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Development of Epileptic Seizure Symptoms Detection Device

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Abstract

This paper shows a seizure detection device developed with a pulse oximeter, accelerometer, and vibration sensor. A 9V battery, LM2596 voltage regulator, and two ESP32 microcontrollers were also used in the development process. The pulse oximeter is a sensor whose purpose is to measure the patient's activity level: oxygen saturation, and heart rate. The accelerometer detects motion or activity in a patient's body, which could indicate a possible seizure. On the other hand, a jerky body movement manifested during seizure is detected by the vibration sensor to help in increasing the efficiency of the seizure detection model. The ESP32 microcontroller was interfaced with the sensors in the proposed device to enable data collection and transmission. The LM2596 voltage regulator was added to ensure that power from a 9V battery is always on. The Blynk app provides notifications or alerts to the caregivers whenever there is a seizure. To epileptic patients, this device assures their safety and quality of life because of providing a fast intervention and on-time monitoring. Complete seizure detection is achieved by integrating different kinds of sensors and microcontrollers, while the Blynk app is there to ensure its proper communication with the caregivers for effective and efficient management of the care.

1. Introduction

Epilepsy is one factor in a chronic neurological disorder where a person has unprovoked seizures because of the rise of abnormal electrical activity in the brain. The seizures come in convulsions, affected consciousness, and strange behaviors. Therefore, epilepsy affects all persons at equal measure, regardless of age and background. Diagnosis usually occurs after a person has had several unprovoked seizures. The major factors that highly contribute to epilepsy include infections, genetic predispositions, trauma to the brain, and structural anomalies in the structure of the brain [1]. Because of its complex etiology, much research is required to unravel the underlying mechanisms until specified interventions are arrived at. The management techniques, though able to control seizures by medication or through alterations in lifestyle and at times surgical interventions, have not been able to procure a permanent cure. These patients need lifelong medical care and support for the management of seizures to keep their impact on everyday life and well-being at a minimum. It is thus of paramount importance that medical research continues and comprehensive therapy should be devised with the purpose of ameliorating quality of life for the sufferers from epilepsy. It will also understand the psychological aspects and research will improve the treatment strategies.

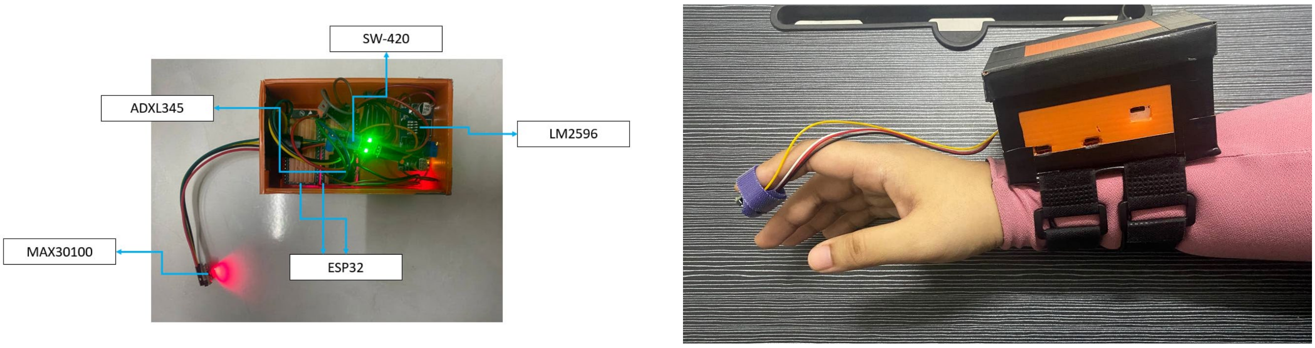
Although the guidelines in treatment plans are developing, epileptic seizures are still the leading reason for disability, chiefly among children. Seizure tracking and monitoring are critical in establishing seizure burden, evaluating recurring risk, and monitoring response to treatment [2]. These are life-long debilitating conditions, and delayed treatment may lead to serious brain complications; hence, early diagnosis and intervention may help in reducing possible mental health risks. Moreover, continuous monitoring of the patient's condition by the caregiver is usually impossible due to their busy schedules [3]. This paper explains the seizure detection system developed with accelerometer, vibration, and pulse oximeter sensors. The measured values thus obtained are integrated for monitoring on the Blynk application. Assessment is carried out for the performance of the developed system in the detection of seizures. Heart rate and blood oxygen saturation are measured by the pulse oximeter sensor, while falls during seizures are detected by hand acceleration in the accelerometer sensor and rapid extreme changes of movement are detected with the vibration sensor. It also provides comprehensive seizure activity monitoring with better managerial care through the Blynk application.

2. Methodology

2.1 Hardware Prototype

The seizure symptom detector is enclosed within the case of an Impra board. It includes, primarily, the ESP32 microcontroller that provides data collection and processing features. Other critical components are a pulse oximeter sensor for measuring heart rate and blood oxygen levels, an accelerometer for hand falls and orientation changes detection, and a vibration sensor to monitor jerking movements. It is powered by a 9V battery having an LM2596 voltage regulator at the end for clean and stable output.

Figure 1(a) depicts this compact setup, ensuring strength and functionality in wearable applications. Figure 1(b) shows the experimental setup where the wearable device will be strapped to the user's forearm with the pulse oximeter sensor to be strapped to the finger. The device will continue tracking vital signs and movement so as to ensure comfort and effectiveness in real-world testing, even for seizure symptom monitoring.



(a) (b)

Fig. 1 *(a) Hardware prototype; (b) Hardware setup*

2.2 Seizure Symptoms Detection System

Figure 2 illustrates the flowchart details of the process for the seizure symptoms detector. The device, at its initial boot-up, utilizes two ESP32 microcontrollers. In this case, ESP1 is connected with the pulse oximeter sensor, recording SpO2 and BPM below the threshold value of 90 percent and above the threshold value of 100 BPM. If these thresholds are crossed, the data is transmitted to be displayed on the Blynk application. On the other hand, ESP2 is connected both to the accelerometer and the vibration sensor. First of all, the fall in a hand will be detected through the accelerometer, and then, in the case of causal jerking movements, vibration sensing will start through the vibration sensor. If none of the sensors detect activity above their threshold value, a reset will be performed, and again, the accelerometer resumes monitoring for hand falls. In this regard, two types of alerts are sent to the caregiver: one at the moment a hand fall is detected and another at a time of a jerking movement. This diagrams a step-by-step process that involves constant monitoring, ensuring timely alerts in order to offer real-time response and support to people at seizure risk. It uses dual ESP32 microcontrollers, ensuring efficient self-sustaining data collection, processing, and communication that make the device quite reliable with respect to seizure symptom detection and management. The integration of these components into a wearable form factor brings about emphasis on comfort and practicality in a bid to enhance its usability for everyday monitoring in real-world applications.

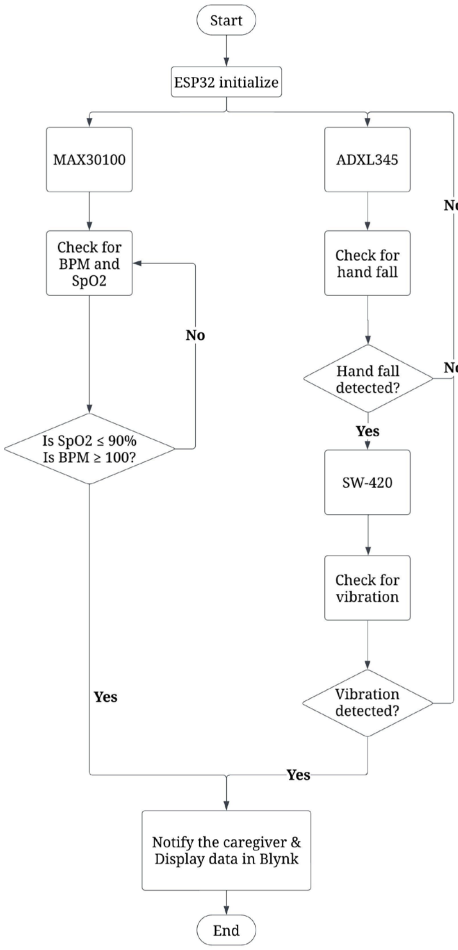


Fig. 2 *Flowchart of the device process*

The integration of the components of the group with the ESP32 microcontrollers is as follows: ESP1 for the pulse oximeter, where its SDA and SCL pins correspondingly link on the ESP32 to GPIO21 and GPIO22, respectively. The accelerometer on ESP2, using the same pinouts; GPIO21 for SDA and GPIO22 for SCL. And, plus the vibration sensor that is going to be connected on ESP2 at GPIO13. At the power input, there is also a mini rocker switch to plug in/connect the power supply of the device. The entire system is powered by a rechargeable 9V battery. It flows through an LM2596 buck converter, which downscales the voltage into a range applicable for both ESP32 microcontrollers and the corresponding sensors that will be connected. Figure 3 shows the complete circuit design. This setup provides reliable operation with efficient power management to enable the device to conduct the necessary continuous monitoring and data processing in seizure symptom detection. Precise connection organization and good power regulation make the device more practical for wearable health monitoring applications because such a device could be more durable.

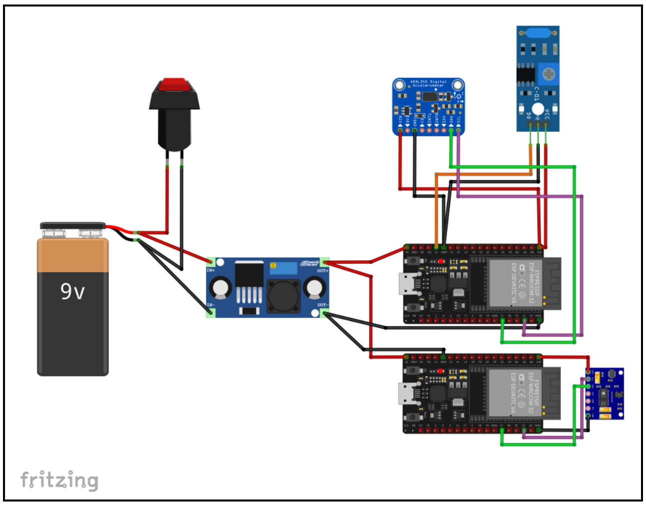


Fig. 3 *Hardware circuit diagram*

3. Results and Discussion

The accuracy of the pulse oximeter sensor will be checked against a smartwatch as it records both the BPM and SpO2 readings. During the test, a subject will simultaneously wear both devices, and data will then be recorded for comparison. There is also an accelerometer drop distance test to be done in order to determine what minimum height will trigger the sensor to indicate that there might have been a fall, ensuring reliability and sensitivity in real life. The vibration sensor will be tested by tapping the device at high and low intensities to test the vibration-detecting functionality. Tests for the pulse oximeter sensor will be conducted on a normal person to ensure that both the readings and the quality of the performance of the sensor are tested under all normal conditions. In-depth testing will validate the accuracy and responsiveness for each sensor, and results from the device must demonstrate effectiveness toward seizure symptom detection.

3.1 Pulse Oximeter Sensor

The bar graph in Figure 4 shows the comparison of the accuracy of BPM and SpO2 with the help of the pulse oximeter sensor and a smartwatch. The values here are represented on the horizontal axis, in ten different trial tests from 1 through to 10. Throughout these trials, the accuracy percentages for BPM and SpO2 fluctuate but consistently remain within the high-precision range of 91.43% to 109.89% and 97.96% to 104.35%. This comparison clearly shows the reliability of both devices in repeated measurements. The pulse oximeter sensor also delivered consistent performance across all tests, which proves it to be a reliable device for continuous health monitoring. The capability to give the same data over different tests shows that it can be used in cases of health monitoring where precision is required. The smartwatch shows no less accuracy and proves to be just as good a device for heart rate and blood oxygen level monitoring.

Table 1 *Readings comparation between pulse oximeter and Amazfit Bip 3*

No.	**Pulse Oximeter**		**Amazfit Bip 3**		**Accuracy (%)**	
	BPM	SpO2 (%)	BPM	SpO2 (%)	BPM	SpO2
1	96	96	105	95	91.43	101.05
2	96	97	98	95	97.96	102.11
3	100	97	98	97	102.04	100
4	99	96	98	96	101.02	100
5	101	96	98	94	103.06	102.13
6	97	96	98	92	98.98	104.35
7	102	96	98	96	104.08	100
8	102	96	97	96	105.15	100
9	96	96	98	95	97.96	101.05
10	100	96	91	98	109.89	97.96

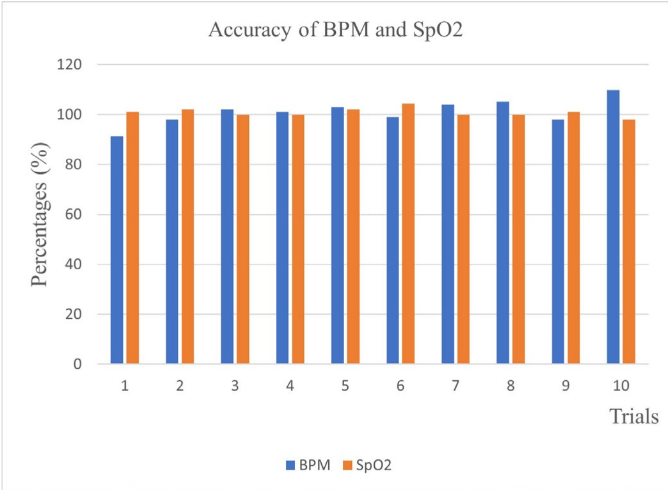


Fig. 4 *Accuracy of BPM and SpO2*

3.2 Accelerometer Sensor

Figure 5 shows the relation of distance, in inches, to the calculated acceleration in m/s^2 with regard to a drop test. The data vary with the highest acceleration between 10 to 15 inches and peaks at 35.16 m/s^2. In spite of this high calculated acceleration, which rise above the threshold for hand fall detection, actual detection was not triggered in the test for these distances. This variation may indicate a problem with the sensitivity or calibration of the accelerometer or, more likely, external factors that influence measurement accuracy. Lower accelerations recorded at higher distances; 20 inches above indicate a more expected drop in acceleration with an increasing drop height. Further investigation is required to explain the lack of hand fall detection and guarantee the reliability of the accelerometer for practical applications.

Table 2 *Drop distance test detection*

No.	Distance		Detected?	Time, *t* (s)	Acceleration, *a* (m/s^2)
	inch	meter			
1	10	0.254	No	0.15	22.58
2	15	0.381	No	0.15	33.87
3	20	0.508	Yes	0.17	35.16
4	25	0.635	Yes	0.25	20.32
5	30	0.762	Yes	0.29	18.12
6	35	0.889	Yes	0.35	14.51

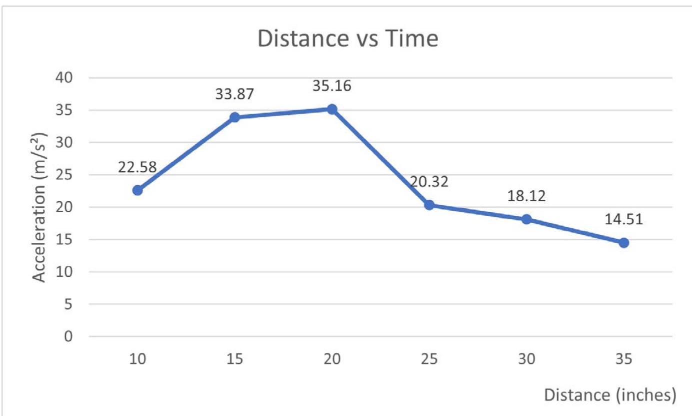
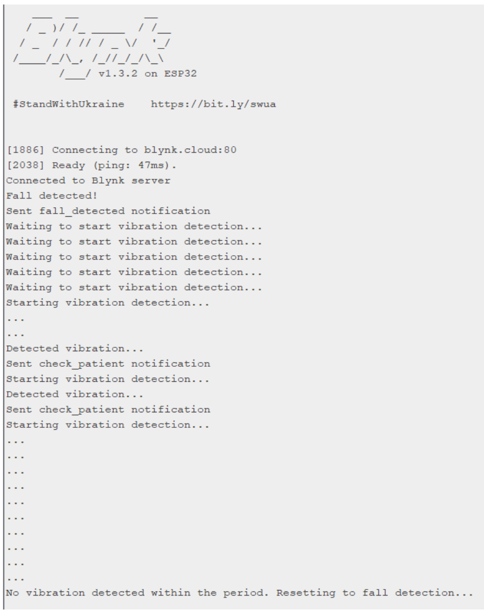


Fig. 5 *Line graph of calculated acceleration vs distance*

3.3 Vibration Sensor

Figure 6 shows that vibration detection will start 5 seconds after a hand fall has been detected. This delay is meant to reduce false alarms for the caregivers instead of receiving immediate notification after a hand fall alarm. If vibrations are not detected after a few seconds, the device will automatically reset to the hand fall detection mode. Furthermore, if there are no detected vibrations after the 5-second delay, the device will reset, and as a precaution, the caregiver is advised to check on the patient just in case.



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        /___/ v1.3.2 on ESP32

 #StandWithUkraine    https://bit.ly/swua


[1886] Connecting to blynk.cloud:80
[2038] Ready (ping: 47ms).
Connected to Blynk server
Fall detected!
Sent fall_detected notification
Waiting to start vibration detection...
Waiting to start vibration detection...
Waiting to start vibration detection...
Waiting to start vibration detection...
Waiting to start vibration detection...
Starting vibration detection...
...
...
Detected vibration...
Sent check_patient notification
Starting vibration detection...
Detected vibration...
Sent check_patient notification
Starting vibration detection...
...
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...
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...
...
No vibration detected within the period. Resetting to fall detection...
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Fig. 6 *Software output of the jerking detection*

3.4 Blynk Application Display

The notifications for caregivers are developed and transmitted through the Blynk app in a defined sequence: at first, the abnormality is caught by the readings, then the processing of data starts, and afterward, an alert is run so the caregivers receive updates in proper time with accurate information on the health of the patient. Figure 7 is the detail process of the Blynk application.

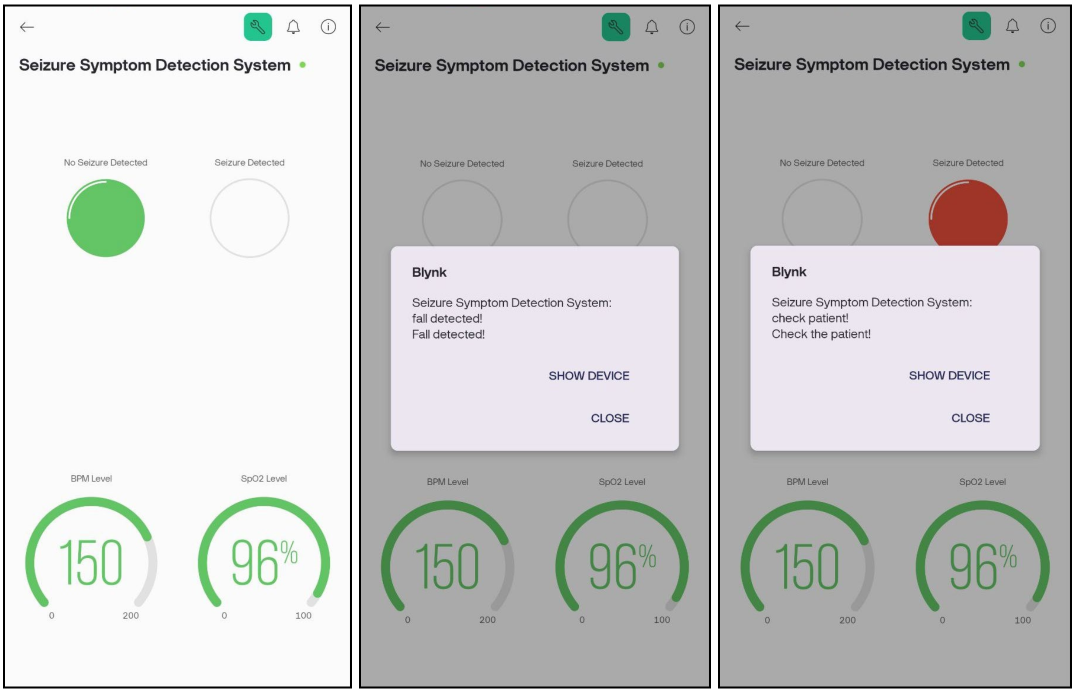

Fig. 7 *(a) The final Blynk interface of this project; (b) The first notification sent when hand fall is detected; (c) The second notification sent when jerking movement is detected*

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4. Conclusion

In conclusion, the symptoms detection system for epileptic seizure users has extended good health-technical advancement to the development level. Integration of sensors like accelerometer, vibration, and pulse oximeter enables real-time monitoring and analysis of vital health parameters. The pulse oximeter sensor ensures accurate monitoring of BPM and SpO2, maintaining precision levels between 91.43% to 109.89% and 97.96% to 104.35% of accuracies in comparation with smartwatch, respectively. During seizure events, timely intervention is facilitated by continuous monitoring. The accelerometer and vibration sensors enhance efficiency in detecting abnormal hand motions associated with seizures. Notably, hand falls within 10-15 inches may not be detected, whereas falls from 20 inches or more are reliably detected. These measurable parameters: BPM, SpO2, hand falls, and jerky motions, are accessible to caregivers through the user-friendly interface of the Blynk application. This innovation promises to significantly enhance the quality of life for epileptics and provide invaluable support to their caregivers, reflecting the evolving landscape of healthcare delivery through technological advancement.

Acknowledgement

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design, data collection, analysis and interpretation of results:*** *Siti Aishah Zamry;* ***draft manuscript preparation:*** *Siti Aishah Zamry, Roshayati Yahya;* ***supervision:*** *Roshayati Yahya. All authors reviewed the results and approved the final version of the manuscript.*

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