. The system incorporates signal processing techniques and computational algorithms to extract gait metrics such as stride length, cadence, and gait phase transitions. By correlating these with physiological signals, the platform offers enriched health monitoring, supporting timely therapeutic decisions and individualized care strategies.

3. Working Model Explanation

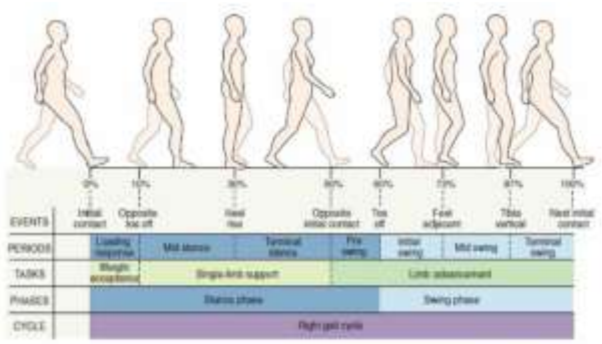
The wearable monitoring system is designed to continuously collect data through an integrated array of onboard sensors that capture biomechanical movement, environmental parameters, and key physiological metrics such as heart rate, body temperature, oxygen saturation, and skin conductivity. These real-time measurements are processed by the Node MCU microcontroller, which serves as the central communication hub. The collected data is wirelessly transmitted to the Thing Speak cloud platform for secure storage and analysis.

To enhance the reliability and accuracy of the acquired signals, the backend infrastructure incorporates noise-reduction techniques, including digital filtering and statistical averaging algorithms.

This preprocessing helps to eliminate artifacts and smooth fluctuations, thereby improving the integrity of the data.

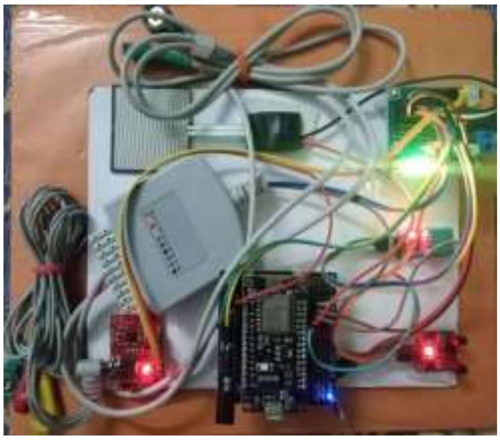
Once processed, the system generates intuitive and dynamic visualizations through the Thing Speak dashboard. These graphical representations allow healthcare professionals to observe longitudinal trends, detect deviations from baseline patterns, and identify potential early warning signs associated with the progression of Huntington's Disease (HD). Customizable alert thresholds can be configured to automatically notify caregivers or clinicians when critical parameters exceed safe limits, enabling timely medical intervention.

This comprehensive IoT-based approach not only supports early diagnosis of HD-related motor and cognitive impairments but also enables personalized, data-driven care. By continuously monitoring the patient's condition in real time, the system empowers clinicians to make informed decisions, adapt treatment strategies proactively, and ultimately enhance the quality of life for individuals living with Huntington's Disease.



4. Result Discussion

Preliminary trials indicate that the system can reliably acquire and transmit multimodal health data, validating its potential for continuous, real-world monitoring of HD symptoms. The integration of both gait and physiological metrics offers a comprehensive picture of the patient's status, highlighting the system's suitability for remote care environments. Such insights can enhance patient engagement and inform clinicians about disease progression or treatment efficacy.



5. Conclusion

This wearable health-monitoring platform offers a scalable and affordable solution for tracking the progression of Huntington's Disease. By merging motion analytics with physiological monitoring, it delivers a holistic assessment tool for both clinical and home-based applications. The system's continuous, real-time feedback loop opens up new possibilities for personalized interventions and early-stage detection of motor and cognitive decline, ultimately contributing to improved patient outcomes.

6. Future Enhancements

* Enhanced Gait Analytics: Incorporating advanced signal processing and machine learning techniques could refine the detection of subtle gait anomalies. For instance, spectral analysis of accelerometer data or the addition of gyroscope input (using the full capability of the MPU6050) could enhance diagnostic precision.

* Visual Gait Event Mapping: Adding real-time graphical representations of gait cycles and raw sensor signals on the Thing Speak interface could aid clinicians in identifying motor disturbances more effectively.

* Fall Detection and Prediction: Implementing threshold-based or machine learning-based fall detection mechanisms using high-frequency

accelerometer spikes could improve safety for patients at risk. Predictive analytics may further anticipate fall events based on longitudinal data.

* Disease Progression Forecasting: Leveraging historical sensor data, machine learning models could be trained to estimate the trajectory of disease progression, helping to customize care plans and foresee critical deterioration phases.

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