Generalised Epileptic Seizure Alert System

Sai Akhil Katukam[1], Sai Charan Palvai[2], Sai Kumar Gorantla[3]

Department of Electronics and Communication Engineering, 4th Semester

Vasavi College of Engineering

Hyderabad 500031, India

[1]saiakhilk.katukam@gmail.com

***Abstract*— Epilepsy is a disorder in which nerve cell activity in the brain is disturbed, causing seizures. During a seizure[1], a person experiences abnormal behaviour, symptoms and sensations, sometimes including loss of consciousness. Persons with epilepsy should be taken care at all times. The caregivers' presence during sleep hours is so much important. There are many instances where they even spent sleepless nights. Our project focuses on alerting the caregivers via call, a text message with location of the victim. Our algorithm is built based on symptoms of the disorder. We intentionally avoided the use of internet for the device we made – a wearable glove model that extends till wrist. Instead, we used Bluetooth as a mean to communicate from device to mobile, and then notify from mobile. By this means, the glove can be termed as a user-friendly and cost efficient model.**

***Keywords*— Bluetooth, Seizure, symptoms, glove model**

I. INTRODUCTION

Epilepsy affects about sixty-five million people worldwide. According to the World Health Organization (WHO) approximately 80 percent of the epilepsy patients live in developing countries and have very limited access to treatment. In many resource constraint communities, there is almost no care for epilepsy patients and neurologic expertise is non existent. Nearly three fourths of people with epilepsy living in low- and middle-income countries do not get the treatment they need.

Epilepsy is a disorder characterized by recurring two or more seizures within a 24-hour period. A seizure is a brief, temporary disturbance in the electrical activity of the brain. It is estimated that there are over 40 different types of seizures; varying in nature, ranging from going blank for a few seconds and wandering around, to falling to the ground and shaking severely. Many seizure cases may start with minor symptoms, prolong, and lead to loss of consciousness or falling. Other seizures may be brief and only last several seconds.

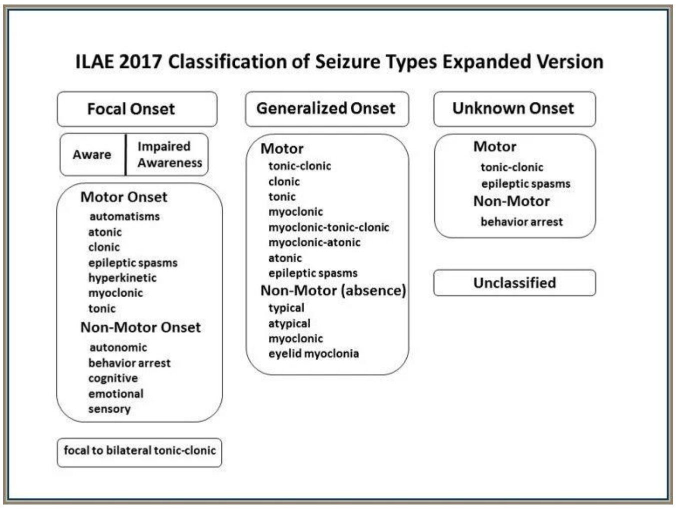

Figure 1: A classification of Epileptic seizures by the International League Against Epilepsy (ILAE).

II. GOALS

Our hope is that the system can help epilepsy patients, particularly those living in resource-constrained communities, to again access to better treatment. This device will work accurately when user keeps his mobile with him within Bluetooth range, while wearing the glove. The application can be installed in mobiles and can be paired with the glove. The application runs as a background service and does not interfere with the cellular data, WiFi or during calls. As said earlier, every disorder has symptoms and we used it to detect the seizures.

We also believe that quantifying and visualizing the seizure data can promote collaborative diagnostics, in communities where limited medical expertise is available.

Furthermore, the data collected can result in optimizing patient-specific-therapy, and consequently improvement of patient care. Availability of such data can also lead into possible onset prediction.

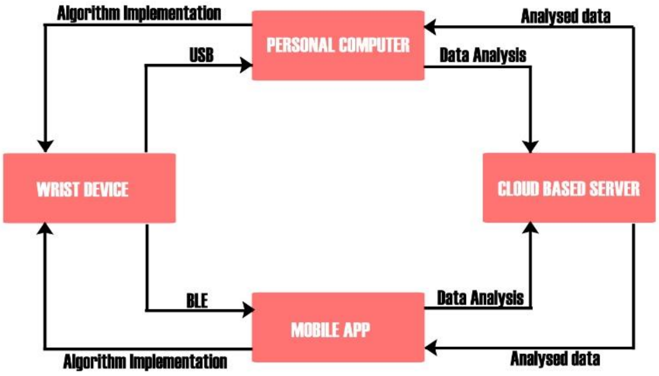

Figure 2: Overview of implementation

III. EVALUATION STRATEGY

The evaluation strategy is based on the symptoms. The following are the symptoms of generalized Tonic Clonic Seizure, one of the types of epileptic seizures which we would be dealing with : Generalized tonic clonic seizures (grand mall seizures) are easily recognized. These seizures usually begin with stiffening of the arms and legs followed by jerking motions of the limbs. Many individuals may fall from a standing position when the seizure occurs; bladder or bowel control may be lost and the person may bite their tongue and/or cheek tissue. The convulsions may last up to about three minutes, after which the person may be feel weak and confused. In this period,the person body's surface temperature arises more. Also, there would be more sweating all over the body and high Heart Rate Variability (HRV). If Tonic clonic seizures last more than five minutes, constitute a medical emergency.

We now focus on these 4 major symptoms. Each of this subsection would describe how to determine the epilepsy.

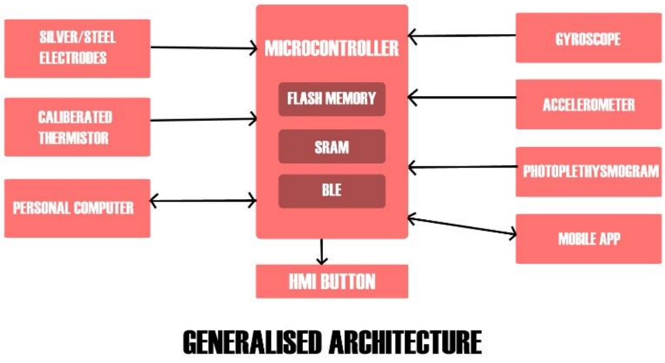

Figure 3: Block diagram of the device.

A. ARDUINO NANO – THE PROCESSOR

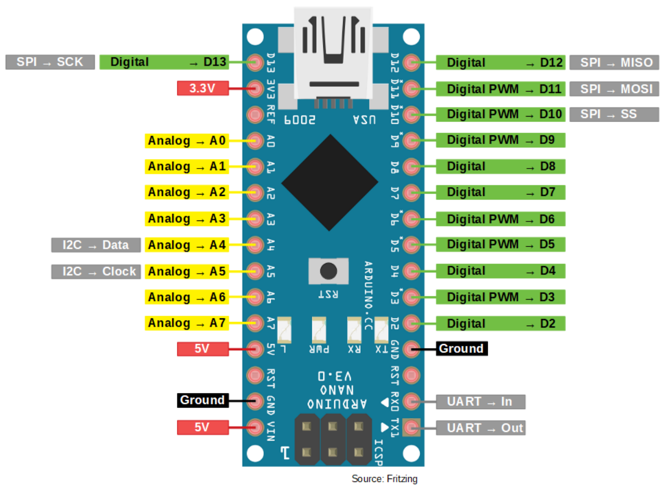

Figure 4: Pinout of Arduino Nano.

The Arduino nano is the suitable option as a microcontroller for its processing speed, compact size, availability of both analog and digital pins[2]. We setup the Arduino IDE environment to upload the sketch required. Proper sampling rates are also setup in the code to get better results. We use the UART serial interface to connect with the Bluetooth module.

B. PHOTOPLETHYSMOGRAM – HRV DETERMINATION

This module is used to measure the pulse rate. Thereby helps in finding the Heart Rate Variability (HRV)[3]. HRV resembles the spikes or the sudden up-rise in the heart beat. This fluctuation in heart beat is clearly seen for a person during onset of epilepsy. We use the Pulse Sensor Playground Library and invoke its built-in functions to easily calculate BPM, thereby finding the HRV with a sampling frequency of 1 sec. Higher the variability, higher is the onset of epilepsy.

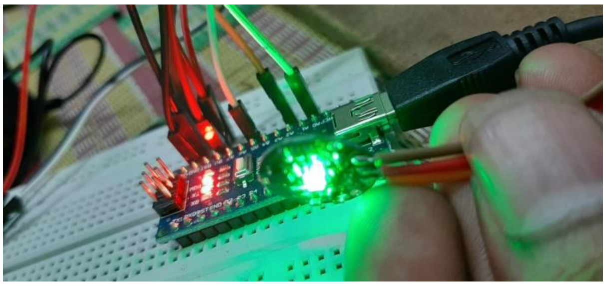

Figure 5: Pulse Sensor.

C. GALVANIC SKIN RESPONSE SENSOR – SWEAT DETECTION

Figure 6: Skin conductance plot over various considerations.

Our body has a dynamic resistance and differs from part to part and changes during the production of sweat from glands under the skin. Under dry conditions, the resistance offered by the human body may be as high as 100,000 Ohms. Wet or broken skin may drop the body's resistance to 1,000 Ohms. To examine the skin conductance, we use two nickel electrodes each attached to 2 fingers of either hand for calibration. We also add a series resistance of 0.5M Ohms to omit the worst case of sweating. Through the electrodes, we pass small currents and find the total resistance and substitute in the code below to find the conductance in micro siemens.

$$R\ (M\ Ohms) = \ 0.5\ -\ \left(\frac{ADC}{2^n}\right)$$

$$EDA\ (\mu S) = \frac{1}{R}$$

Where EDA stands for Electro Dermal Activity, R is the resistance only due to skin (neglecting the series resistance). ADC is the analog value read. 'n' is the number of bits per channel. For analog to digital conversion, it is 10 bits per channel. To convert analog to digital, we can use any ADC converters, but here we used Grove-GSR sensor by seeed developers.

The following link is an excel document on the experiments in understanding the EDA response in many scenarios.

- https://drive.google.com/open?id=1O48BQA4qNZxkiGowEyi_IXoZoDrUuAdK

D. ACCELEROMETER – JERKS DETECTION

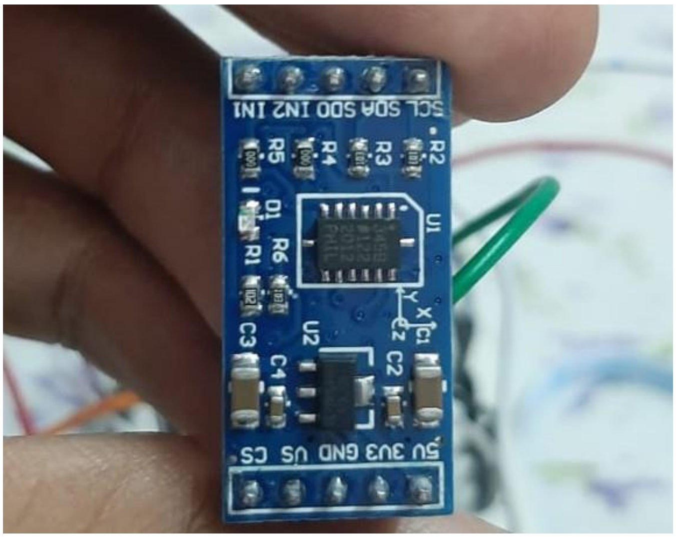

Figure 7: 3-axis accelerometer – ADXL 345.

An accelerometer, also called the ACM, measures the acceleration due to gravity in 3 axes – x, y, z directions. We have three possibilities in using the ACM. The first is to train various cases, that includes Deep Learning which cannot be deployed on Arduino. The second is that any seizure results the person lose control over his body and makes the person fall off to the ground. This is a common case for any type of epileptic seizure. From the datasheet of ADXL[4], we can directly use the instances to write the code when a person falls to the ground.

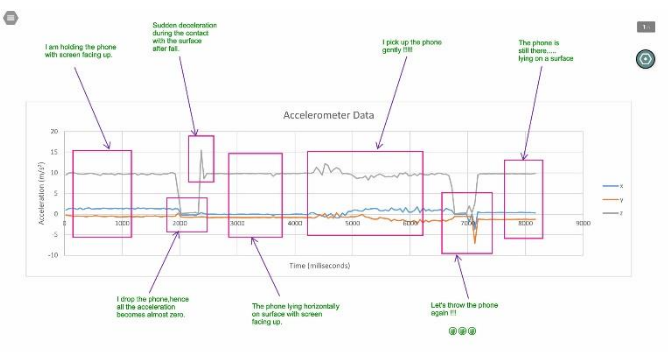

Figure 8: Free-fall algorithm of ACM

This method however is applicable when person stands and not at sleeps. So we finally move to the Standard Deviation algorithm to determine the jerks. The analog data from the accelerometer is processed to calculate G-force. G-force is calculated from the accelerometer using the formula

$$ACC = \frac{ADC - Cmin}{Cmax - Cmin}$$

Where ACC (g) is the Accelerometer value in g-force (g). Cmin is the minimum calibration value which is 195.0, Cmax is the maximum calibration value which is 335.0. We must calculate g-force for all the 3-axis. The net g-force is calculated using root mean square formula.

$$RMS = \sqrt{(x^2 + y^2 + z^2}$$

Figure 9: Output of g-force output wave form of all the 3-axis

RMS value is further used to calculate the mean and standard deviation of the signal. When there is any movement then the output signal deviates from the mean. Figure 10 shows the mean and standard deviation plot. The blue line in the graph represents the calculated standard deviation and orange line in the graph represents the calculated mean value from the RMS value. The standard deviation is used in the algorithm to calculate movement.

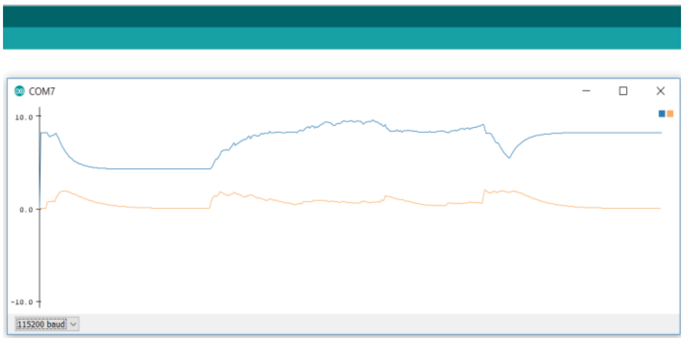

Figure 10: RMS and standard deviation plot

E. CALIBRATED LM35 – TEMPERATURE SENSOR

The LM35 can be calibrated with respect to our body temperature and can be used to detect high fevers. The analog data from the temperature sensor is read and preprocessed using below procedure.

$$Voltage\ (mV) = (ADC) * \left(\frac{3300}{1024}\right)$$

$$DegreesC = \frac{Voltage - 500}{10}$$

$$DegreesF = \left(DegreeC * \frac{9.0}{5.0}\right) + 32.0$$

The above formula converts the number 0-1023 from the ADC into 0-3300mV (= 3.3V). Centigrade temperature = [(analog voltage in mV) - 500] / 10, converts millivolts into temperature. This centigrade temperature is then converted to Fahrenheit to measure the temperature of the body in Fahrenheit. Fahrenheit temperature = (Centigrade * 9.0 / 5.0) + 32.0.

F. HC-05 – BLUETOOTH MODULE

The HC-05 is a both master as well as a slave device. By default it acts as a slave device, which we wanted to be too. To configure the baud rate and match with the heart rate sensor, we must enter AT command mode and set it to 115200 baud.

Figure 11 shows how to connect the HC-05 to Arduino nano. Interchanging the pins to the same names, activating enable pin by holding the power button while giving supply power helps us to enter AT mode[5].

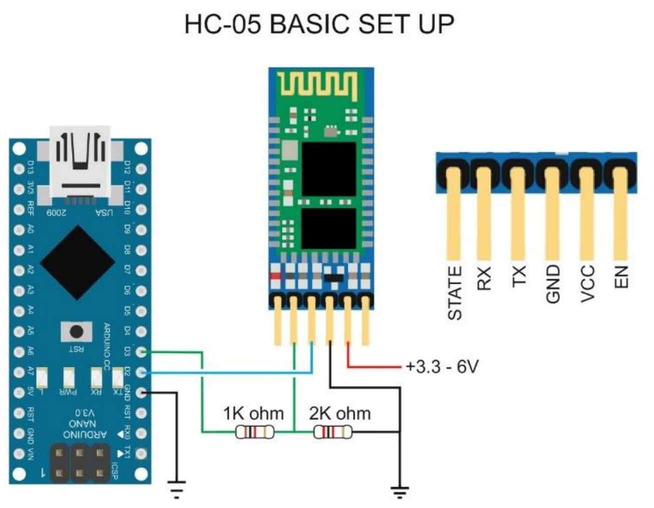

Figure 11: Circuit connection with HC-05

G. MOBILE APP – TO NOTIFY CAREGIVERS

Figure 12: Circuit connection with HC-05

Application is developed in Android Studio using Java that requests permissions to access Bluetooth, location & internet (if required) and constantly receives bytes from HC-05 slave device. When the Arduino detects epilepsy, it sends certain stream of bytes that is decoded by application and send text messages (with last known location) and a call to caregivers concerned.

IV. WORKING OF DEVICE

The Arduino nano continuously runs the code based on the values it senses from all its peripheral modules, each of which has separate sampling frequency as mentioned earlier. The threshold value of LM35 is 100.6 F. For GSR sensor, if there is an increase of $20\,\mu S$ in one sampling interval, it can be considered positive. For General tonic clonic seizure standard deviation is observed and lies between 0.1g and below 0.8g. Any standard deviation greater than 0.8 is considered as normal motion. If the standard deviation is within the range and it is measured again after 10 seconds to check if the movement or standard deviation still lies in the range. If the result is positive, then the movement is detected. If the results of both accelerometer and EDA/GSR are positive after watching for 10 seconds, then an epileptic seizure is detected. The Bluetooth module when paired sends a byte request to have an uninterrupted connection with the mobile application. When the result is positive, it sends another set of bytes that are pre-programmed to be identified by the application. When this occurs the mobile application uses GPRS provider and send latitude and longitude pleading for a help and also using Call intent[5] functionality both written in android studio. The application thread runs in background in 3 layers with one handler, making it uninterruptable when using cellular network or when connected to any wireless devices.

V. OUTPUT

The following is the output when a seizure is detected. The caretaker’s mobile number was entered as per choice by the person with epilepsy. The test case was done by our team by enacting the jerks while laying down on bed. After 25 attempts, we could verify our output as we could not reach to any hospital during lockdown. Observe Figure 13 that on 10th of March, 2020 calls were made and continuous beacon of messages were sent to the caregiver.

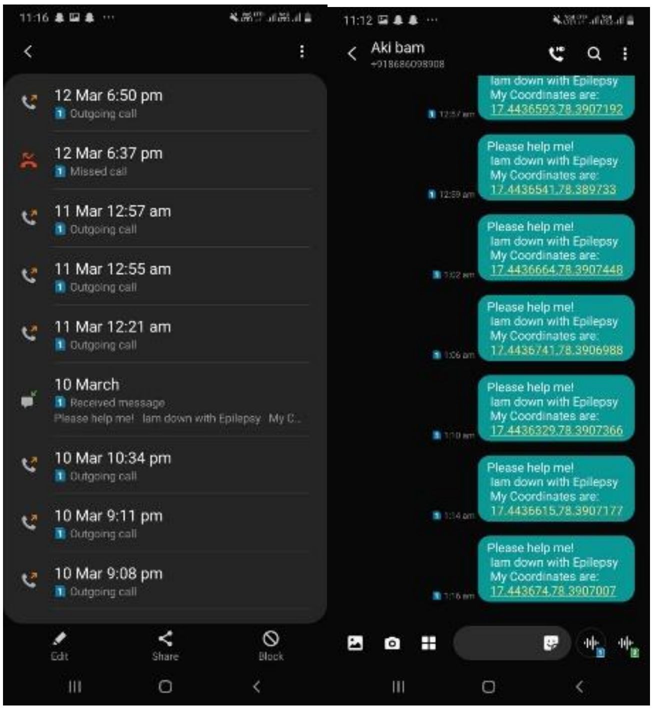

Figure 13 : Output when seizure is detected

VI. CODES TO VERIFY OUTPUT

The links mentioned here redirect you to the Google Drive. The first link is the android application source code that can be opened in Android Studio. You may even use any text editors to open only source code. The second link is the link to the Arduino implementation. Comments added can be used to easily identify what the line means.

- https://drive.google.com/open?id=1-TiOBpdrNN6DYhMyXCHBIMsjPtphX_Dh
- https://drive.google.com/open?id=1kT_x982jEo-SQ77ldjrhxDjC78XzeAum

VII. CONCLUSIONS

In this paper, we presented a proof-of-concept wearable prototype that can detect specific seizure activity, namely generalized clonic, in epilepsy patients.

This work focused on two important areas:

1. Designing a robust and computationally low intensive real-time seizure detection algorithm.
2. Further, Utilization of a scalable cloud-based data management system to record, analyse, and visualize the received seizure data. More clinical testing is required to evaluate the reliability and accuracy of the proposed seizure.

VIII. ACKNOWLEDGEMENT

We sincerely thank our faculty V. Krishna Mohan sir, Assistant professor, Department of Electronics and Communication Engineering, Vasavi College of Engineering for giving us a golden opportunity to perform a research in medical field and come up with a device that can solve a real-life problem, which has the scope of saving epileptic disordered persons all across the world, in affordable expenses. It is a privilege to take up this project as it improved our way of solving problems, build device from scratch and most importantly defined us and the true intention of being an Engineer.

IX. REFERENCES

[1]Article,https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4448698/

[2]Website tutorials, https://www.allaboutcircuits.com/projects/using-the-arduinos-analog-io/

[3]Websitecontributors,https://www.firstbeat.com/en/blog/what-is-heart-rate-variability-hrv/

[4]Alldatasheetcontributors,https://www.alldatasheet.com/datasheet-pdf/pdf/254714/AD/ADXL345.html

[5] https://howtomechatronics.com/tutorials/arduino/how-to-configure-pair-two-hc-05-bluetooth-module-master-slave-commands/

[6] Stack overflow providers, https://stackoverflow.com/questions/4275678/how-to-make-a-phone-call-using-intent-in-android