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IOT Based Epilepsy Monitoring Device for Children

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ABSTRACT:
Epilepsy is a common neurological disorder caused by hypersynchronous electrical discharges in the human brain, which leads to seizures in both children and adults. Many people lose their lives due to epilepsy, as there are limited devices available to detect seizures in time. Even when such devices exist, they often fail to provide accurate indications of epileptic episodes or timely alerts to guardians. To overcome this problem, we are developing an **IOT-based Epilepsy Monitoring Device** designed to enhance the care and safety of children with epilepsy. The system continuously monitors the child's **heart rate** using a pulse sensor and detects **abnormal body temperature** through a temperature sensor. When the patient suddenly got fall means accelerometer sensor send signal to the controller. In case of any unusual activity, the **GSM module** instantly notifies parents, guardian and family physicians. So as to ensure immediate help, the GPS module at the same time provides the child's accurate location. Also, the device is linked to an IOT platform, which allows for remote monitoring via a web or mobile application. A buzzer and a local LCD display also permit staff in nearby areas see shortly. This integrated method, that provides immediate detection and care during epileptic episodes, keeps children with epilepsy far safer overall.

Keywords: Epilepsy, seizures, sensors, controller.

INTRODUCTION

Now a days finding of epilepsy two difficult mainly in children .In epilepsy, seizures are caused by sudden bursts of improper electrical signals, which can happen unchecked by medication. Surgery may be helpful in some situations, but first doctors must identify the precise location in the brain creating the seizures. Traditional EEG techniques only provide estimated 3D maps and can overlook important data, particularly in young patients. In order to address this, scientists created a brand-new approach known as IDC-ESL, which more precisely defines the "seizure zone" by utilizing modern computer tools and 3D visualization. This helps surgeons know precisely where area of the brain to remove, making surgery safer and more successful **[1]**. Epilepsy is a long-term brain disorder where people suddenly get seizures, and this can happen even if they are taking medicine. To keep patients safe, doctors need systems that can detect seizures in real time and send alerts quickly. The problem is that seizures are hard to detect because brain signals (EEG) are very complex and noisy. This research introduces a new method that studies the “heavy-tail” patterns of brain signals and uses a special math tool (alpha-stable estimator) to detect seizures more accurately and with fewer false alarms, even when the signal has noise **[8].** Epilepsy happens when brain cells send out abnormal signals, causing seizures. Medicine is the most common treatment, but about 30% of patients still don't get better with drugs alone. Surgery is another option, but it often doesn't fully solve the problem. A small implantable device known as a programmable system-on-chip (SOC) was developed by researchers to assist these patients. It can monitor brain impulses and regulate seizures through the use of electrical and visual stimulation. Patients who do not react to traditional treatments may have hope thanks to this new technology, allowing doctors with more accurate methods to identify and prevent seizures **[12].** For people with epilepsy and their families, unexpected seizures can be horrible and unsafe. Although most current devices use visible sensors, some people may avoid due to the stigma, real-time seizure detection allow caregivers to act quickly. Scientists created Lamps, a secret video monitoring seizure detection device integrated into a standard light fixture, to address this issue. Lamps are a useful and discrete option for daily life because they operate in real time on tiny, inexpensive devices like Raspberry Pi, achieving excellent accuracy without the need for complex setup **[6].** Although some people with epilepsy benefit from medication, approximately one-third of patients with this brain illness continue to experience recurrent seizures. Deep brain stimulation (DBS), a more recent treatment, can be beneficial, however the equipment available today can only stimulate the brain and is unable to accurately track seizures in real time. Because of this, physicians find it challenging to assess the effectiveness of the treatment. In order to address this issue, researchers created an internal seizure monitor that can both record seizure activity in great detail and stimulate the brain.. This system gives doctors more accurate information to adjust treatment and could also be adapted for other brain disorders like Parkinson's disease or mood problems **[9].** Epilepsy is a brain disorder that causes seizures and affects people's daily life. To study epilepsy, doctors often use EEG devices to record brain activity over long periods, but these devices are usually heavy, use a lot of power, and create huge amounts of data. This research introduces a wearable EEG system-on-chip (SOC) that only selects and transmits the parts of EEG signals likely to contain seizures. By reducing unnecessary data, the device saves power, is smaller, and makes it easier for doctors to review important information, helping them diagnose epilepsy more efficiently **[7].** Epilepsy is a brain disorder that causes repeated seizures and can also lead to anxiety and depression. Detecting epilepsy early is very important so that doctors can treat patients effectively. EEG signals, which measure brain activity, are useful for spotting these problems. This research uses deep learning to turn EEG signals into pictures called spectrograms and then trains a neural network to detect epilepsy automatically. The method achieved very high accuracy, making it a promising tool for early diagnosis and better care for patients **[15]**.

LITERATURE SURVEY

In 2024, this author Shin and colleagues developed IDC-ESL**,** a method using intracranial EEG and 3D visualization to locate brain areas causing epilepsy in children. It works well for focal epilepsy, helping predict surgery success when affected areas are fully removed. The method is less effective for Lennox-Gastaut syndrome because lesions are deep or spread out. Overall, IDC-ESL helps plan pediatric epilepsy surgery but needs careful use in complex cases. **[1]**.In 2025, this researcher Theeban Raj Shivaraja and colleagues developed OPTIEEG**,** a portable EEG system to monitor epilepsy at home. It uses Open BCI technology, dry electrodes, 3D-printed headgear, and a mobile app. They tested it on 14 people (10 healthy and 4 with epilepsy) with tasks like eye open-close, breathing exercises, and light stimulation. The results showed that OPTI EEG gives similar brain signal quality as a hospital EEG machine and is reliable for repeated use. It is a low-cost, portable option for remote monitoring, but the study had a small number of participants and did not test long-term seizure monitoring **[2].** In 2024, Bhagubai and colleagues ran a grand challenge to improve seizure detection using wearable EEG. They used data from 42 patients with behind-the-ear EEG recordings. The best algorithm used a decision tree with data augmentation. This study shows that wearable EEG and machine learning can help monitor seizures outside hospitals **[3].** In 2021, author Jahromi and colleagues studied intracranial EEG in 8 children with drug-resistant epilepsy. They tracked how spikes, ripples, and fast ripples propagate in the brain and identified the onset electrodes. The overlap of spike and ripple onsets was a specific marker of the epileptogenic zone, helping guide surgery. Fast ripples were also found to propagate over larger brain areas than previously known **[4].** In 2021, researcher Iranmanesh et al. developed a wearable EEG SoC that reduces power by selecting only seizure-relevant data. It achieves sensitivity while transmitting just EEG signals. The device is small, low-power, and suitable for long-term home monitoring of epilepsy patients **[5].** In 2024, author Servin-Aguilar et al. proposed a real-time epilepsy detection method using EEG signals by analyzing their heavy-tail statistical behavior. They applied an alpha-stable estimator to detect seizures efficiently, showing robustness to noise below 3.8 dB. The approach improved detection accuracy and reduced false positives compared to previous methods, making it useful for continuous monitoring of epilepsy patients **[6].** Researcher Fleming et al. (2025) developed an implantable system to track seizures in real time for patients with drug-resistant epilepsy. The device monitors brain activity during neuromodulation therapy, enabling clinicians to optimize treatment and assess long-term outcomes **[7].**

PROPOSED METHODOLOGY

Aim of the project is to monitor the children how are suffering with epilepsy. The proposed system connects multiple sensors, including a heartbeat sensor, temperature sensor, and accelerometer, all of which are connected with a microcontroller. The microcontroller processes the required sensor data and, upon detecting values beyond restrictions in place, alerts both local and remote alerts. Additionally, a GPS module is combined to provide continuous location updates. All collected data are transmitted to a cloud platform for real-time monitoring. Parents and healthcare professionals can comfortably access the child's health parameters and location information via a smartphone application or a web-based dashboard.

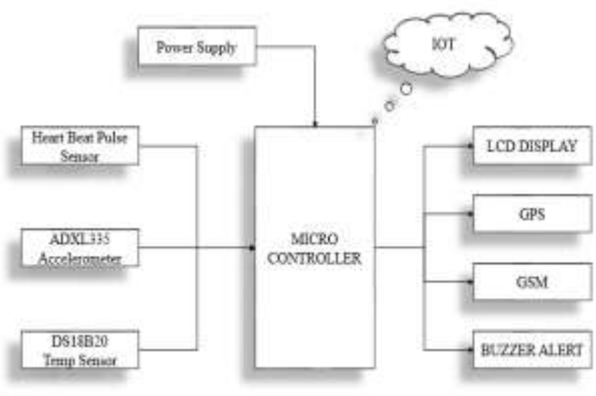

Fig.1. Block diagram of the proposed methodology

HARDWARE WORK FLOW:

- **PULSE / HEARTBEAT SENSOR:**

FIG.2. HEARTBEAT SENSOR

This project use a heartbeat sensor, such as the Pulse Sensor, to measure the heart's beat. It monitors how the blood flow varies while the heart pumps by explaining a tiny light on the skin, generally the finger. This is known as PPG. The microcontroller (NODE MCU) then receives signals from the sensor. The signal enters one of the node MCU input pins immediately if the sensor is analogy. Special connections known as I^2C are used to link digital sensors, such as the MAX30102. To clearly see every pulse, the microcontroller reads this data numerous times per second, typically between 50 and 100 times. It employs filters to eliminate noise from movement or unsteady hands in order to clean the signal. In order to determine beats per minute (BPM), the system then searches for peaks in the signal—the tall portions that correspond to heartbeats—and counts them. The device sounds an alert if the heart rate is too high, low, or extremely irregular. Additionally, it double-checks whether the changes are genuine or the result of movement using the motion sensor. This improve the true nature and safety of the monitoring.

TEMPERATURE SENSOR:

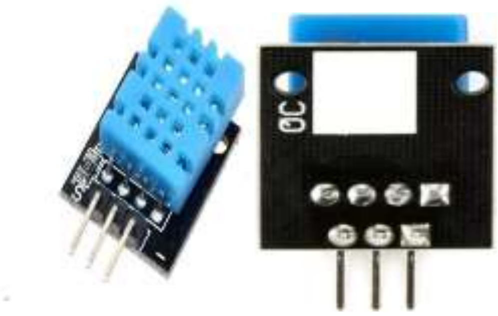

FIG.3. TEMPERATURE SENSOR:

This project uses a temperature sensor to monitor the child's body temperature or the ambient temperature. It is a tiny digital sensor with a fairly accurate temperature reading, typically within 0.5 degrees. One data cable, together with power and ground, connects the sensor to the microcontroller (NODE MCU). To keep the readings, a tiny resistor (4.7 KΩ) is also placed between the power and data wire. Since temperature changes take longer than movement or heartbeat, the microcontroller requests the sensor for a readout every few seconds, often between 5 and 30 seconds. It may take up to a second for the sensor to complete its measurement before returning the temperature data. The NODE MCU checks if the temperature is within the allowed limits. For instance, if the temperature consistently exceeds 39 °C, it could indicate that the youngster is overheated or has a fever. In this situation, an alert will be set off. This sensor is effective for long-term use because it consumes extremely little electricity. You can test it by putting it in warm or cold environments or by discussing its reading with that of a standard thermometer.

ACCELEROMETER SENSOR:

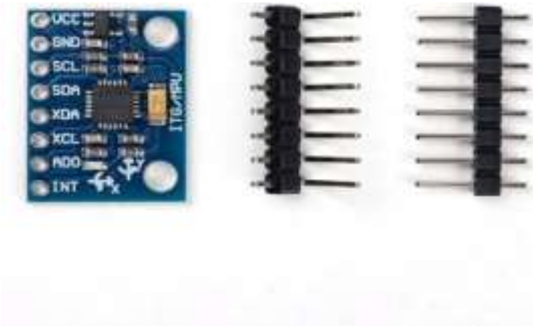

FIG.4 ACCELEROMETER SENSOR

This project uses an accelerometer to detect movement in three directions: forward-backward, left-right, and up-down. This is important because kid may experience sudden, strong, regular shaking movements during an epileptic seizure. The microcontroller (NODE MCU) receives the data from the accelerometer when it detects these changes. The accelerometer gives 3 separate signals, one to each direction, that link to the input pins of the NODE MCU. In addition to having a unique pin that may "wake up" the NODE MCU when motion is detected, the MPU6050 and ADXL345 link via I²C cables, making wiring simpler. When abrupt activity is detected, the NODE MCU begins recording movement at a high rate (50 to 200 times per second) for a few seconds. Normally, the accelerometer is kept in low-power mode. The NODE MCU then combines the X, Y, and Z data to determine the shaking's intensity. A warning is sent if the shaking lasts longer than two seconds and is more intense than a specific limit, which could indicate a seizure. You can manually shake the device to see if the system is successfully sending an alert.

NODE MCU

FIG.5. NODE MCU

The brain of this epilepsy monitoring system is the NodeMCU. It collects information from every sensor, makes choices, and communicates with physicians and parents. The NodeMCU pins are used to connect the motion, temperature, and heartbeat sensors. Special I²C pins (D1 for SCL and D2 for SDA) are used by digital sensors such as the accelerometer (MPU6050) and temperature sensor (DS18B20). The single ADC pin (A0) is used for analogy sensors, such as a basic pulse sensor. To allow the NodeMCU to sound alarms, the buzzer and LED are connected to standard GPIO pins. Through its serial connection pins

(TX/RX), the GPS or GSM modules can be linked. First, the firmware (the software that runs on it) connects to the internet and turns on Wi-Fi. In order to transmit health data and alarms in real time, it then connects to the MQTT broker, a cloud service. The NodeMCU reads the temperature every few seconds, the pulse sensor continuously, and the accelerometer only in answer to sudden changes during normal use. The NodeMCU transmits the GPS location, uploads the warning, and sounds the buzzer whenever any value rises or drops below safe limits. The data can then be viewed by parents or doctors on their dashboard or phone.

LCD DISPLAY:

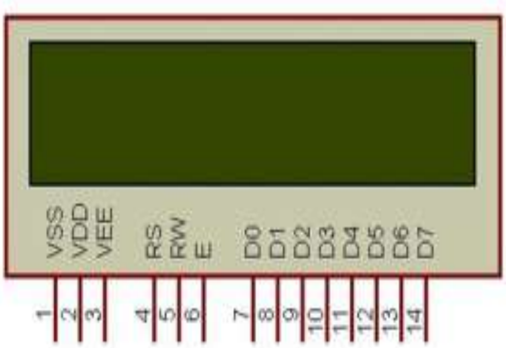

FIG.6. LCD DISPLAY

In this project, the LCD or OLED display works identical to a small screen that displays the system's present state. Without the need for an app, it enables parents, doctors, or even the child to make sure what the device is doing. I²C pins (D1 for SCL and D2 for SDA) are used to connect the display to the NodeMCU. Because only two data wires, added to power and ground, are required, wiring becomes easier. The NodeMCU updates data on the screen every few seconds. For instance, it can display the battery power, body temperature, heart rate, and Wi-Fi connectivity. The screen will instantly switch to a warning message such as "ALERT — Seizure Suspected" along with the GPS coordinates in the event of an emergency, such as a possible seizure. In this manner, anyone in the area can rapidly realize the issue. The display does not update a lot to conserve battery life, and after a period of absence of activity, the OLED brightness or backlight can be switched off. The NodeMCU will continue to provide alerts by MQTT and Wi-Fi even if the display stops. You can test it by verifying if alert messages show during simulated events and if the correct values appear.

GPS MODULE

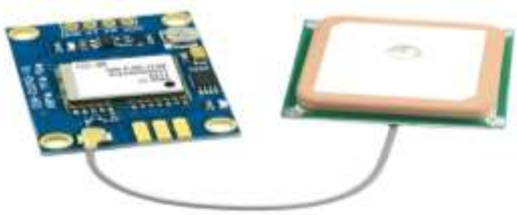

FIG.7. GPS MODULE

GSM MODULE:

FIG.8. GSM MODULE

The device's inside GSM module acts like to a mobile phone. When Wi-Fi is not available, it allows the system to send messages or use mobile data. This makes it a very helpful backup so that even when the child is outside without Wi-Fi, parents and physicians always receive alerts. The module uses the TX and RX UART pins to communicate with the NodeMCU. GSM modules require a steady power source with a separate 4–5V source and specific capacitors to prevent abrupt resets since they use more power—up to 2 amps during signal spikes. AT commands are basic text-like commands that the NodeMCU uses talk with the module. It can send an SMS with the child's GPS location, temperature, and heart rate, for instance. The NodeMCU will quickly turn to GSM mode and send an emergency SMS if Wi-Fi is lost and the system is unable to access the cloud. Although SMS is faster and more reliable for important alerts, it may also transfer data to the cloud via GPRS (mobile internet). In some designs, SMS commands can even be sent to the GSM module to reset or operate the device. Checking the network signal strength and SMS delivery speed should be part of the testing process.

BUZZER:

FIG.9.BUZZER

This system's buzzer works as a loud alarm that quickly alerts people in the area if the child may have a seizure. It makes a heard beeping sound, allowing caregivers to promptly arrive and assist. A transistor, sometimes known as a MOSFET, is a small electronic switch connecting the buzzer to the NodeMCU. This is crucial since the buzzer can't get sufficient power directly from the NodeMCU. To protect the circuit, a resistor and occasionally a diode are added. The NodeMCU simply needs to turn on or off an active buzzer, which already has a built-in sound circuit. If it is a passive buzzer, the NodeMCU uses PWM, or quick on/off signals, to produce sound patterns. The firmware is set up so that the buzzer first produces short warning beeps when the system senses danger, and then it switches to a loud, continuous sound if no one answers. The system will note when parents use the smartphone app or a button on the device to switch off the buzzer. For silent alerts, a small vibration motor is an optional addition. Checking various beep patterns, sound volume, and making sure it is not too harsh are all part of the testing method.

NETWORK SETUP:

This epilepsy monitoring system's network setup lets parents and doctors get all sensor data and alerts quickly. Wi-Fi is the main method that the NodeMCU connects to the internet. In the initial setup, the device can create a temporary hotspot of its own, allowing parents to use a smartphone to enter inside Wi-Fi name and password. MQTT, a lightweight communication protocol frequently seen in Internet of Things devices, is the system that the NodeMCU uses once it is linked. The NodeMCU regularly sends sensor data, especially motion, temperature, and heart rate, to a cloud platform via MQTT. The NodeMCU quickly sends a alert message with information like GPS location and health data if an alert is triggered. This data is stored on the cloud, which also updates the dashboards and sends parents and doctors SMS alerts. In the event that Wi-Fi is not available, the system can fall back on the GSM module, which transmits SMS or uses mobile data. Because the network design was created with trust in mind, caregivers can still access the data even if one connection fails. Testing involves searching for real-time updates on the app and disconnecting Wi-Fi to see if GSM takeover works.

Data & alert flow:

This project's data pipeline shows how sensor data flows from the device to parents and medical doctors. First, the NodeMCU processes the data locally after the sensors (heartbeat, temperature, and accelerometer) gather measurements. The device responds instantly if the readings surpass a danger threshold. By activating the buzzer and displaying a warning message on the LCD screen, it initiates a local alert. To swiftly record the child's location, the GPS module is also set to high-frequency mode. After that, the NodeMCU sends a wireless MQTT alert message. This alert offers information like the GPS locations, device ID, event time, and sensor that caused it. A link to the raw sensor data for testing may also be covered, if desired. The alert is sent by a specific function in the cloud, stores it in a database, updates the live dashboard, and alerts parents and doctors by SMS or push notifications via mobile apps. After then, parents can launch the app and tap Acknowledge. The app use MQTT to transmit this command back to the device. So as let caregivers know that the alert was addressed, the device accepts it, moves off the buzzer, and updates its state.

RESULT & DISCUSSIONS:

The system was tested under different conditions to check how well each component responds and works together. The heartbeat pulse sensor was able to measure the user’s heart rate with acceptable accuracy, and the readings remained stable when the finger was placed properly. The ADXL335 accelerometer successfully detected body movements and posture changes, helping to identify abnormal conditions like sudden falls or unusual motion. The DS18B20 temperature sensor provided consistent body temperature readings without major fluctuations. All the sensor data was processed by the microcontroller and displayed clearly on the LCD, making it easy to monitor in real time. The GPS module accurately tracked the location, and the GSM module was able to send alerts without delay when abnormal values were detected. The buzzer alert also responded immediately, giving a local warning. Overall, the system performed reliably, with good coordination between hardware components. Minor issues like sensor placement sensitivity and signal noise were observed, but they did not affect the overall functionality in a major way.

CONCLUSION:

The system works as intended by monitoring vital parameters and giving timely alerts during abnormal conditions. It combines multiple sensors effectively, making it useful for basic health and safety tracking. The overall setup is simple, low-cost, and easy to use in real-time situations. In the future, the system can be improved by adding more accurate sensors and connecting it to a mobile app for better monitoring. Further development can also include cloud storage and data analysis to track long-term health patterns.

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