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Wireless IoT system towards GAIT Detection in Stroke Patient

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Abstract: *This project presents a Wireless IoT System designed for gait detection in stroke patients. By utilizing wearable sensors equipped with accelerometers and gyroscopes, the system continuously monitors and analyzes gait patterns. The collected data is transmitted wirelessly to a central platform, where advanced algorithms process and interpret the information. This enables real-time feedback and monitoring, facilitating personalized rehabilitation and tracking of patient progress. The system aims to enhance the accuracy of gait assessment, support effective rehabilitation strategies, and ultimately improve patient outcomes..*

Keywords: Raspberry Pi, Gyroscope, WiFi module, Blutooth module, Rechargeable Lithium-Ion Battery

I. INTRODUCTION

Stroke is one of the leading causes of serious long-term disability, affecting millions of individuals worldwide. The aftermath of a stroke often results in impaired mobility and altered gait patterns, which can significantly hinder a patient's ability to perform daily activities. Understanding and monitoring these changes are essential for effective rehabilitation. However, traditional methods for gait analysis typically occur in clinical settings and can be cumbersome, leading to gaps in continuous patient monitoring [1,2]. The development of wireless Internet of Things (IoT) technologies presents a novel solution to these challenges. By embedding sensors in wearable devices, it becomes possible to capture gait data in real-time, allowing for continuous monitoring outside clinical environments [3]. This capability is particularly beneficial for stroke patients, who often struggle with mobility and may benefit from a system that tracks their rehabilitation progress in the comfort of their own homes [4]. The integration of IoT technology into healthcare is increasingly recognized as a transformative approach to patient monitoring. The system developed in this project is designed to be user-friendly and non-intrusive [5], ensuring that stroke patients can utilize it without added stress.

By bridging the gap between clinical assessments and daily monitoring, this project aims to empower both patients and healthcare providers, fostering improved rehabilitation outcomes.In recent years, the advent of wireless Internet of Things (IoT) technology has opened new avenues in healthcare, enabling real-time data collection and analysis. By incorporating wearable sensors into the rehabilitation process, healthcare providers can obtain continuous, objective measurements of gait parameters, leading to a more nuanced understanding of a patient's recovery journey. This project report focuses on the development of a wireless IoT system specifically designed for gait detection in stroke patients.The proposed system comprises a network of wearable sensors that monitor various gait metrics, including stride length, cadence, and balance. These sensors transmit data wirelessly to a central server, where advanced algorithms analyze the information in real time. This setup allows for the identification of deviations from normal gait patterns, facilitating timely interventions and personalized rehabilitation plans.

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II. LITERATURE SURVEY

The integration of wireless Internet of Things (IoT) systems in healthcare has opened new avenues for monitoring and rehabilitating stroke patients, particularly in gait detection and analysis [1,2]. Among the notable contributions in this field is the work by Majumder et al., who developed a multisensory system aimed at predicting cautious gait in stroke patients. Their system utilizes a smartphone's built-in sensors in conjunction with an IoT-enabled shoe equipped with a Wi-Fi communication module [3]. This setup discreetly monitors insole pressure and the patient's motion accelerations, enabling the detection of abnormal gait patterns that may indicate a heightened risk of falling. By analyzing spatiotemporal gait parameters, the system can alert users to potential gait abnormalities, thereby assisting in fall prevention and promoting safer mobility for stroke survivors. This approach underscores the potential of IoT-based solutions in providing continuous [4], real-time monitoring of gait patterns outside clinical settings. Such systems offer a cost-effective and accessible means for early detection of gait abnormalities, facilitating timely interventions and personalized rehabilitation strategies [5]. While the work of Majumder et al. represents a significant advancement, further research and development are necessary to enhance the accuracy, reliability, and user-friendliness of these systems [6]. Future studies could explore the integration of machine learning algorithms to improve gait pattern recognition and the incorporation of additional sensors to capture a broader range of physiological data[7]. The convergence of wireless IoT technology and gait analysis presents a promising frontier in stroke rehabilitation, offering the potential to improve patient outcomes through enhanced monitoring and personalized care[8,9].

III. METHODOLOGY

The wireless IoT system for gait detection in stroke patients provides a visual representation of the system's architecture and data flow. At the initial stage, the system comprises wearable sensors placed on the patient's body—typically on the ankle or waist. These sensors are equipped with accelerometers and gyroscopes that capture key gait metrics such as stride length, cadence, and angular velocity. Once the data is collected, it is transmitted wirelessly to a microcontroller unit. This unit acts as an intermediary between the sensors and the cloud-based platform, processing the raw data before sending it for further analysis. The microcontroller is programmed to filter and format the data, ensuring that only relevant information is transmitted to minimize bandwidth usage and enhance efficiency. The data is then uploaded to a cloud platform, where it is stored securely and subjected to machine learning algorithms. These algorithms analyse the data to identify trends, assess gait stability, and detect any anomalies indicative of deterioration in the patient's condition. The cloud platform also serves as a repository for longitudinal data, which can be invaluable for research and further analysis. Healthcare providers can access the processed data through a web or mobile application, which presents the information in an easily interpretable format, including graphs and alerts for significant changes in gait patterns. Patients also have access to their data, fostering engagement and motivation in their rehabilitation journey.

HARDWARE IMPLEMENTATION

A. Raspberry pi

The Raspberry Pi is a small, affordable, single-board computer that provides a platform for creating a wide range of applications, including IoT systems. It's equipped with processing power and various input/output interfaces, making it ideal for data collection, processing, and communication tasks in IoT-based systems.

Key Features:

Processor: Raspberry Pi is powered by a multi-core ARM processor (e.g., Quad-core ARM Cortex-A72 in the Raspberry Pi 4) that is capable of running an operating system such as Key Features:

Measurement: A gyroscope typically measures the angular rate (in degrees per second or radians per second) around

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Fig. 1 Raspberry Pi

Linux

RAM: Different versions come with varying amounts of RAM (e.g., 1GB, 2GB, 4GB, or 8GB), depending on the input/output (GPIO) pins, HDMI, USB ports, and camera modules, allowing flexibility in connecting sensors and other peripherals.

Connectivity: The Raspberry Pi has built-in Ethernet, Wi- Fi, and Bluetooth support (depending on the model), which is ideal for communication with other devices and cloud platforms.

Storage: Storage is typically provided by a microSD card where the operating system and software are stored.

Role in IoT System for Gait Detection:

The Raspberry Pi serves as the central hub for the system, receiving and processing data from the sensors (like the gyroscope).

It can host the necessary software for data analysis (e.g., machine learning algorithms) and provide real-time feedback via a user interface (e.g., a web dashboard or mobile app).

It can transmit processed data over Wi-Fi or Bluetooth to remote servers or healthcare providers.

Gyroscope

A gyroscope is a sensor used to measure orientation and angular velocity, which are critical for detecting changes in body posture and movement during gait

one or more axes—commonly three (X, Y, and Z), allowing for 3D motion tracking.

Accuracy: Modern MEMS (Micro-Electro- Mechanical Systems) gyroscopes are small, accurate, and suitable for wearable applications.

Integration: Gyroscopes are often combined with accelerometers in a single sensor module, allowing for both linear and rotational motion tracking.

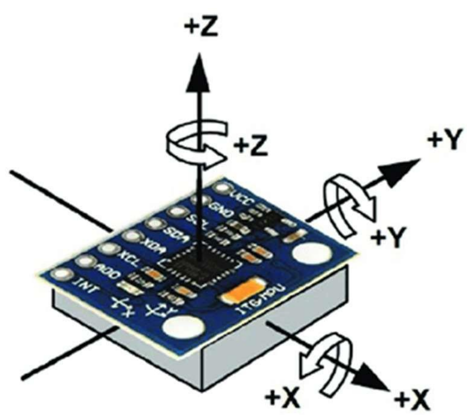

Fig 2 Gyroscope

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Role in IoT System for Gait Detection:
The gyroscope provides valuable data on the rotation and angular velocity of the body parts involved in walking (e.g., hips, legs, feet), helping to assess gait abnormalities and irregularities in stroke patients.
By measuring how the patient's body moves and tilts, the system can detect issues such as instability, asymmetry, or abnormal motion, which are common in stroke survivors.

WiFi Module
A Wi-Fi module is a device that allows for wireless communication over a Wi-Fi network. It is essential for transmitting data between the wearable sensors (or Raspberry Pi) and cloud servers or healthcare devices for remote monitoring.

Fig 3 WiFi Module

Key Features:
Connectivity: Wi-Fi modules (like the ESP8266 or ESP32) enable the device to connect to an existing Wi-Fi network, allowing for data transfer over the internet or local network.
Low Power Consumption: Some modules are designed to be power-efficient, making them ideal for IoT applications.
Data Transfer Rates: Depending on the module, Wi-Fi data transfer rates can range from 2 Mbps to over 50 Mbps, sufficient for transmitting sensor data and other information.
Role in IoT System for Gait Detection:
The Wi-Fi module connects the system to the internet or a local area network (LAN), facilitating communication between the wearable devices and cloud-based servers or healthcare applications.
It enables real-time data transmission for continuous gait monitoring and analysis, allowing healthcare professionals to track a patient's progress remotely.

Bluetooth Module
A Bluetooth module allows for short-range wireless communication between devices. It's ideal for applications where low power consumption, ease of pairing, and local wireless communication are required.

Fig 4 Bluetooth Module

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Key Features:

Low Power Consumption: Bluetooth Low Energy (BLE) modules (e.g., HC-05, HC-06, or nRF52840) are optimized for low energy usage, making them ideal for wearable devices.

Short-Range Communication: Bluetooth has a limited range, typically up to 100 meters, which makes it suitable for local wireless communication within a confined area.

Compatibility: Bluetooth modules are compatible with smartphones, tablets, and Raspberry Pi, enabling easy integration with other devices.

Role in IoT System for Gait Detection:

The Bluetooth module enables communication between the wearable sensors (such as the gyroscope or accelerometer) and the Raspberry Pi or smartphone.

It can transmit real-time data from the sensors to a central processing unit, where it can be analyzed, visualized, or stored for further review by healthcare professionals.

Rechargable lithium-ion

A rechargeable lithium-ion (Li-ion) battery is commonly used in portable IoT devices because of its high energy density, long lifespan, and compact size.

Fig 5 Rechargable lithium-ion

Key Features:

Energy Density: Li-ion batteries have a high energy density, meaning they can store more energy relative to their size and weight, making them ideal for portable devices.

Rechargeability: Li-ion batteries can be recharged many times without significant loss of capacity, making them a sustainable choice for continuous or long-term usage.

Safety: Modern Li-ion batteries are equipped with protective circuits to prevent overcharging, overheating, and short-circuiting, ensuring safe operation.

Role in IoT System for Gait Detection:

The rechargeable lithium-ion battery powers the wearable sensors, Raspberry Pi, and other connected components, enabling continuous monitoring without the need for constant plugging into a power source.

The battery ensures portability and flexibility in deploying the system, allowing patients to wear the sensors throughout the day without interruption.

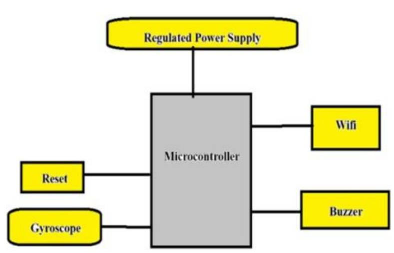

Fig 6 Block Diagram

Wearable sensors: Devices such as accelerometers, gyroscopes, and inertial measurement units (IMUs) can be worn on the body to monitor gait parameters like stride length, gait speed, and balance in real-time. Data from these sensors are transmitted wirelessly to healthcare providers for analysis.

The Raspberry Pi is a versatile microcontroller that can be programmed to do a variety of functions, allowing for customization and flexibility in the design of the system.

Smart Insoles: Embedded with sensors, these insoles capture detailed gait data as patients walk. They can provide insights into weight distribution and pressure points, which are crucial for understanding gait abnormalities.

APPLICATIONS

- Wireless systems can provide continuous and real time data on a patient's gait, allowing for immediate adjustments and timely interventions.
- Healthcare providers can access data remotely, facilitating monitoring without requiring frequent clinic visits. This can be particularly beneficial for patients with mobility issues.
- The systems can gather large volumes of data from various sensors, leading to more comprehensive and accurate assessments of gait patterns.

IV. CONCLUSION AND FUTURE WORK

The wireless IoT system for gait detection represents a significant advancement in stroke rehabilitation, offering continuous, real-time monitoring of gait parameters. By integrating wearable technology and machine learning, the system enhances clinical assessments and facilitates personalized rehabilitation strategies. Patient feedback highlights increased engagement and motivation through accessible data. Furthermore, the ability to identify subtle changes in mobility allows for timely interventions, improving overall rehabilitation outcomes. This project underscores the transformative potential of IoT in healthcare, paving the way for future innovations that enhance patient care and support recovery in stroke survivors.The future scope of wireless IoT systems for gait detection in stroke patients offers significant potential for advancing patient care. Integration with AI and machine learning can enable personalized rehabilitation programs and predictive analytics to track recovery progress. Enhanced data security and privacy measures will be essential for ensuring compliance with healthcare regulations. The system can also provide real-time feedback to both patients and healthcare providers, allowing for dynamic adjustments to treatment plans. Moreover, expanding capabilities for remote monitoring and integrating telemedicine will enable stroke survivors to receive continuous care at home, promoting better outcomes and reducing hospital visits

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