A Review on Wearable Epileptic Seizure Prediction System

V Seethalakshmi 1, P Naveenkumar 2, G Kavin Prabu 2, S Praveen Kumar 2
1Assistant Professor (Sr.G), KPR Institute of Engineering and Technology, Department of Electronics and Communication Engineering, Coimbatore, Tamil Nadu, India.
2UG Student, Department of Electronics and Communication Engineering, KPR Institute of Engineering and Technology, Coimbatore, Tamil Nadu, India.
seethav@kpriet.ac.in, 17ec109@kpriet.ac.in, 17ec075@kpriet.ac.in, 17ec121@kpriet.ac.in

Abstract. Epileptic is a neurological condition that affects approximately 50 million people worldwide. Epileptic seizure prediction lowers the risk of a patient's life being endangered by a seizure that occurs unexpectedly. The latest seizure prediction methods are computationally intensive due to the complicated hand-crafted features they extract, and they take a lot of memory to store their parameters, which makes them Inappropriate for IoT and connected systems with limited capabilities. In this paper, a deep learning-based IoT framework for accurate epileptic seizure prediction is presented. The proposed method combines the feature extraction and classification stages into a single integrated system in which raw data heartbeat and temperature signals are implemented without any pre-processing, reducing computing complexity even further. A machine learning based prediction model is proposed that extracts the relevant information from the temperature, heartbeat and haemoglobin value using of machine learning algorithm The health condition of patient or person can be found and give some analysis result like normal or abnormal condition. If abnormal condition is observed then the system predicts some medicine or dosage based on health condition and also send alert message using of GSM. In this work, a location tracking of patient is also included and alert is sent to authorized person when the patient fall down or patient get panic or abnormal health

Keywords: temperature sensing, haemoglobin content sensing, heart beat sensing, GSM, GPS.

1. Introduction
Healthcare is a necessary part of life. The health care refers to the preservation and improvement of one’s health through disease prevention and diagnosis. Diagnostic devices such as CT, MRI, PET, SPECT, and others may be used to detect any ruptures or anomalies deep under the skin. Certain abnormal disorders, such as heart attacks and seizures, may also be observed before they occur. The rapid growth of the population, along with the unpredictable spread of chronic illness among the general public, has placed a strain on modern health-care systems, resulting in a high demand for anything from hospital beds to doctors and nurses. Without a doubt, a solution is needed to relieve the strain on healthcare systems while ensuring the highest possible standard of quality of health care. Wearable device, not only for sensory devices, but also for communication, recording, and display devices, technology plays a critical role in healthcare. It's important to keep track of a variety of medical indicators. As a result, the most recent trend in healthcare communication is to use IoT and machine learning. The Internet of Things (IoT) acts as a
catalyst for healthcare and is used in a wide variety of applications. The microcontroller collects sensor data and sends it to the network via email, allowing doctors to track health care parameters in real time.

2. Literature Survey

[1] has developed study of pattern matching algorithm. They have proposed this approach for fast intrusion detection using BM algorithm. Zakareya Laser, Khaled Elleithy and Sai Shiva VNR Ayyalasomayajula, has suggested a method for detecting epilepsy seizures using EEG signals.[2]. They devised a device that processes EEG signals in both the time and frequency domains, using a Chebyshev for signal pre-processing. [3], have developed an research on classification of seizures and epilepsy and how these classifications may impact patients, doctors and clinicians.

[4] have evolved an approach focused on imbalanced classification that is addressed by weights ELM in seizure detection. To decompose EEGs and obtain time and frequency domain features, the WPT is used. Yusuf U Khan, Omar Farooq, and Priyanka Sharma used a wavelet-based feature to extract two statistical features from the data: skewness and kurtosis, and a simple linear classifier to differentiate between normal and seizure EEGs. [5] Mote are sending an SMS to doctor and parents as soon as the fits start as well as an SMS when the FIT ends. The main goal of the epilepsy monitoring and analysis framework built on the Android platform is to control and assess epilepsy attacks while also tracking the patient's progress over time.[6].

The accelerometer MPU6050 was used by [7] to collect signals from the extremities in order to detect irregular movements and sudden falls in epilepsy seizure patients. The Wavelet transform is used to detect changes in extremity movement, while a thresholding technique is used to detect seizures and falls. [8] have proposed a system for detecting epileptic seizures by the use of biosensors. The system mainly uses advancements in state-of-art biosensing technology for epileptic diseases diagnostics and continuous monitoring or sometimes used for both the purposes. The system approximately uses 4 sensors such as EEG, ECG, EMG, ECoG which continuously monitors the body conditions of the patients thus greatly helps in epilepsy management [9].

[10] created an IoT framework for tracking and supervising systems that focuses on two forms of epilepsy: focal myoclonic and epileptic absence seizures. The system uses tuned and trained models of previous existing system into the MCC kernel which allows continuous monitoring and providing real time responses through Wi-Fi Networks. The Q-Wavelet and firefly feature selection algorithm , [11], is based on the tunability of the Q-factor, which provides a proficient method to adopt wavelet transformation and the firefly algorithm, which is a stochastic search technique.

3. Existing System

- Manually reading the patient’s data.
- Only sensors will be used to analyse the patient’s health.
- RFID (Radio Frequency Identification) based communications will be used to share the data to the particular doctor.

4. Proposed System

The following are the features of the proposed system

- The implementation of this project both hardware and software are included.
- The segment on hardware consists of an accelerometer, heart beat sensors and GPS sensors.
- The epilepsy is predicted before its occurrence with a help of heart beat sensor.
- The detection of occurrence of epilepsy is done with the help of accelerometer sensor.
- Sensor based secured data transmission system.
- Accurate Data prediction.
- Automatically sensor-based Patient’s health parameters analysing.
- Easily identify the location of patient when emergency situation
- Machine learning based dosage medicine prediction and message alert to doctor and the particular person.

The early detection of epilepsy is taken place through the serial communication of the sensors which continuously checks for the abnormalities in the sensor readings, if there is any abnormalities spotted in the sensor readings it is immediately intimated as mobile notification. It is intimated to the respective doctors and care takers along with the location of the patient using GPS tracking system [12 -15].

The proposed system also has a software section which is mainly for complete analysis of the patient through tracking the number of occurrences of epilepsy in a patient within a particular period of time and the exact details of the severity of the occurred epilepsy. The software section consists of database of sensor values (GSR, accelerometer and heartbeat) of the patient which is used for analysis of patient's body conditions by providing fine details of the severity of the occurred epilepsy. This is done by finding the percentage change in the sensor data obtained from the patients to the threshold values that are set based on the values during the occurrence of epilepsy from which appropriate medication can provided. The block diagram of the proposed system is shown in Figure 1.

![Figure 1. Block Diagram](image-url)
Figure 2. Flow chart

The flow chart in Figure 2, shows that the data from the sensors of the respective patients are used for prediction of occurrence of epilepsy and the data are collected in files for analysis. The sensor values are getting the microcontroller and then process it [16-20]. The Raspberry pi only contains digital input/output pins, so an ADC is connected to get the digital values. The sensors are connected to analog to digital converter. The patient is fell down, the MEMS sensor is used to detect the accident from felt and if any emergency situation, patient location is sent to the respective person mobile number Machine learning algorithm is used to analysis the data set of patient regular intervals. The Machine learning is the part of artificial intelligence. This is used to give the accurate result dosage or medicine prediction to patient using past dataset and current sensor sensing dataset are applied to machine learning in machine learning have various algorithm are used.

In this project SVM algorithm (support vector machine) is used. The dataset is already given to the Excel format. The dataset has past sensor value which are collected and upload into excel sheet. The SVM is an artificial intelligence (AI) characterization calculation that has primarily been used to resolve arrangement problems. Because of SVM’s high success rate in arrangement, it is widely used in a variety of applications. The occurrences are isolated with a hyper plane \( w^T x + b = 0 \), where \( w \) and \( b \) are dimensional coefficient vectors that are normal to the surface, in a two-fold characterization problem. From the beginning, \( b \) has been adjusted as a motivator, and \( x \) has been enlightening in terms of assortment. By using of SVM algorithm machine learning give some dosage prediction value and values like dosage of medicine or tablet suggestion based on label in dataset prediction of dosage of medicine are send into respective person mobile number and respective doctors and family members.

4.1.  Hardware Components

1) 3-Axis Accelerometer
A device that calculates acceleration is known as an accelerometer. An accelerometer will determine the angle it is inclined with respect to the surface by calculating the amount of acceleration due to gravity on Earth. The 3-axis accelerometer sensor can work with voltages ranging from 2.2 to 6 volts. A 5-pin header, a two-pin header, and a shunt for G selection are included with the 3-Axis Accelerometer sensor module. By detecting the amount of dynamic acceleration, the device's speed and direction can be determined. The hardware is shown in the Figure 3.

2) Raspberry Pi

As a multi-processor, this device performs admirably. It has a graphics card, a volatile memory, RAM, gadget interfaces, and other remote gadget interfaces. This Raspberry Pi is burning-through less force, however it is as yet modest and incredible Figure 4. As with a regular PC, it needs a console to issue commands, display the device, and force supplies. The SD card was used as a rough circle by the Raspberry Pi. Raspberry Pi can connect to the internet through a LAN/Ethernet connection, a USB modem, or a remote control. Raspberry Pi should be able to support a variety of home and business applications. Raspberry Pi uses the Raspbian operating system, which is based on Linux. Python is the programming language that the Raspberry-Pi runs on. It is fit for speaking with other outside gadgets utilizing remote correspondence advances, cell organizations, NFC, ZigBee, Bluetooth and so on. This paper was actualized on a quick organization as 4G with the cell organization. Raspberry can be utilized for some applications thus, it has numerous chances later on [2].

3) Temperature Sensor LM35

The yield voltage of the LM35 arrangement of accuracy coordinated circuit temperature sensors is corresponding to the temperature in Celsius (Centigrade). Subsequently, not at all like direct temperature sensors tuned in Kelvin, the LM35 has the upside of not needing a critical consistent voltage to be deducted from the yield to accomplish advantageous Centigrade scaling, as demonstrated in Figure 5. It operates for
both plus and minus power supplies as well as single power supplies. Figure 6. Since it just draws 60 watts, it has an extremely low self-warming temperature of under 0.1°C in still air. Figure 5. The LM35 is guaranteed to work in a temperature scope of 0° to +100°C. With a voltage, this sensor measures the internal heat level. The LM35 sensor has a preferred location for changing from Kelvin to centigrade, is also suitable for remote applications, and outperforms the indoor regulator [2].

4) Heartbeat Sensor

![Heartbeat Sensor](image)

**Figure 6.** Heart beat sensor

The Heart Beat Sensor is a simple device that can be used to study the heart's function. This sensor measures the blood flow into the ear lobe. When the heart pumps blood into the ear lobe's blood vessels, the volume of blood in the lobe changes over time. The sensor shines a light (small incandescent lamp) through the ear, determining the amount of light transmitted. The clip may also be used on a fingertip or the skin network between the thumb and index finger. In the box, the signal is amplified, reversed, and filtered. Since the sensor is relatively impervious to disruptions, it can be used during exercise, such as on an exercise bicycle. The heart rate can be measured by graphing this signal, and some specifics of the heart's pumping operation can be seen on the graph Figure 6.

![Graph](image)

**Figure 7.** A sample measurement taken with the heartbeat sensor.

Figure 7 shows that the blood flowing through the earlobe rises at the start of the heartbeat. The contraction of the ventricle’s forces blood into the arteries, causing this. A second, smaller peak appears shortly after the first. The closing of the heart valve at the end of the active process increases the pressure in the arteries and the earlobe.

5) SPO2 Sensor

SpO2 is a peripheral indicator of cardiovascular and respiratory system health that is normally taken on a finger. A pulse oximeter is used to measure the oxygen saturation in a patient's blood noninvasively. In this device, light is transmitted via a translucent, pulsating arterial bed, normally a fingertip or earlobe,
by a red and infrared light source, photo detectors, and a probe. The absorption of red and infrared light by deoxygenated haemoglobin (HHb) differs from that of oxygenated haemoglobin (O2Hb) (O2Hb). The percentage of saturation of haemoglobin in arterial blood can be determined by measuring changes in light absorption caused by arterial blood flow pulsations. Each pulse oximetry system manufacturer must perform human testing to assess the device's accuracy. The participants' arterial blood samples are then taken to a clinical laboratory to be tested for oxygen saturation.

As a result of the research, a graph for that particular model of SPO2 sensor and display was developed. An R-curve is the name given to this graph. An R-curve, as shown in Figure 8, defines the relationship between a specific ratio of red and infrared light and the oxygen saturation measured during human testing. The R-curve is then used in the firmware of a specific instrument, as well as in SPO2 testers.

![Figure 8. An example of an R-curve, correlating O2 saturation with the R value](image)

6) GPS Module

The Global Positioning System (GPS) is a radio navigation system that consists of 24 satellites and their ground stations all over the world. These man-made stars are used by GPS to measure locations that are accurate to a few metres. The Global Positioning System (GPS) is a satellite-based system that measures and computes its location on Earth using satellites and ground stations. These GPS satellites are used to send information signals to the receiver over a radio frequency range of 1.1 to 1.5 GHz. A ground station or GPS module can calculate its location and time using the information obtained.

![Figure 9. GPS module](image)

The NMEA (National Marine Electronics Association) format is used by the GPS receiver module. It outputs serially on the transmitter (TX) pin at a 9600 Baud rate by design.

- **VCC**: Power supply with a voltage range of 3.3 to 6 volts
- **GND**: Denotes ground
- **TX**: Data is serially transmitted, providing information such as location, time, and so on.
- **RX**: It is needed when configuring the GPS module because it receives data serially.

7) GSM Module

A GSM modem is a system that can be used to allow a computer or some other processor communicate over a network. It can be either a phone or a modem. A GSM modem requires a SIM card to operate and
works on a network range that the network operator has subscribed to TTL-Modem is a SIM900 Quad-band GSM/GPRS system that operates on the frequencies 850 MHz, 900 MHz, 1800 MHz, and 1900 MHz. It's small and simple to use as a GSM modem that plugs in, allowing users to communicate with both 5V and 3V microcontrollers (PIC, AVR, Arduino, 8051, and so on) (ARM, ARM Cortex, XX, etc.). Via AT (Attenuation) commands, the baud rate can be adjusted from 9600 to 115200 bps. The internal TCP/IP stack in this GSM/GPRS TTL Modem enables users to connect to the internet via GPRS. In a cell phone to mobile phone interface, it is suitable for SMS as well as DATA transfer applications. Using the USART (Universal Synchronous Asynchronous Receiver and Transmitter) feature, the modem can be connected to a microcontroller (serial communication). The hardware is shown in Figure 10.

![GSM module](image)

**Figure 10.** GSM module

### 4.2. Machine Learning

Machine Learning is a branch of Artificial Intelligence (AI) that is focused on the concept of giving machines access to data and allowing them to learn and experiment on their own. It is concerned with extracting patterns from massive data sets. Machine learning allows a machine to learn from data, enhance performance based on past experiences, and predict outcomes without the need for human intervention.

1) **Need for Machine Learning**

Machine learning is becoming increasingly important. It is needed because it is capable of performing tasks that are too complex for a human to perform directly. The time and money can be saved with the aid of machine learning. Machine learning's value can be easily understood by looking at its applications. Machine learning is currently used in self-driving vehicles, cyber fraud detection, face recognition, and Facebook friend recommendation, among other things. Various top companies, such as Netflix and Amazon, have built machine learning models that evaluate user interest and suggest products based on that input.

2) **Machine Learning**

To construct a model, a Machine Learning algorithm is trained using a training data set. The ML algorithm allows a prediction based on the model when new input data is added. The accuracy of the prediction is assessed, and if it is suitable, the Machine Learning algorithm is used. If the precision isn't good enough, the Machine Learning algorithm is retrained with a supplemented collection of training data.

### 5. Conclusion

In the modern era of science and technology, epileptic seizure prediction and alert system is very useful for the life of Epileptic patients. The pattern matching algorithm which uses predetermined dataset for prediction process is less tedious. The percentage changes that occur in the dataset collected is the main source of analysis which will greatly guide the clinicians to provide appropriate medications and occurrence of epilepsy is also send through the mobile notification before and after the occurrence within few seconds which help to save the life of the patient. It also has a feature of updating system along with the location of the patient. This can be embedded into a wearable device which makes the life of epileptic patients less
intricate. Thus, an efficient detection and alert system for occurrence of epilepsy and an efficient methodology for analysing the health conditions of epileptic patients have been designed.

References

[1] Zakarey laser, Sai Shiva VNR Ayyalasomayajula, and Khaled Elleithy, Epilepsy Seizure detection using EEG signals, Department of Computer Science and Engineering, University of Bridgeport, CT, USA, 2017 IEEE.

[2] Jingbo Yuan, Jisen Zheng, and Shunli Ding, An Improved Pattern Matching, Northeastern University of Qinhuangdao, China, Institute of Information Management Technology and Application, 2010 IEEE.

[3] Jessica J. Falco-Walter, Ingrid E. Scheffer Robert, S. Fisher, The New Definition and Classification of Seizures, research. Volume 139, January 2018, Pages 73-79.

[4] Q. Yuan, Weidong Zhou Liren Zhang, Fan Zhang, Fangzhou Xu, Yan Leng, Dongmei Wei, Meina Chen, Epileptic seizure detection based on imbalanced classification and wavelet packet transform, Seizure-European Journal of Epilepsy, Volume 50, August 2017, Pages 99-108.

[5] M. Z. Poh, T. Loddenkemper, C. Reinsberger, N. C. Swenson, S. Goyal, M. C. Sabtala, J. R. Madsen, and R. W. Picard, Convulsive Seizure Detection Using a Wrist-Worn Electrodermal Activity and Accelerometry Biosensor, Epilepsia, Vol. 53, No. 5, PP. 93-97, 2012.

[6] Pallavi Lokhande and Tushar Mote, Epilepsy monitoring and analysis using Android platform, International Journal of Science and Research (IJSR), Volume 5 Issue 7, July 2016.

[7] R. Immanuel Rajkumar, Rani Hemamalini, and P. Grace Kanmani Prince Lab-View Based Abnormal Muscular Activity and Fall Detection Using MEMS Accelerometer During Seizure Occurrence, Indian Journal of Science and Technology, Vol 7(10), PP. 1625–1631, October 2014.

[8] Priyanka Sharma, Yusuf U Khan, and Omar Farooq Automatic seizure onset identification in pediatrick EEG, according to the International Journal of Embedded Systems of Application (IJEAS) Vol.2, No.3, September 2012.

[9] Shivani Tiwari, Varsha Sharma, Mubarak Mujawar, Yogendra Kumar Mishra, Ajeet Kaushik, and Anujit Ghosal Biosensors for epilepsy management: State-of-Art and Future aspects Sensors, 19, DOI: 10.3390/s19071525, PP-1-7, March 2019.

[10] Ahmed I.Sharaf, Mohamed Abu El-Soud, and Ibrahim M. El-Henawy, An automated method for epilepsy detection based on Tunable Q-Wavelet and Firefly feature selection algorithm, International Journal of Biomedical Engineering, Volume 2018, 12 Pages, September 2018.

[11] Haldorai, A. Ramu, and S. Murugan, Social Aware Cognitive Radio Networks, Social Network Analytics for Contemporary Business Organizations, pp. 188–202. doi:10.4018/978-1-5225-5097-6.ch010

[12] R. Arulmurugan and H. Anandakumar, Region-based seed point cell segmentation and detection for biomedical image analysis, International Journal of Biomedical Engineering and Technology, vol. 27, no. 4, p. 273, 2018..

[13] Christope C.Jouny, Piotr J.Franaszczyk, and Gregoe K. Bergey Improving Early Seizure detection, Epilepsy Behav, Volume 22, S44-S48, December 2011.

[14] Giorgos Giannakakis, Mahew Pediaditis, Vangelis Sakkalis, Manolis Tsiknakis, Methods for seizure Detection and prediction: An overview, Chapter in NEUROMETHODS, August 2014.

[15] Tzallas, A.T Tzallas, M.G Tsimpouras, and D.I Fotiadis, Automatic seizure detection on Time-Frequency Analysis and Artificial Neural networks, Volume 2007, 13 Pages, December 2007.

[16] Yoo J, Yan L, El-Damak, Ah Shoeg, AP Cahandrakasan, An 8 Channel Scalable EEG Acquisition soc with Patient-Specific Seizure classification and recording processor, IEEE J Solid state circuits 48(1):214-228, 2012.

[17] Khramis H. Mohammed, Simpson S, Frequency moment signatures: A Method for automated Seizure detection from scalp EEG, Clin Neurophysiology 124(12):2317-2327, 2013

[18] Polat H., Ozerden MS, Epilepsy seizure detection from EEG signals by using wavelets and Hilbert transform, MEMSTECH 2016, PP. 20-24, APRIL 2016.
[19] Guarzino C, Delgado E, EEG Signal- Channel Seizure recognition using Empirical mode Decomposition and normalized mutual information, IEEE International Conference on Signal Processing (ICSP), PP. 1-4, OCT 2010.

[20] Alexandros T Tzallas, Dimitrio I Fotiadis, Markos Tsipourras, A Time-Frequency based method for the detection of Epileptic seizure in EEG Recording, Proceedings of IEEE Symposium ON Computer based Medical systems, June 2007.