# Human Activity Recognition-Proposed Device for Detecting Convulsions

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*Abstract*— **Human Activity Recognition is classifying or sensing the body movements of humans with the help of sense detectors. This is a growing field in the wearable devices world with several applications like surveillances, wearable inertial sensors, gyroscope, accelerometer, compass, proximity, GPS etc. In this paper, we'll be discussing the extension of smart-watches which includes detecting a change in heart-rate, and jerky or twitchy movements in the body during convulsions, along with general movements like walking, standing, limping, running, jumping, climbing. Once the movements are detected, based on the severity of the movements, a notification is sent to the emergency contact, seeking for help. We will be using accelerometer, touch sensors, IoT for developing the device. Our motive is to deliver rapid and accurate results so that the person can get immediate assistance during the time of emergencies.**

**Keywords— Convulsions, Arduino, Accelerometer, Pulse sensor, Temperature sensor, ESP8266**

## I. Introduction

A violent, irregular and sudden movement of the body, which is due to reflexive contraction of muscles is known as a convulsion. It is often also known as fits, seizure, attack, spasm etc. This is related to brain disorders such as epilepsy, etc. In 2017, it was observed that about 1.2 crore of population in India had cases of epilepsy. 14 out of 1000 people in India are said to be having epilepsy, who are generally children, youngsters of rural population. Our project, Human activity recognition-extension of wearable devices deals with the detection of convulsions which is one of the symptom of epilepsy. In this paper, we have used the concept of human activity recognition which is "the problem of classifying sequences of accelerometer data recorded by specialized harnesses or smart phones into known well-defined movements" (Brownlee)[3]. This paper, consists a detailed study of convulsions detection wearable devices that are an extension of wearable devices that detect walking, running, jumping, sitting, climbing etc. We will be particularly considering tonic-clonic convulsions which are jerky muscle movements, a main factor in our paper. As discussed above a violent, irregular and sudden movement of body- known as convulsion; often called as seizures but seizures are caused due to electrical disturbances in the brain. Having said that, we can say that, seizures can cause convulsions, but not always. Meaning, convulsions are one of the many symptoms of having a seizure. These convulsions can keep up for a few seconds or few minutes. They can occur in one particular part of the body or can occur in the whole body. Convulsions can be caused due to several reasons say, Epileptic seizures, febrile seizures, Migraine, Medical reactions. The severities of the convulsions are:

- If the convulsions last for less than 5 minutes, it can be neglected.
- If the convulsions last for more than 5 minutes and occur on a regular basis, they must be consulted to a doctor, immediately.

Some ways through which one can assist a person suffering through these seizures are:

- Settling them on to the ground.
- Away from sharp and hard objects.
- With something soft under their head.
- Removing their glasses (If they have any).
- Loosening if there's anything tight around their neck or waist.
- In case the convulsions continue even after 5 minutes, call for an ambulance.

## II. Literature Survey

On deep study of papers we found out the following:
"Human Activity Recognition (HAR) has been a challenging problem yet it needs to be solved. It will mainly be used for eldercare and healthcare as an assistive technology when ensembles with other technologies like Internet of Things (IoT). HAR can be done with the help of sensors, smartphones or images." (Jobanputra, Bavishi and Doshi)[7]. This study further defines the different state-of-the-art methods used in HAR with the help of conducting various surveys and using machine learning techniques on the dataset obtained by them. In another paper, using the SVM approach of ML, which concludes the following: "we introduced a new publicly available dataset for HAR using smartphones and acknowledged some results using a multiclass Support Vector Machine approach." (Anguita, Ghio, et al.)[1].

"Epilepsy affects almost 1% of the population and most of the approximately 20–30% of patients with refractory epilepsy have one or more seizures per month. Seizure detection devices allow an objective assessment of seizure frequency and a treatment tailored to the individual patient. A rapid recognition and treatment of seizures through closed-loop systems could potentially decrease morbidity and mortality in epilepsy. However, no single detection device can detect all seizure types. Therefore, the choice of a seizure detection device should consider the patient-specific seizure semiologies". (Ulate-Campos, Coughlin, et al.)[10]. A paper further helps us in recognising the different kinds of physical human activities by generating the acceleration data using the cell phone of the user (Bayat, Pomplun and Tran) [2]. Similarly, a research paper matching the needs of ours stated "The solution is based on a Wearable Device to be located on a wrist connected to a Smartphone, which in turns implements Mobile Cloud Computing services and has access to Cloud Computing services as well. The global goal is detecting the seizures, storing information from the sensory system,

generating alarms and notifications, performing machine learning techniques on the data to learn the best models to detect or to visualize the data, sharing data, and providing processed information to the medical staff, among others." (Vergara, Marín, et al.)[11] in their conclusion.

We also did some literature survey on the change of heart rate of an individual during convulsions. From the studies we can see that seizures do bring a change in the heart rate of the person experiencing it and sometimes it can be abnormally high which might need medical attention immediately. In one paper we could find the conclusion as, "There was an increase in heart rate of at least 10 beats/minute in 73% of seizures (93% of patients) and this occurred most often around seizure onset. In 23% of seizures (49% of patients) the rate increase preceded both the electrographic and the clinical onset. ECG abnormalities were found in 26% of seizures (44% of patients). Long seizure duration increased the occurrence of ECG abnormalities." (Zijlmans, Flanagan and Gotman)[12]. In one of the papers published by the NCBI, the conclusion says, "Both cardiac and respiratory functions are affected by seizures, and dysfunction of the respiratory system during seizures can affect cardiac function." (Nei)[8]. An article on whether the sudden change in heart rate can lead to death or not said that, "The electrical activity in the brain during a seizure can also change our pulse and usually causes an increase in heart rate. However, during some seizures, the heart can slow or even stop temporarily. One study found 21% of the people had their hearts stop during a seizure." (Ghearing)[6].

"The clinical data suggests that autonomic and respiratory dysfunction following seizures, especially tonic-clonic seizures, is critical to mechanisms of sudden unexpected death in epilepsy (SUDEP)." (Friedman)[5]. Through these studies, we can see that the seizures brings out a lot of changes in an individual's body, in which we would like to mainly focus on the heart rate changes, body temperature changes as well as the jerky movements of the limbs caused during that time.

## III. METHODOLOGY

With the advancement in the field of technology, we now have devices for 'keeping a baby busy' to 'helping elders in keeping a tab on their memory'. So, we thought why not propose a design for people who face seizures on a daily basis or at regular intervals of time and can't get help at the right time, resulting in loss of life? And that's when we decided to put two and two together and come up with a device that might get them the help they need or require. Seizures can be caused due to several factors. For this device, we have considered three factors: Convulsions (jerky hand movements), Heartbeat, and Body temperature. We have used Arduino Uno, Accelerometer (ADXL335), Temperature sensor (LM35), Pulse sensor (LM358N), WiFi module (ESP8266), LCD (16x2), Jumper wires. We'll further be discussing the main parts of the device and their working and finally to the proposed circuit diagram of the device.

### Arduino Uno

Arduino Uno is a series of micro-controllers called ATMEGA AVRs connected by crystal resonator that controls how fast the micro-controller is running. There's another micro-controller in the PCB (printed circuit board) that acts as a bridge between the main controller (Arduino and computer.) It also has the code that will be dumped to the program running for back and forth messages.

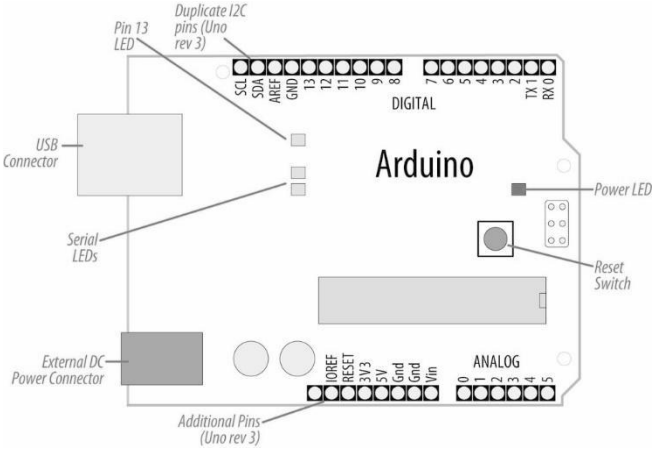


*Figure 1. Arduino Uno Pin Configuration*

9 Volts DC power jack for external power supply. 5 Volts voltage regulator that will reduce the voltage to 5 volts in case of excess voltage. Reset button to reboot the Arduino program. The pins on the left side of the chip are for analog inputs, outputs and the pins on the right side of the chip are for digital inputs, outputs. Tx(1) and Rx(0) are the transmitting and receiving pins. Analog inputs are used to measure continuous voltages from 0v-5v. The '~' in front of input and output indicates, the usage of them to output pulse with modulated square waves. Arduino software, arduino.cc is installed and connects computer to Arduino using USB cable. To start the software development environment to make sure that the software is connected to right type of Arduino by going to port and checking the connection. Every Arduino program has setup in which input and output pins connection can be configured to do certain things; loop that contains the code which repeats over and over again as long as Arduino has power to it.

### Accelerometer (ADXL335)

Smartphone processors have accelerometers, gyroscopes, magnetometers to understand orientation in 3D space and take actions accordingly.

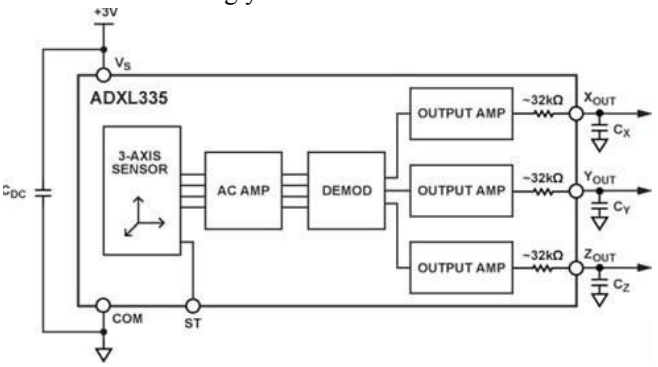


*Figure 2. Accelerometer (ADXL335) Block Diagram*

A general spring displacement theory (2D) in physics, given, acceleration= f(x), where f(x) is the function of displacement 'x' of the block connected to the spring. This general theory is hard to interpret in accelerometers (3D), so a new concept of MEMS (Micro Electro Mechanical Systems) has been introduced. These MEMS are fabricated at 20µm in the IC. ADXL335 is a 3-aixs accelerometers with analog output from analog devices. The measurement range is 1g-3g with a supply voltage ranging from 1.8v-3.6v (3v in general). This has three outputs 'X', 'Y', 'Z' i.e acceleration on specific axis. At the midpoint of the accelerometer with a=0g, the output voltage is half the supply voltage. Accelerometer can be used not only for acceleration but also orientation as it can sense gravitational force pointed to the center of the earth. And this is the factor we consider in out device to detect convulsions i.e jerky hand movements by setting a threshold value.

**Temperature Sensor (LM35)**

LM35 is an analog linear temperature sensor meaning, the output voltage is analog and linear in change with temperature.

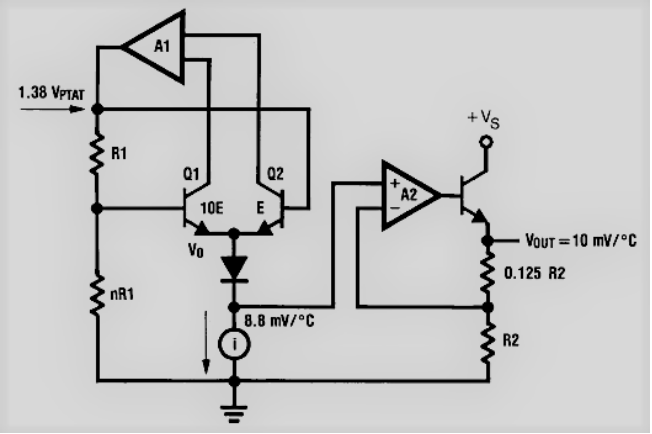


*Figure 3. Temperature Sensor (LM35) internal circuit*

It is a three terminal device VCC (input), GND (ground) ranging from 4v-20v and Sig, the output based on the temperature. The point at 8.8 mv/C gives temperature dependent output voltage that is buffered by amplifier A2 which is connected to output pin. Q1 and Q2 are used to create band gap voltage difference i.e constant voltage reference irrespective of power and temperature difference, which is why the voltage varies from 4v-20v. Since LM35 is an analog device with analog output, the output pin Sig should be connected to AD i.e Analog- Digital convertor. Luckily, Arduino has in built ADC, so, the analog pin of Arduino to output pin of LM35 with a scale of 0.01v per degree Celsius. LM35 is low self-heating due to its drawing which is approximately 60µA. There are three kinds of LM35 say A (55ºC-150ºC), C (40ºC-110ºC), D (0ºC-100ºC). We will be using the LM35-D. Using formula $V_{out}$ = (5/1023) * x with 5 being the 5v in Arduino and 1023 is 5V in Arduino in code we convert these digital values to corresponding temperature values using scale factor with 0.1 per degree Celsius i.e Temperature= $V_{out}$*100. We set a threshold value for temperature sensor too, and depending on the severity the message is sent to the responsible person.

**Heartbeat Sensor (LM358N)**

Heartbeat sensors measure heartbeat based on psycho-physiological signal, which is used as stimulus for virtual-reality system. Heartbeat sensor has three pins VCC (input), GND (ground) and, $V_{out}$, the output. IR_TX, IR_RX sense heart pulses in circuit. They measure how much light is reflected or absorbed. The heart pumping rate depends on the reflected or absorbed light and on oxygen generated blood levels in blood content. In order to make sure that the right amount of IR rays are passing through the finger the current must be restricted to a good proportion such that the oxygenated blood gives higher resistance for rays to pass and lower resistance to deoxygenated blood. This can be done by adjusting the given 470 ohm preset.

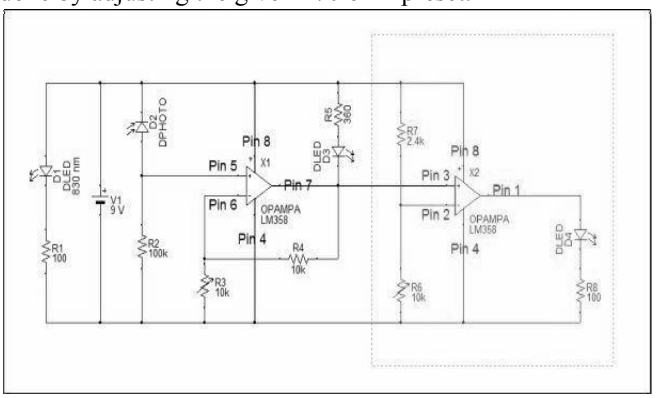


*Figure 4. Heartbeat Sensor (LM358N) internal circuit*

The output of IR_RX is given to the op-amp through capacitor to block DC components of signal. Output of first op-amp is sent to second op-amp which is connected to LED with output to pin-7. LED flashes in response to received pulses from IR diode. Based on the cut off value that is set, a message is sent.

**Wi-Fi module (ESP8266)**

ESP8266 is a low cost serial to Wi-Fi routers and connect to internet from micro-controller. 9600 is the band rate to communicate with the micro-controller. ESP8266 is a self

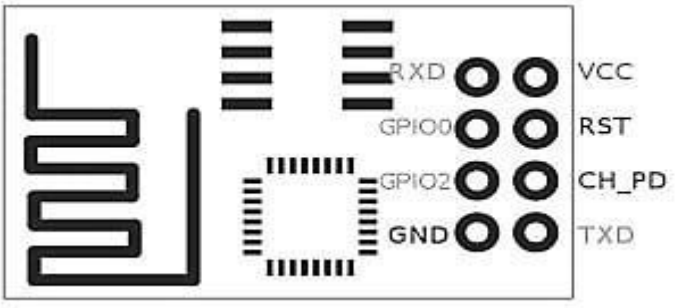


*Figure 5. Wi-Fi module (ESP8266) Pin Configuration*

contained SOC (system on chip) that uses TCP/IP protocols to connect to web server. Using AT commands we can communicate with firmware and extract whatever information and do with module over the internet. RF_TX, RF_RX are for processing the signals. ESP8266 can communicate till 400m distance and can work on Wi-Fi-frequency band of 802.11b/g/n. It is P2P i.e. pier to pier communication. The TRC switch is the transmitter that gives access to antenna and the 8266 receives. Balun is a

type of electrical transformer that is used to connect unbalanced circuit to balanced circuit. As it is a high frequency network, we need LNA, power amplifier and matching network.

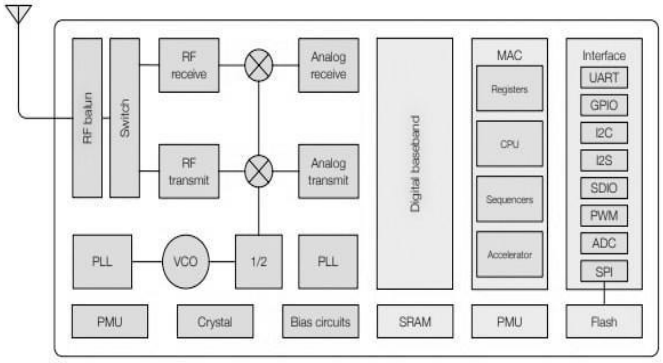


*Figure 6. Wi-Fi module (ESP8266) Block Diagram*

PLL, phase lock loop to lock output signal of 8266 to frequency of input to know better signals. DCXO is used for either modulating or demodulating signals over Wi-Fi. Based on the conditions from the temperature sensor, heartbeat sensor and accelerometer, the ESP8266 sends information to the connected device to get the required help.

**Proposed device design for detecting convulsions**

Using the above components we came up with a circuit to detect convulsions (jerky hand movements) along with rise in their body temperature and pulse rate.

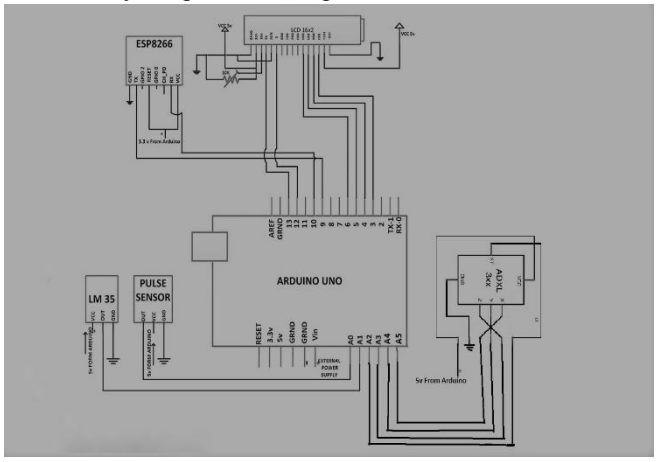


*Figure 7. Proposed device circuit diagram*

From circuit, it is clear that the discussed parts say Arduino, Accelerometer, Heartbeat sensor, Temperature sensor, Wifi module are brought together along with LCD for display purpose and jumper wires for connection purpose and external power supply of 5v. This is a prototype model so why there's a need for LCD in order to display the readings. This LCD can be removed when circuit is shifted to small controller or SOC. After the connection, using USB cable, connect the Arduino to computer. Make sure you have installed arduino.cc before-hand in order to compile and run the code with specific requirements. In case of heartbeat, set a range of 60BPM-100BPM, for body temperature set a range of 36.1ºC-37.2 ºC and for accelerometer set a negative value to z-axis. Once the conditions are set, compile and run the code. Then the LCD display lights up and soon it shows getting data, then place your fingers on the heartbeat sensor and temperature sensor and the values are shown. In order to check, increase the temperature and shake the circuit, as the conditions are not met, soon a notification will be sent to your phone, how? This is through the WiFi module ESP8266 and Blynk application in your phone, which is an IoT platform for the developers. Once you finish the download, create an application with name convulsions detection and fill in the fields required i.e temperature, pulse rate and convulsions. Soon a pin will be generated that needs to be loaded in the Arduino.cc code which will connect the phone to Arduino and exchanges the data. Thus, if the given conditions are not met, the notification is sent to the phone as warning and help can be arranged to the person in danger. This is the proposed device design for the people who are losing lives during seizures and not being able to get help at the right time.

## IV. Conclusion

We have discussed about convulsions and their study by several others and came up with a solution of developing a device that detects a change in body temperature, heartbeat and jerky hand movements. Given approval, time and proper funding, we can build the proposed device and necessary changes can be made for the better version.

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