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EPIALERT – A Wearable IoT-Based Device for Early Detection and Alerting of Epileptic Seizures

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Abstract
Epilepsy is a chronic neurological disorder charac- terized by recurrent and unpredictable seizures that can pose serious risks to patient safety if not managed promptly. Many existing seizure monitoring systems are either expensive, hospital- centric, or lack real-time alerting and location tracking capabili- ties. This paper presents EPIALERT, a low-cost wearable Inter- net of Things (IoT)-based device designed for early detection and real-time alerting of epileptic seizures. The system continuously monitors physiological and motion-related parameters such as body temperature, sweat levels, and abnormal movements using embedded sensors. Upon detecting seizure-like conditions, the device triggers local alerts and automatically notifies caregivers through a Telegram bot along with the patient's live GPS location. An OLED display provides real-time feedback on sensor readings and system status. The proposed solution aims to enhance patient safety, enable faster medical response, and support continuous health monitoring while remaining affordable and portable.

Keywords: *Epilepsy, Seizure Detection, Internet of Things, Wearable Devices, Real-Time Alerting, Telegram Bot*

1. Introduction
Epilepsy affects millions of people worldwide and is marked by sudden, recurrent seizures that can occur without warning. These episodes may lead to severe injuries, long-term health complications, or even fatal outcomes if immediate assistance is not available. Traditional seizure monitoring approaches primarily rely on manual observation by caregivers or post-event clinical analysis, which often results in delayed response. Recent advancements in wearable technology and IoT have enabled continuous monitoring of physiological parameters, offering new opportunities for early seizure detection. How- ever, many existing solutions are costly, lack automated alert- ing mechanisms, or fail to provide real-time location tracking. To address these limitations, this paper proposes EPIALERT, a wearable IoT-based system that integrates multiple sensors, real-time processing, and instant caregiver notification to ensure timely intervention during epileptic seizures. Epilepsy is a chronic neurological disorder characterized by sudden, recurrent, and unpredictable seizures resulting from abnormal electrical activity in the brain. These episodes may lead to convulsions, loss of consciousness, or autonomic disturbances, placing individuals at significant risk of in- jury and medical emergencies. Traditional clinical monitoring methods such as EEG-based systems are highly accurate but require hospital environments, continuous electrode contact, and trained medical personnel, making them unsuitable for everyday use. Recent advancements in wearable technology, Internet of Things (IoT), and edge-based artificial intelligence (AI) have provided new opportunities for real-time health monitoring outside clinical settings. By integrating physiological sensors, embedded machine learning models, and wireless communi-cation, it is now possible to build compact, low-power devices capable of detecting seizure symptoms and alerting caregivers instantly. This technological evolution forms the foundation of EpiAlert, a wearable IoT-based seizure detection and alerting system.

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2. Problem Statement

Epileptic seizures occur suddenly and require immediate medical attention to prevent serious harm. Although portable seizure monitoring devices are available, most of them are expensive and do not provide instant alerts to caregivers. Many systems focus primarily on data logging rather than real- time detection and emergency notification. Additionally, the absence of live GPS tracking in existing solutions can delay medical assistance. Therefore, there is a need for an affordable, wearable IoT-based device capable of early seizure detection and automatic real-time alerting with location tracking.

3. Objectives

The main objectives of the proposed system are:

- To design a wearable IoT-based device for early detection of epileptic seizures.
- To provide real-time alerts to caregivers during seizure events.
- To include live GPS tracking for accurate and rapid medical response.
- To develop an affordable and reliable health monitoring solution for epileptic patients.
- To enable continuous health data collection for long-term analysis and personalized care.
- To support remote monitoring through mobile or cloud- based platforms.

4. System Design and Methodology

The EpiAlert system is designed as a compact, wearable IoT-based health monitoring solution aimed at the early de- tection and alerting of epileptic seizures. The system fol- lows a layered architecture that integrates sensing, processing, communication, and alerting modules to ensure real-time monitoring and rapid response. The methodology involves continuous acquisition of physiological and motion-related data, preprocessing and analysis of sensor readings, detection of abnormal patterns indicating a seizure, and immediate notification to caregivers along with location details. The wearable device continuously monitors the user's body temperature, sweat activity, and motion patterns using em- bedded sensors. These parameters are chosen as they exhibit noticeable variations during epileptic seizures. The collected data is first preprocessed locally to remove noise and check predefined threshold values. Once abnormal behavior is iden- tified, the system confirms the seizure event and triggers both local and remote alerts. The architecture ensures low latency, reliability, and energy efficiency, making it suitable for continuous daily use.

4.1.Hardware Overview

The hardware design of the EpiAlert system consists of low- power, compact, and cost-effective components integrated into a wearable form factor. The core processing unit is the ESP32 microcontroller, which provides sufficient computational capa- bility, built-in Wi-Fi connectivity, and low power consumption. In addition, the XIAO nRF52840 microcontroller is utilized for sensor interfacing and initial preprocessing due to its efficient handling of sensor data and integrated accelerometer support. Body temperature is monitored using the LM35 tempera- ture sensor, which provides accurate and linear temperature readings. Sweat levels are measured using a sweat sensor to capture changes in skin conductivity, which can increase during seizure episodes. Motion and abnormal body move- ments are detected using the built-in accelerometer, enabling the identification of sudden or repetitive movements associated with seizures. An OLED display is incorporated to provide real-time vi- sualization of sensor values, system status, and alert messages such as "Seizure Detected." A buzzer is used for immediate local alerts to notify nearby individuals. For location tracking, a GPS module is integrated to obtain real-time geographical coordinates during emergency situations. The entire system is powered by rechargeable 18650 lithium-ion batteries. A Battery Management System (BMS) and buck converter are employed to ensure safe charging, volt- age regulation, and stable power delivery to all components. This hardware configuration ensures portability, safety, and uninterrupted operation of the device.

4.2.Software Overview

The software architecture of EpiAlert is designed to support real-time data acquisition, processing, communication, and alerting. The firmware for the ESP32 and XIAO nRF52840 is developed using the Arduino IDE, enabling efficient inte- gration of sensor drivers, communication libraries, and control

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logic. Sensor data acquisition modules continuously read temper- ature, sweat, and motion values at defined intervals. The pre- processing stage involves filtering noise, normalizing values, and comparing readings against predefined threshold levels. If abnormal patterns are detected, the software flags a potential seizure event. The decision logic confirms the event before triggering alerts to minimize false positives. For communication, the ESP32 utilizes Wi-Fi connectivity along with secure HTTPS protocols. The Telegram Bot API is integrated using the UniversalTelegramBot and WiFiClientSe- cure libraries. Once a seizure is detected, the system automat- ically sends real-time alert messages containing seizure status, sensor readings, and live GPS location to registered caregivers through Telegram. The OLED display module is controlled through dedicated libraries to show live sensor data and alert notifications. The software also manages power-efficient operation by optimizing sensor polling and communication intervals. The modular design of the software allows future integration of machine learning models for enhanced seizure prediction and cloud- based data storage for long-term health analysis.

4.3.Workflow

- The wearable system is activated and enters continuous monitoring mode.
- Physiological and movement-related parameters of the user are continuously observed.
- The collected data is analyzed in real time to identify abnormal patterns.
- The system evaluates whether the detected patterns indicate a seizure event.
- If no abnormality is detected, normal monitoring contin- ues without interruption.
- When a seizure event is identified, an emergency alert is generated.
- The alert is communicated to the caregiver to enable timely medical assistance.

5. Existing System

Existing epileptic seizure monitoring systems primarily rely on manual observation by caregivers, family members, or medical staff. In most cases, seizure detection occurs only after visible symptoms appear, which can significantly delay medical intervention. Continuous supervision is often required, making these methods unreliable and impractical for indepen- dent patient monitoring. Some portable monitoring devices are available; however, they are generally expensive and limited in functionality. Many existing systems focus mainly on data recording and post- event analysis rather than real-time detection and immediate alerting. As a result, caregivers are not notified instantly during emergency situations. Additionally, most current solutions lack integrated location tracking, which can delay emergency response when the patient is alone or outdoors. Limited use of wearable IoT technology and poor remote accessibility for healthcare pro- fessionals further restrict the effectiveness of existing systems. These limitations highlight the need for an affordable, real-time, and automated seizure detection and alerting solution.

6. Proposed System

The proposed system, EpiAlert, is a wearable IoT-based so- lution designed for the early detection and alerting of epileptic seizures. The system continuously monitors key physiologi- cal and movement-related parameters of the user to identify abnormal patterns that may indicate seizure activity. This enables timely detection and rapid response during emergency situations. Unlike existing systems, the proposed solution provides real-time alerting by automatically notifying caregivers when a seizure event is detected. The system also shares rele-vant emergency information, allowing caregivers to respond promptly. Continuous monitoring ensures uninterrupted super- vision without the need for constant human observation. The proposed system is designed to be affordable, portable, and user-friendly, making it suitable for daily use by epileptic patients. Its wearable design supports remote monitoring and quick assistance, thereby improving patient safety and reduc- ing response time during critical situations. which can increase during seizure episodes. Motion and abnormal body move- ments are detected using the built-in accelerometer using a sweat sensor to capture changes in skin conductivity, which can increase during seizure Figure 1 shows Architecture diagram

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7. Architecture Diagram

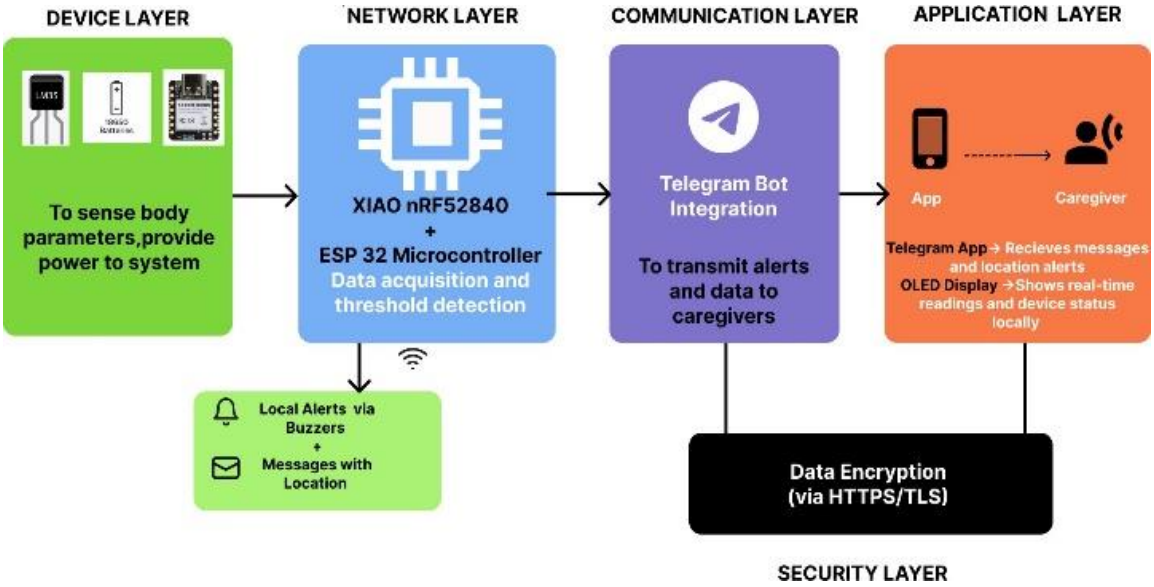

Figure 1 Architecture diagram

8. Advantages of The Proposed System

- Early detection of epileptic seizures enabling timely in- tervention.
- Real-time alerts with live GPS location sent to caregivers.
- Use of Telegram bot for instant, cost-effective communi- cation.
- Continuous health monitoring through IoT-based sensors.
- Low-cost and energy-efficient components for affordabil- ity.
- Automatic emergency notifications to ensure rapid re- sponse.
- Compact, wearable, and user-friendly design.
- layered wearable architecture that integrates sensing, processing, communi- cation, and alerting modules to enable continuous health monitoring and rapid emergency response. The architec- ture ensures reliable operation, low latency, and efficient power utilization, making it suitable for long-term daily use by epileptic patients.
- The wearable device continuously monitors key physi- ological and motion-related parameters, including body temperature, sweat levels, and body movement, using an LM35 temperature sensor, a sweat sensor, and an in-built accelerometer. These parameters are selected due to their observable variations during epileptic seizure episodes. The sensor data is collected in real time and subjected to initial processing to remove noise and check for abnormal variations.
- The microcontroller performs threshold-based analysis and motion pattern evaluation to identify potential seizure conditions. By correlating multiple sensor readings, the system reduces false detections and improves the relia- bility of seizure identification. When abnormal patterns exceed predefined limits, the system confirms the occur- rence of a seizure event.
- Upon seizure detection, the system immediately initiates the alerting mechanism. A buzzer is activated to provide a local alert, notifying nearby individuals of the emer-gency. Simultaneously, a real-time notification containing seizure status and live GPS location is transmitted to registered caregivers through a Telegram bot, enabling quick medical intervention.
- An OLED display is integrated into the

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system to provide continuous visual feedback by displaying live sensor readings, system status, and alert messages such as “Seizure Detected.” This enhances usability and allows on-device monitoring without the need for external inter- faces.

- The entire system is powered by rechargeable batteries supported by appropriate power management circuitry. This ensures stable voltage regulation, safe charging, and efficient energy utilization. The compact and wearable design of the system, combined with reliable communi- cation and alerting features, makes EpiAlert an effective solution for real-time epileptic seizure monitoring and emergency responseThe EpiAlert system is designed as a Figure 2 shows System Architecture

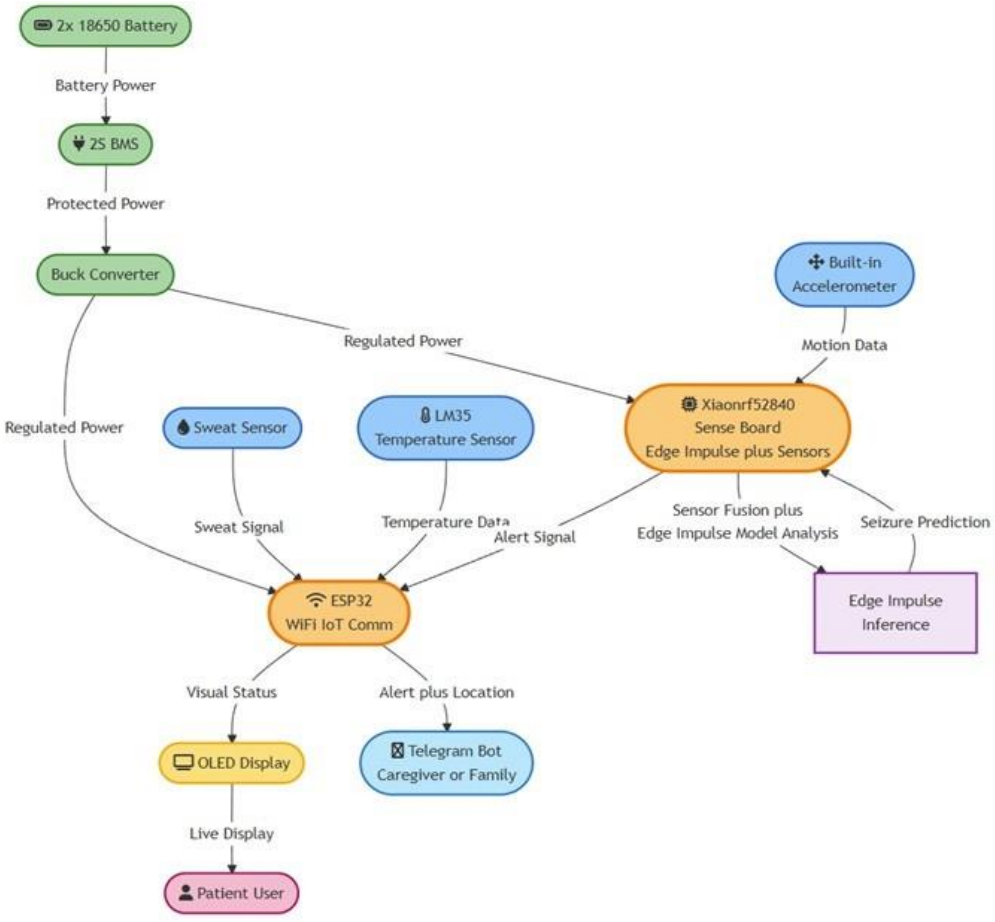

Figure 2 System Architecture

9. Telegram Bot Integration

A Telegram bot is created using the BotFather platform, which generates a unique bot token. The bot token and caregiver chat ID are integrated into the microcontroller code for authentication. Secure communication is es- tablished using HTTPS. When a seizure or abnormal condition is detected, the system automatically sends an alert message containing patient status and temperature readings to the caregiver’s Telegram application, ensuring instant and reliable communication without the need for third-party IoT services.

10. Current Implementation

- At the current stage of development, the EpiAlert system has been partially

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implemented with a focus on core hardware integration and basic monitoring functionality. The wearable device successfully interfaces with essential sensors to collect physiological and motion-related data in real time. Temperature and sweat sensing modules are operational and provide continuous readings that are displayed on the onboard OLED screen.

- The microcontroller firmware has been developed to support continuous data acquisition and threshold-based monitoring. Initial logic has been implemented to iden- tify abnormal variations in sensor values, enabling basic detection of emergency conditions. The OLED display effectively presents live sensor readings and system sta- tus, improving user awareness and device usability.
- Wireless communication capabilities have been estab- lished, allowing the system to connect to a network for alert transmission. Local alert functionality using a buzzer has been implemented and is triggered when abnormal conditions are detected during testing. This ensures immediate nearby notification even before remote alerts are delivered.
- Power management for the wearable device has been implemented using rechargeable batteries and regulation circuitry to provide stable and safe operation. The sys- tem has been tested for basic reliability and continuous operation under controlled conditions.
- Advanced features such as machine learning-based seizure prediction, fully automated caregiver alerting with detailed health analytics, and long-term cloud data storage are not yet implemented in the current phase. These enhancements are planned for future development stages to improve detection accuracy, scalability, and overall system performance.

Results and Discussion

- The initial implementation of the EpiAlert system demon- strates the feasibility of using a wearable IoT-based archi- tecture for continuous health monitoring and emergency alerting. During Phase-I testing, the system successfully monitored physiological and motion-related parameters and displayed real-time readings on the OLED screen. The stable acquisition of temperature and sweat data indicates reliable sensor integration and consistent system operation.
- Threshold-based analysis enabled the identification of ab- normal parameter variations during simulated emergency conditions. When predefined limits were exceeded, the system responded by triggering local alerts, validating the effectiveness of the basic detection logic. The buzzer- based alert mechanism provided immediate notification, which is essential in scenarios where caregivers are nearby.
- Wireless communication functionality was verified through successful network connectivity and alert trans- mission. The system demonstrated the ability to generate real-time notifications, indicating that the communication pipeline is suitable for remote caregiver alerting. This confirms the practicality of integrating IoT communica- tion into wearable healthcare devices.
- Power management tests showed that the device operates reliably using rechargeable batteries with stable voltage regulation. The wearable form factor and low-power com- ponents support continuous operation, making the sys- tem appropriate for long-term usage. The OLED display provided clear visualization of system status and sensor values, improving usability and monitoring convenience.
- While the current results validate the core functionality of the proposed system, the detection mechanism is limited to threshold-based logic, which may result in false positives under certain conditions. The absence of machine learning-based prediction restricts the system's ability to adapt to

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individual patient patterns. These lim- itations highlight areas for improvement and justify the integration of advanced analytics and predictive models in future phases.

- Overall, the results confirm that EpiAlert provides a strong foundational framework for real-time seizure monitoring and alerting. The Phase-I implementation success- fully validates system architecture, sensor reliability, alert responsiveness, and power efficiency, forming a solid basis for further enhancements.

Conclusion and Future Work

- This paper presented EpiAlert, a wearable IoT-based system designed for the early detection and alerting of epileptic seizures. The proposed system aims to enhance patient safety by enabling continuous monitoring of phys- iological and movement-related parameters and providing timely alerts to caregivers during emergency situations. By integrating sensing, processing, communication, and alerting mechanisms into a compact wearable device, EpiAlert addresses the limitations of conventional seizure monitoring approaches.
- The system architecture emphasizes real-time operation, reliability, and user convenience, making it suitable for daily use by individuals with epilepsy. Automated alert generation and caregiver notification reduce dependence on constant human supervision and help minimize re- sponse time during critical events. The inclusion of location-based information further supports rapid medical assistance.
- Future enhancements will focus on improving detec- tion accuracy and adaptability through the integration of intelligent data analysis techniques such as machine learning. Cloud-based data storage and remote access for healthcare professionals can enable long-term monitoring and personalized treatment planning. Additional physio- logical sensors, improved power efficiency, and extensive real-world validation will further strengthen the system's effectiveness. With continued development, EpiAlert has the potential to serve as a comprehensive, affordable, and scalable solution for intelligent seizure monitoring and emergency response.

References

[1]. Raja Mourad; Ahmad Diab; Zaher Merhi; Mohammad Khalil; Re´gine Le Bouquin Jeanne´sr, "Epileptic Seizure Detection Using Energy Thresholding," IEEE Access, vol. 9, pp. 10035–10045, 2021.

[2]. A. V. D. Meer, A. S. Patel, J. R. Britton, and M. S. Richardson, "Wearable seizure detection devices: A review," Epilepsia, vol. 61, no. 5, pp. 1039–1051, May 2020.

[3]. Empatica Inc., "Embrace2: FDA-cleared seizure monitoring system," 2020. [Online]. Available:https://www.empatica.com/embrace2

[4]. Empatica Inc., "EpiMonitor FAQ," 2024. [Online]. Available: https:// support. empatica. com/hc/en- us/ articles/ 29007125819421-EpiMonitor-FAQ

[5]. P. L. N. Rani, K. S. Rajasekaran, and S. A. Priya, "IoT-based health monitoring system using wearable sensors," in Proc. 2022 Int. Conf. on Smart Healthcare Systems, Chennai, India, pp. 56–62.

[6]. M. Beniczky et al., "Automated real-time detection of tonic–clonic seizures using a wearable accelerometer," Epilepsia, vol. 54, no. 4, pp. e58–e61, 2013.

[7]. A. Patel and K. K. Tripathi, "Low-cost IoT-based patient monitoring system," in Proc. 2021 IEEE Int. Conf. on IoT and Applications (ICIOT), pp. 45–50.

[8]. A. Milosevic, J. J. O'Shea, and T. Fahey, "Clinical validation of wearable seizure detection devices: A systematic review," Seizure: European Journal of Epilepsy, vol. 72, pp. 37–44, 2019.