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Monitoring epilepsy patients using Internet of Things technology

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Abstract—

This research presents a system that utilizes Internet of Things (IoT) technology in conjunction with the NeuroSky MindWave device, Bluetooth, GSM, and Global Positioning System (GPS) to remotely monitor epilepsy patients. The NeuroSky MindWave device is used as a measuring device for brainwave signals and detecting abnormal activity patterns associated with seizures. The data is wirelessly transmitted to an IoT gateway device using Bluetooth technology. The IoT gateway device serves as a central hub that collects the brainwave data from the NeuroSky MindWave device and sends it to a cloud-based server using GSM technology. The cloud-based server processes the data using advanced analysis algorithms to identify seizure patterns and contributing factors. In addition to the brainwave data, the system incorporates GPS technology to track the patient's location in real-time. This information is transmitted along with the brainwave data to the cloud-based server, enabling accurate documentation of seizure occurrences and their geographical locations. Caregivers and healthcare professionals can access the cloud-based server through a web or mobile application, which provides a user-friendly interface for visualizing the brainwave data, monitoring the patient's location, setting up personalized seizure detection alerts, and managing medication reminders. When abnormal brain activity indicative of a seizure is detected, the system triggers an alert through the mobile application and sends an SMS notification to designated caregivers or emergency services. This prompt response allows for immediate assistance and intervention, potentially reducing the severity and duration of seizures. The proposed system aims to improve the quality of life for epilepsy patients, enhance seizure management, and facilitate timely medical interventions.

Keywords— Internet of Things (IoT), Epilepsy Monitoring, NeuroSky MindWave, Electroencephalography (EEG), Seizure Detection, Bluetooth Communication, GSM Technology, Global Positioning System (GPS), Cloud Computing, Remote Patient Monitoring, Real-Time Alerts, Mobile Health (mHealth)

I. INTRODUCTION

Epilepsy is one of the most common neurological disorder rs and affects around 50 million people worldwide according to world health organization (WHO). People with epilepsy tend to have more physical problems (such as fractures and bruising from injuries related to seizures), as well as higher rates of psychological conditions, including anxiety and depression. Wearable devices can use accelerometry to detect convulsions and other seizure-related movements, as well as sensors for measuring changes in heart rate (HR) and electrodermal activity

(EDA) during seizures. In this paper we will develop a system that can effectively monitor patients with epilepsy and detect early seizures using Wi-Fi technology. The device is fixed on the patient's body, records movement and acceleration using a gyro sensor, and GPS is used to determine the patient's geographical location in real time. GSM is also used to send notifications and warnings to medical supervisors or family members in the event of a patient having an epileptic seizure.[1,2]

II. RESEARCH PROBLEM

Epilepsy is a prevalent and impactful disease characterized by sudden convulsions and loss of consciousness. While medications are commonly used to control seizures, they may not always be effective and can have significant side effects. Moreover, individuals with epilepsy are at risk of experiencing unexpected seizures, which can lead to accidents and injuries. As a result, continuous medical care and close monitoring are essential for these patients.

To address these challenges, the development of a device for monitoring epilepsy and detecting seizures early using Wi-Fi technology, Arduino, gyro sensors, GPS, GSM, and a height sensor becomes crucial. This device is designed to be worn by the patient and analyze movement and acceleration. By doing so, it can detect epileptic seizures at an early stage and facilitate timely medical intervention.

The primary objective of this paper is to address the difficulties faced by epilepsy patients, such as the lack of effective monitoring and early seizure detection, which can result in severe injuries and harm. By designing a monitoring and early detection device for epilepsy, the aim is to enhance the quality of life for individuals living with this condition.

III. PAPER OBJECTIVES

The objective of this paper is to design a device for monitoring patients' system and detect seizures early and other injuries experienced by patients. Using brain wave sensing headset, NeuroSky's mindset, which detect electrical signals produced by the brain and other attached sensors. The signals are then processed and interpreted using NeuroSky's algorithms, allowing users to interact with various applications and games through brainwave-based input. Utilizing Wi-Fi technology, Arduino, a gyro sensor, GPS, GSM, and a height sensor allows early detection of seizures providing comprehensive and effective monitoring capabilities which helps to provide timely assistance in case of accidents or injuries.

IV. REQUIREMENTS FOR A RESEARCH

Based on the paper description you provided, some key requirements for designing an epilepsy monitoring device and early detection of seizures using technology can be identified Wifi using Arduino, Gyro sensor, GPS and GSM, in addition to a height sensor to detect falls and other functions. Here are some important requirements:

1.Arduino: An Arduino board must be used to collect data from the sensors, analyze it, and send it to the CPU.

2.Gyro sensor: The gyro sensor must be used to analyze movement and acceleration and detect epileptic seizures.

3.GPS: GPS should be used to locate the patient and record location data to assist doctors in analyzing the data.

4.GSM: GSM should be used to send text messages or alerts to doctors or family members when seizures occur.

5.BMP280: The BMP280 is a popular sensor module used for measuring barometric pressure, temperature, and altitude of parient.

6.Esp8266: Wi-Fi technology must be used to transfer data and connect to the Internet.

7.NeuroSky' sensor: this sensor typically consists of a headset with sensors that detect electrical signals produced by the brain. The signals are then processed and interpreted using NeuroSky's algorithms, allowing users to interact with various applications and games through brainwave-based input.

8. Bluetooth module. Figure (1) below shows the structure of the paper.

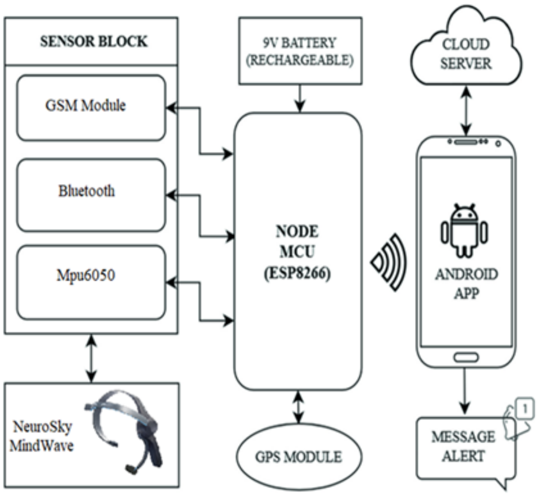

Figure (1) Design block diagram.

V. MIND WAVE AND EEG SIGNAL ACQUISITION

Mind waves, also known as brainwaves, are the electrical patterns generated by the brain's neural activity. These patterns can be measured using various techniques such as electroencephalography (EEG). These waves are oscillating electrical voltages in the brain measuring just a few millionths of a volt. Mind waves provide valuable insights into the functioning of the brain and can be used to understand different cognitive states and mental processes. There are five widely recognized brain waves, and the main frequencies of human EEG waves are listed in Table 1 along with their characteristics.[3.4]

Table (1) Characteristics of the Five Basic Brain Waves

Frequency band	Frequency	Brain states
Gamma (γ)	> 35 Hz	Concentration and problem solving
Beta (β)	12 - 35 Hz	Anxiety dominant, active, external attention, relaxed
Alpha (α)	8 - 12 Hz	Very relaxed, passive attention
Theta (θ)	4 - 8 Hz	Deeply relaxed, inward focused
Delta (δ)	0.5 - 4 Hz	Sleep

Below are brain wave samples for different waveforms are shown in Figure (2).

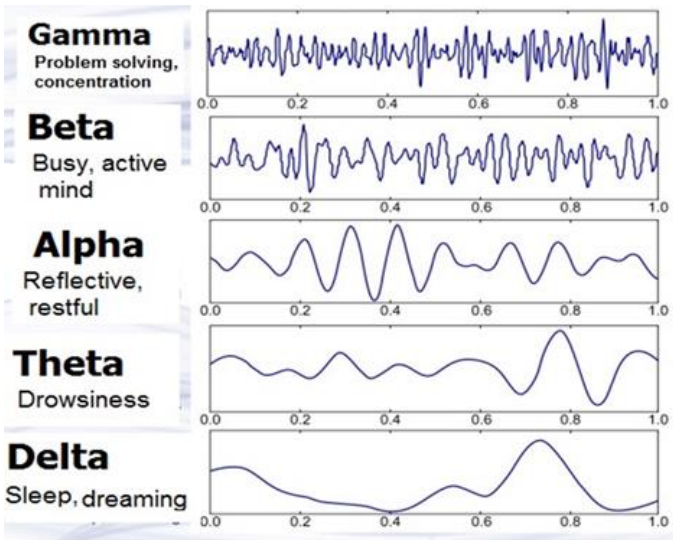

Figure (2). Brain wave samples with dominant frequencies belonging to beta, alpha, theta, and delta bands and gamma waves.[6]

1.Electroencephalography signals

Electroencephalography (EEG) is one of the Brain-Computer Interface (BCI) methods to communicate and interact between the human brain and external devices or computer systems. It is a neurophysiological technique used to record and measure the electrical activity of the brain. It involves placing electrodes on the scalp to detect and amplify the small electrical signals generated by the brain's neurons.[7]

2. Epileptic seizure detection system

The electrodes used in EEG are typically metal discs or sensors that are attached to the scalp using a conductive gel or adhesive. These electrodes are strategically placed at specific locations on the scalp according to standardized electrode placement systems, such as the international 10-20 system. The placement of electrodes allows for the measurement of electrical activity from different regions of the brain. [8]

During an EEG recording, the electrodes detect the electrical potentials generated by the synchronized activity of large groups of neurons. These electrical signals, known as brainwaves or EEG waves, are represented as voltage fluctuations over time. The measured signals are amplified and filtered to remove any unwanted noise or artifacts.[9]

The output of an EEG recording is a series of waveforms that correspond to different frequency bands mentioned in table (1). These frequency bands are associated with specific brain states and cognitive processes. As mentioned earlier, the main frequency bands observed in EEG recordings are gamma, beta, alpha, theta, and delta waves. Figure (3) below shows the process of seizure detection.[10]

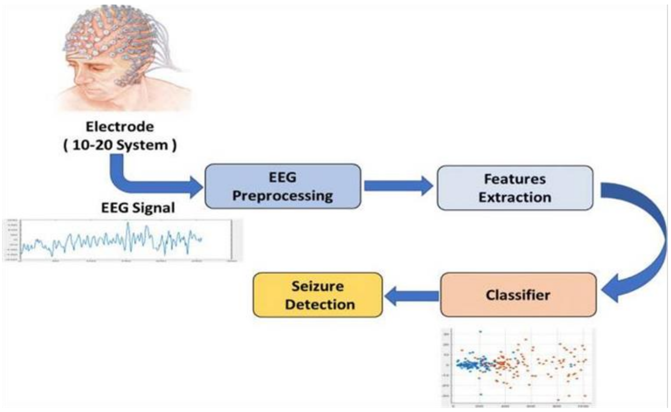

Figure (3) Seizure discovery framework

3. NeuroSky MindSet Technology

The NeuroSky MindWave is an EEG device developed by NeuroSky, Inc. It measures brainwave activity to provide insights into users' mental states. The device consists of a headset with sensors that detect brainwave signals, and a wireless module that transmits the data to a computer or mobile device. See figure (4).

The primary purpose of the MindWave is to enable users to interact with applications and games using their brainwaves. It measures different types of brainwave activity, including delta, theta, alpha, beta, and gamma waves, allowing users to monitor their attention and meditation levels in real-time. The device uses a single electrode placed on the forehead to capture brainwave signals.

The MindWave finds applications in neuro feedback, brain-computer interfaces (BCIs), and biofeedback. Users can gain insights into their mental states, enhance focus and attention, and engage in brain-training exercises. It is primarily marketed to consumers for personal development, stress management, and entertainment purposes.[11]

Figure (4) NeuroSky MindSet

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VI. THE HARDWARE COMPONENTS

1. ARDUINO BOARD (MEGA)

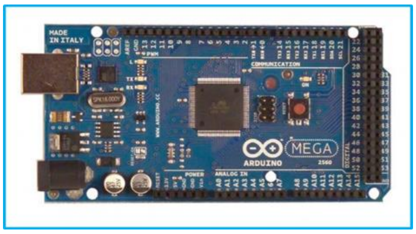

Figure (5) Arduino board (MEGA).

2. GPS MODULE (NEO-6M)

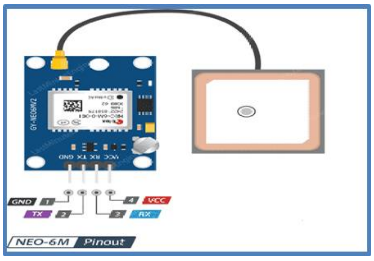

Figure (6) Pin diagram for NEO-6M GPS module.

3. SIM900 GSM SHIELD

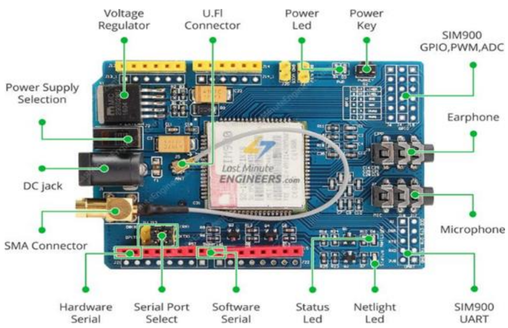

Figure (7) Pin diagram for SIM900 GSM/GPRS shield.

4. MPU-6050 (3-AXIS ACCELEROMETER & GYROSCOPE)

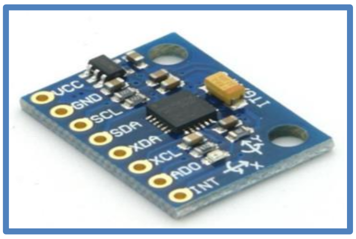

Figure (8) MPU-6050 (Triple axis gyroscope & accelerometer)

5. LITHIUM BATTERY (3.7V)

Figure (9) Lithium battery (3.7v) .

6. WIRED JUMPER, PCB AND LEDS

Figure (10) wired jumper, pcb and leds .

7. ESP8266: WI-FI

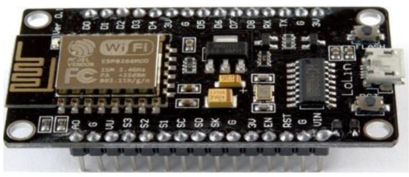

Figure (11) Esp8266: Wi-Fi Module.

8. NEUROSKY' SENSOR

Figure (12) NeuroSky' sensor.

9. BLUETOOTH MODULE (HC-05)

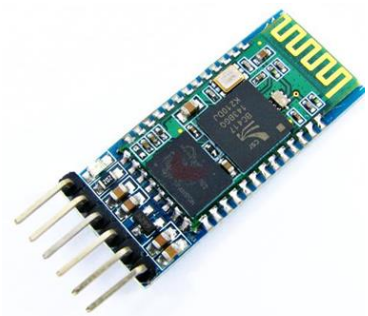

Figure (13) Bluetooth module (hc-05)

VII. DESIGN AND PRACTICAL IMPLEMENTATION

A. connecting neurosky' sensor to the arduino mega

To connect a NeuroSky MindWave sensor to an Arduino MEGA using Bluetooth, follow these simplified guidelines:

1. Gather the necessary components: Arduino MEGA board, NeuroSky MindWave sensor, Bluetooth module (e.g., HC-05 or HC-06), jumper wires.
2. Connect the Bluetooth module to the Arduino MEGA, ensuring proper wiring between the module's RX and TX pins and the Arduino's TX and RX pins. Connect the module's VCC and GND pins to the respective power and ground pins on the Arduino MEGA.
3. Configure the Bluetooth module using the provided documentation and set it to a suitable mode for serial communication.
4. Connect the MindWave sensor to the Arduino MEGA as instructed earlier, making the appropriate RX and TX connections.
5. Write Arduino code to read data from the MindWave sensor and send it wirelessly via the Bluetooth module. Establish serial communication with both the MindWave sensor and the Bluetooth module.
6. Pair and connect the Bluetooth devices: Put the Bluetooth module in pairing mode, enable Bluetooth on the receiving device, locate and pair with the Bluetooth module.
7. Develop a program or application on the receiving device to receive and process the data transmitted by the Arduino MEGA via Bluetooth.[12]

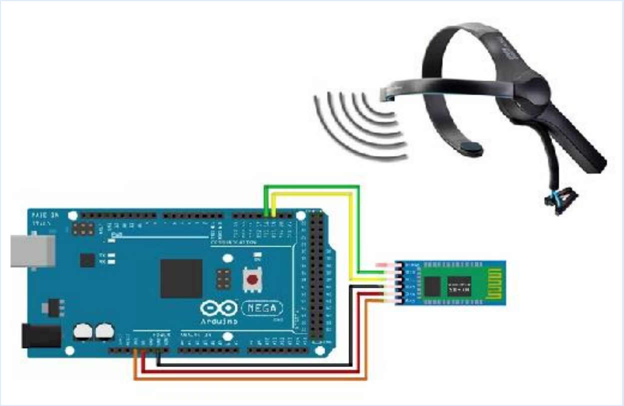

Figure (14) Connecting NeuroSky' sensor to the Arduino MEGA.

B. paper idea

The Epilepsy Monitoring and Early Seizure Detection Paper Using Technology relies on using a set of devices and components to collect and analyze vital data to detect epileptic seizures and take appropriate measures. Figure (15) involves using an Arduino board as the main controller to collect data and perform calculations. The rotation sensor is used to measure body movement and acceleration and detect epileptic seizures. GPS unit used to accurately locate the patient and record continuous location data. GSM technology is used to send alert messages when an epileptic seizure occurs. The altitude sensor is used to measure atmospheric pressure, temperature, and altitude and analyze their effect on epileptic seizures. Wi-Fi technology is used to transfer data to the cloud or other devices for analysis and sharing. The NeuroSky sensor can be used to monitor brain activity and detect abnormal changes. Bluetooth module is used to establish wireless connection between devices and exchange data. These components work together to monitor and detect epileptic seizures and send alerts and location information to doctors or relevant people to take necessary action.[13]

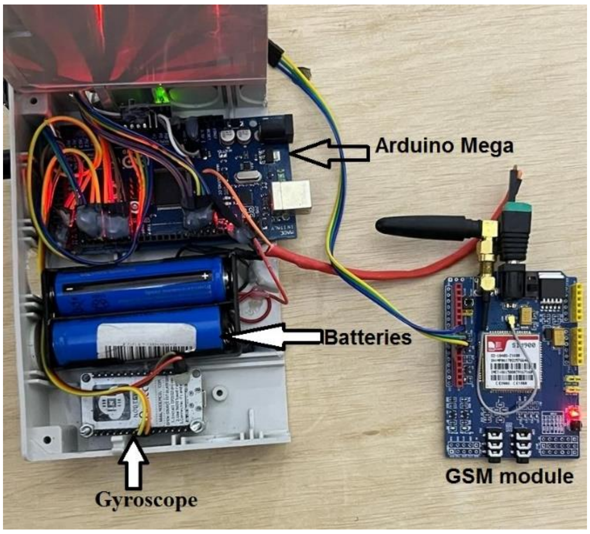

Figure (15) Paper circuit.

C. application interface

The application interface used in this paper as shown in figure (16) provides a simplified and user-friendly platform for monitoring epilepsy patients and managing their data. It includes features such as real-time EEG monitoring, seizure detection and alerts, location tracking, historical data analysis, medication reminders, communication and collaboration tools, and personalized settings. The interface aims to improve epilepsy management and ensure timely medical interventions for patient care.

When entering from the main interface, the interface shown in Figure (16) appears to us, which contains the angle of inclination and the critical ratio for the acceleration sensor when falling, as well as the number of times the fall. [14]

Figure (16) Memory data.

Through the interface shown in the figure (17), adjustments (Setting) can be made, such as specifying the target phone number, critical angles of fall, activating the alarm, and also the number of falls.

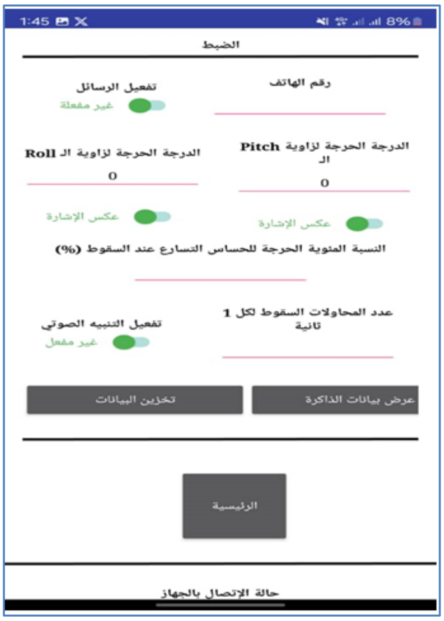

Figure (17) Setting interface.

The readings and location interface, as shown in Figure (18), displays the results of the readings relied upon in the paper, including latitude and longitude, as well as the inclination angles of the acceleration sensor, the number of falls, and the rate of the brain's attention and contemplation.

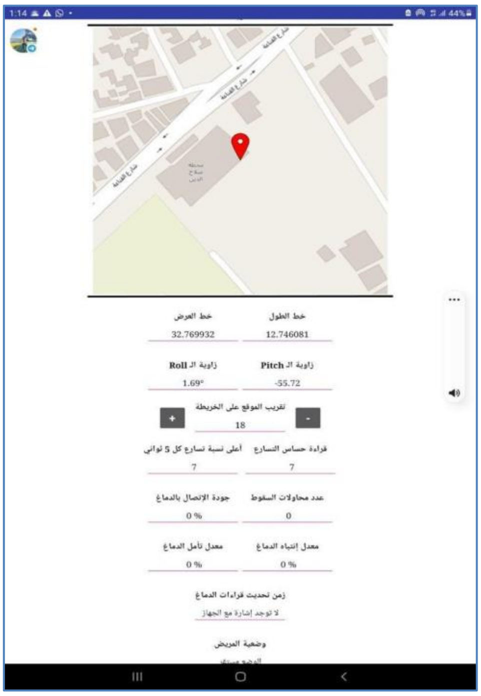

Figure (18) Interface for readings and locating.

CONCLUSION

This paper revolves around designing a device for monitoring epilepsy and early detection of seizures using Wi-Fi technology. The paper aims to provide an unconventional and effective means of continuous monitoring for epilepsy patients and early detection of seizures before they occur.

The design involves the use of a set of sensors and medical devices suitable for monitoring the electrical signals in the brain and analyzing them. The data is collected and transmitted from the device to the home network infrastructure using Wi-Fi technology. The data is remotely analyzed using signal processing algorithms to detect abnormal patterns or suspicious signals indicating the possibility of a seizure.

Upon detecting a potential seizure, immediate notifications are sent to relevant individuals, such as doctors or family members, through a smartphone application or text messages. The concerned individuals can take prompt actions to provide necessary assistance to the patient.

This paper stands out for providing comfort and safety for epilepsy patients, as they can have continuous monitoring and early detection of seizures, reducing potential risks and ensuring timely medical care. Additionally, the collected data can be used for statistical analysis and the development of more effective diagnostic and treatment tools for epilepsy patients.

This paper represents an opportunity to enhance skills in engineering design, network technologies, and signal processing, with a significant positive impact on the lives of epilepsy patients and the quality of healthcare they receive.

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