STEM EGYPT

Keywords
Epilepsy
GSR
Conditions
Ai Chatbot

Seizure Shield

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Abstract

Desiring the development of Egypt, addressing the grand challenges that it faces became a must. This project holds two grand challenges: Work to eradicate public health issues and increase the industrial bases of Egypt. This study is specifically geared towards the enhancement of chronic diseases. The solution involves the utilization of specialized gloves designed to enhance generalized epilepsy seizures. These gloves not only manage immediate symptoms but also transmit an alert to the patient's family, providing the patient's location and alerting people around the patient. Two of the major findings are the fast response and high accuracy when an epileptic seizure occurs. It can be concluded that if it is implemented on a wide scale with the cooperation of the government, it will help to address many of Egypt's significant problems.

Introduction

Egypt is facing numerous grand challenges making it a must to find effective and innovative solutions to tackle them. These challenges start from pollution and end with horrible public health issues accomplished by climate change. This semester's capstone challenge is to use information and communication technology (ICT) to improve public health by enhancing the lives of people with disabilities or chronic diseases and improving the industrial base of Egypt.

The problem of scope is the lack of immediate first aid for patients who experience generalized epileptic seizures, which is a chronic disease affects about 81,600 individuals in Egypt annually. Epilepsy causes frequent seizures, which can be life-threatening if not treated in its first few minutes, as they can cause complications, such as brain damage and sudden death. As a result, the mortality rate of epilepsy rose from 5.83 in 1999 to 11.59 per million in the US, **as shown in Figure 1**. While searching for prior solutions, many projects that involve immediate intervention for epilepsy seizures were found. One of them is the RNS system, which is a device implemented in the skull and connected to the responsible part of seizures in the brain. When it detects any abnormal signals that can develop into a seizure, it automatically sends small pulses to prevent seizure. The project has the advantages of being highly efficient in reducing seizures by 77% and reducing the demand for epileptic medication. It also has some weaknesses when it comes to its price, surgical complications, and side effects.

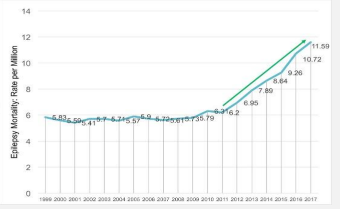


Figure 1 Mortality rates in the US from 1999 to 2017.

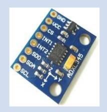
The second project is the Emfit Seizure monitor, which consists of a combination of pressure, heart rate, and acoumeter sensors that are placed in the patient. The device can detect the patient's movement and vital signs such as heart and breathing rate. When irregular movements indicate a seizure occurs, the alerting system starts to alarm family members through the mobile app, to early rescue him and reduce complications. The project has the advantage of real-time monitoring accuracy, and the detailed reports provided by the system. It also has some weaknesses, such as the high cost (between 400S to 800S), and its reliance on an internet connection which may delay sending the alerts.

From these priors, two measurable design requirements were established that must be met to ensure its success. The first requirement is to be fast in detecting seizures and respond by alerting in real time less than 10 seconds, and the second one is being more than 80% accurate in detecting seizure cases from different datasets of patients.

By analyzing the leading parameters of seizure, the solution was found to be a wearable glove with sensors to measure the skin's electric conductivity, temperature, and body movements. Once the values exceed the normal range, the system sends a warning WhatsApp message to the hospital and family members followed by sensors readings and the precise location of the patient. The system also enables a warning mode on the patient's website followed by loud sounds and instructions. An AI chatbot is implemented to help the surrounding people.

The solution addresses the design requirements of being fast in detection and responding with the warning message in less than 10 seconds. Also, it has shown greater accuracy than 80% in detecting seizures. Materials and methods play a great role in the solution; therefore, they will be discussed in the next section.

Materials

Item	Half finger glove	ESP 32	ADXL345 sensor	Bread board	Gsr Sensor	DS18b20	4.7K resistor	Lithium Batteries	Battery Shield	Jumpers
Picture										
Description	Used to install sensors on it	a chip that provides Wi-Fi and (in some models) Bluetooth connectivity for embedded devices	Used to detect the motion at x, y &z directions	A temporary circuit board made of thin plastic to connect the electrical components of the prototype with the ESP23S board	Used to measure the electrical conductance of the skin	used to measure body temperature	It is a fixed carbon resistor ¼ watt	Used to powerup the prototype	designed to recharge batteries	Connects items on the breadboard to the header pins of the ESP23S board
quantity	1glove	1 ESP Module	1 sesnor	1 breadboard	1 sensor	1 sensor	1 resistor	2 lithium Batteries	1 battery shield	23 Jumpers

Methods

1- A circuit model for the project has been made **as shown in Figure 2**.

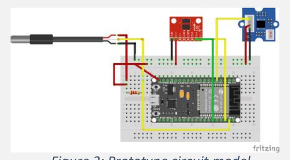


Figure 2: Prototype circuit model

2- The Accelerometer ADXL3345 was interfaced with the ESP with pins 22 and 21 and subsequently affixed onto the gloves.

3- The Galvanic Skin Response (GSR) sensor is positioned at pin 34 and affixed to the middle and index fingers **as shown in Figure 3**.

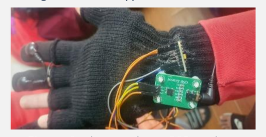


Figure 3: shows where GSR and accelerometer placed.

4- The DS18B20 temperature sensor was integrated into pin 23 and positioned between gloves and Fingers **as shown in Figure 4**.


Figure 4: shows DS18B20 sensor place.

5- The conditions for detecting seizure were set in the code of the ESP32.

6- The ESP32 was connected to ThingSpeak server to update and visualize sensor data in graphs.

7- A website was coded using HTML, CSS, and JavaScript to display sensor readings and record user's precise location.

8- The WhatsApp messaging system was set to send warning messages with website sensors' readings and precise location when seizure is detected.

9- A warning mode with audible alerts and customized instructions generated by AI was added to the website. Ai chat bot was implemented, **as shown in Figure 5** to compose reports on seizures and answer questions.

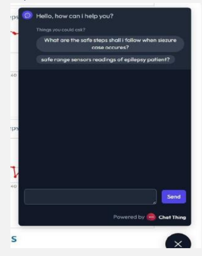


Figure 5: shows the chatbot implemented in the website

Safety precautions:

1- Anti-electric insulating gloves were used while measuring electricity the test plan. Protection gloves were used also during the soldering process of sensors.

2- The compatibility of sensor voltage levels with the ESP was confirmed to preventovervoltage issues.

3- Adequate insulation was implemented for exposed wires to prevent short circuits and enhance safety.

Test plan:

The prototype has undergone the following steps to determine if it meets the design requirements or not:

1- Seizure conditions were simulated by immersing the temperature sensor in hot water, elevating the temperature to surpass 37.8°C.

2- The system's response time was measured by initiating a stopwatch **as shown in Figure 6** when the temperature rose until the warning message was transmitted via WhatsApp, and the website activated the alerting mode.

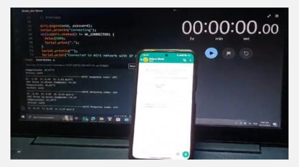


Figure 6: shows way of measuring time response.

3- Five trials were conducted, and the average response time was calculated.

4- To evaluate the system's accuracy, data values from a dataset containing information about epilepsy patients were tested into the system code **as shown in Figure 7.**

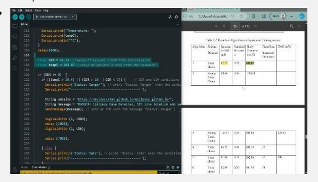


Figure 7: shows the testing of patient's dataset value sin the code.

5- The accuracy was determined by counting detected and undetected cases, subsequently calculating the accuracy percentages.

Results

Negative Results:

The test plan revealed many negative results that affected the prototype.

- Initially a GSM sensor with SIM card was used to send the warning message, but it was extremely slow that required immediate replacement with another method.
- The webserver (ThingSpeak) used to update data to the website in its free plan only updates sensors reading every 15 seconds, therefore it is only used in displaying reading not in detecting seizure.

Positive results:

- The system demonstrated great performance in terms of detecting seizures and time responding with an average time of 5.658 **as shown in Table 1**.
- When the system is tested on 12 patient datasets from a research paper, it could detect 10 out of 12 with an accuracy of 83.3%., as shown in Table 2.

Trials	Time (s)
First	4.45s ± 0.10
Second	5.52s ± 0.10
Third	8.93s ± 0.10
Fourth	5.27s ± 0.10
Fifth	4.12s ± 0.10
Average	5.658s ± 1.309

Table 1: Shows the average system's responding time.

Patients	GSR	Temperature	Detection
1-	43.78	39.6	Detected
2-	44.62	39.1	Detected
3-	48.99	39.51	Detected
4	39.51	37.9	Not Detected
5	40.36	39.03	Detected
6	49.77	39.31	Detected
7	42.73	39.81	Detected
8	39.66	37.98	Not detected
9	49.27	39.26	Detected
10	43.53	39.52	Detected
11	41.06	39.42	Detected
12	42.04	38.62	Detected

Table 2: shows the data set of epilepsy patients.

Analysis

Generalized epilepsy, As studied in BI3.03, is a neurological disorder characterized by recurrent, unprovoked seizures that affect the entire brain **as shown in Figure 8**. This condition arises from abnormal electrical activity in the brain, disrupting the delicate balance of neurotransmitters and signaling pathways.

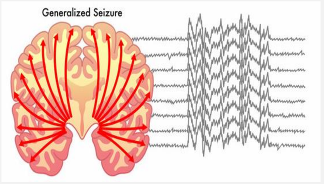


Figure 8: shows how Generalized epilepsy affects the entire brain.

Genetic determinants exert a significant influence, with specific genetic mutations potentially predisposing individuals to generalized epilepsy. Moreover, perturbations in neurotransmitter concentrations, particularly those of gamma-aminobutyric acid (GABA) and glutamate, exert a contributory influence on the pathophysiology of seizures. Recent scientific inquiries have elucidated encouraging results in discerning physiological changes associated with epileptic seizures by employing sensing methodologies such as galvanic skin response (GSR), temperature sensors, and accelerometers.

Galvanic Skin Response (GSR): The GSR sensor can detect generalized epilepsy by measuring the electrical conductance of the skin, which changes due to sweat gland activity and skin moisture. These changes are influenced by the autonomic nervous system, which is altered during seizures. Seizures cause sympathetic nervous system activation, which increases skin conductance. GSR sensors can identify abnormal patterns in skin conductance during seizures, and combining GSR data with other physiological parameters can improve seizure detection systems.

GSR sensors provide a non-invasive and potentially real-time way to monitor and manage generalized epilepsy. The GSR is an analog sensor that measure skin conductivity by directing a microcurrent of electricity through closely positioned electrodes**, as shown in Figure 9.** The ensuing current fluctuations are then amplified and recorded. This variability arises due to factors such as skin humidity (perspiration), epidermal thickness, and vasoconstriction.
The conventional human GSR range falls within 5-40 micro-Siemens (μS). Analog readings are converted to micro-Siemens (μS) by using this equation **shown in Figure 10** which VCC= 5 (operating voltage), ADC= sensor analog readings, and "n" denotes the channel's bit count, set at 10.

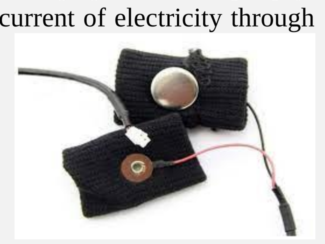


Figure 9: shows GSR sensor 2 electrodes.

$$EDA(\mu S) = \frac{\frac{ADC}{2^n} . VCC}{0.132}$$

Figure 10: shows how to convert from GSR analog readings to micro-Siemens (μS)

Temperature Measurement

Temperature is an important parameter for the identification of epilepsy seizure. Seizures frequently cause physiological symptoms including high change in body temperature, heightened muscle activity and augmented metabolic requisites of the brain during seizure may induce localized hypothermia. Scientific studies have shown a clear link between the start of seizures and changes in skin temperature, where some people show temperature rises before, during, or after seizure events.
The DS18B20 sensor, **as shown in Figure 11**. is a device that measures temperature in Celsius with an accuracy of ±0.5°C, As studied in **PH2.15**, it works by detecting the voltage difference between the transistor and the emitter terminals of the diode. When the temperature rises, the voltage difference increases. A resistance of 4.7 is used to pull up the data line and limit the current flow.

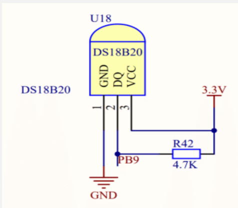


Figure 11: Internal structure of the DS18B20 temperature sensor

Accelerometer

The ADXL 345 uses a MEMS (micro-electro-mechanical system) structure that consists of fixed and moving plates that form capacitors. When the sensor experiences acceleration along an axis, the capacitance between the plates changes due to the displacement of the moving plates. The change in capacitance is converted into an analog voltage signal by capacitance-to-voltage circuit. The sensor comes with some built in sensing functions such as free-fall detection, tap detection and activity/inactivity detection.
Researchers have found that generalized seizures involve characteristics and rhythmic body movements. These movements can be measured using the accelerometer sensor. The method used to identify seizure is by using the concept of local maximum and local minimum, as studied in **MA3.02,** A local extremum is a point that has the highest or lowest value in its neighborhood, **as shown in figure 12**, and its derivative is zero. A seizure can be detected by detecting four or more consecutive local extrema, which can indicate the rapid vibrations of the body during a seizure.

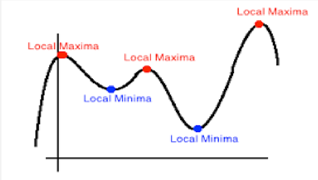


Figure 12: local maximum and local minimum withing a graph

ESP32 code flow and website code

Based on the previous parameters, the project ESP 32 code was developed to follow the **flowchart in Figure 13**. The system takes four parameters (GSR, Temperature, Accelerometer, and location) and continuously checks for seizure conditions (GSR > 40, Temp > 37.8, and 4 consequent local extrema in position graphs). If it occurs, it sends a warning message with the patient's website link to view the sensors readings and location. The system also enables alerting mode followed by a loud sound and custom AI written instructions. The working mechanism in each step is discussed in the following points.

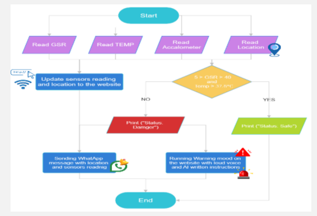


Figure 13: A flowchart of the implemented ESP32 and website code

ThinSpeak Live data server

As studied in **PH3.03** and **PH3.04** about communication systems. WI-FI communication system is used to upload and update sensors readings from the ESP 32 to an IOT platform called ThingSpeak. It offers visualization of sensors data. It consists of channels each channel consists of multiple fields each representing a sensor readings **as shown in Figure 14**. The graphs can be easily implemented in the website and update sensor data every 15 seconds, which is a drawback of using Thingspeak.

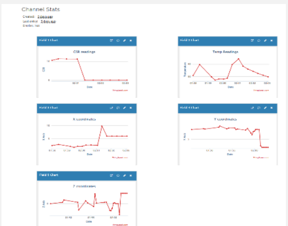


Figure 14: ThingSpeak live sensors graph (GSR, Temperature, accelerometer)

Website Development and location permission

The website is coded using HTML, CSS, and JavaScript programming languages. ThingSpeak sensor graphs are implemented on the website. The website asks for location permission for the first time. As studied in **PH3.04,** updating location depends on satellite communication between the patient's phone and satellites, then it uses WI-FI to update and display the location on the website.

The website automatically displays and updates precise location every 10 seconds on a backend database using NodeJs (Javascript framework), **as shown in Figure 15**. The website was hosted online using GitHub webpages, which allows anyone by entering this URL (https://seizureshield .github.io/project) to access the website from anywhere.

Figure 15: A screenshot of real location displayed and updated on the website.

Automatic Sending Warning Messages on WhatsApp
To send alerting messages on WhatsApp, the Call Me Bot API was used. It is a free service on WhatsApp that can be integrated with the code through its application programming interface (API), which is an example of WI-FI wireless communication as studied in **PH3.04.** It works by enabling the ESP32 to send a GET HTTP request containing the specified number and message content.
Using the Arduino IDE, the HTTP request is modified to send the warning message with a website that includes the patient's precise location and sensor readings to the chosen number, when a seizure occurs, **as shown in Figure 16**. The Call Me Bot API has shown impressive results in its speed for sending warning messages. The website also enables warning mode followed by loud sound and AI written instructions.

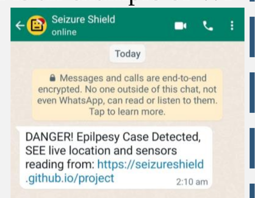


Figure 16: A screenshot of the WhatsApp warning message

Artificial intelligence chatbot: An artificial intelligence chatbot is implemented inside the website. It can be used in two ways: firstly, normal chatbot mode which can answer questions of the patient and give him health advice. The second use is to automatically write a report about the patient's status.

The Chatbot works by connecting ChatGPT with the website through the API, **as shown in Figure 17**, which allows the bot to send messages to ChatGPT and receive responses. The chatbot was trained on dozens of questions and articles about epilepsy seizure and first aid.

Figure 17: Mechanism of sending and receiving messages of the ChatBot

Conclusion

A lot of work has been done while defining the problem, researching, designing the prototype, and testing it to fulfill the design requirements. According to the results obtained above, the project contributes to providing high accuracy in detecting generalized epileptic seizures and fast responding in dealing with them. The Solution, which consists of a glove that contains GSR, temperature, and accelerometer sensors has successfully achieved the design requirements. The project is expected to help the development of Egypt's public health by establishing a secure environment for individuals with generalized epilepsy.

Recommendations

- **Raspberry pi4**

Instead of using ESP32, it is recommended to use Raspberry Pi 4; **as shown in Figure 18** since it has great computational powers in terms of its processer (quad-core ARM Cortex-A 72 1.5Ghz) with the ability to execute 1.5 billion instructions per second, while ESP32 executes 500 million instruction per second. In terms of random-access memory (RAM), Raspberry Pi 4 comes with 4GB of RAM and up, while The ESP32 comes with 0.5GB, which means extremely fast sensor reading and warning compared to the ESP32. It is also counted as a fully integrated computer that offers the capability of connecting a small screen and monitoring sensors readings and vital health information in an isolated operating system hosted on the board.


Figure 18: Raspberry Pi4 board

- **Satellite communication**

On a real-life scale, it is recommended to use satellite communication instead of WI-FI due to its high coverage area compared to Wi-Fi communication, which allows users in remote areas and challenging terrains where WI-FI signals are limited especially in African countries that record the height rates of epilepsy worldwide. Satellite communication offers a more reliable communication in terms of the speed of transiting data and reducing the risk of signal interruptions, which can occur through WI-FI communication, therefore, satellite communication provides a more robust and reliable future enhancement to the project.

- **EEG (Electroencephalogram) sensor:**

EEG is more effective than a GSR sensor in epileptic seizure detection since it directly measures electrical activity in the brain **as shown in figure 19**, providing vision into which neurological patterns are occurring during seizures. On the other hand, GSR sensors that measure skin conductance are affected by various factors when it comes to detecting seizure events, EEG sensors can safely and accurately detect seizures in a way that is more precise and accurate. Also, EEG data can be analyzed quantitatively, which allows the characterization of seizure types, based on the analysis of the EEG data.

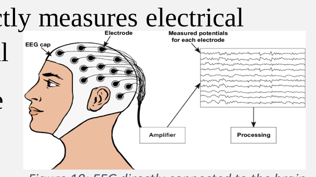


Figure 19: EEG directly connected to the brain.

- **ThingSpeak Premium Edition:**

It is recommended to use the premium version of ThingSpeak to update data from the sensors to the website. ThingSpeak premium offers advantages in terms of the speed of transmitting data as it updates the data instantaneously without the 15-second limit of the free version. In addition, it also offers a high level of data storage capacity and unlocks more in-depth analysis of the data. All these factors enhance the overall effectiveness of the project monitoring system.

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