IoT-Vision Enabled Assistant For Epileptic Patients

Relevant System Comparison

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1 Introduction

1.1 Executive summary

IoT-Vision Enabled Assistant for Epileptic Patients is an innovative and comprehensive solution that aims to detect, prevent and forecast seizures in real-time to improve the lives of epileptic patients. The system uses cameras to monitor the patient's activities in real-time and then sends them to cloud server to analyze the data where it detects any abnormal patterns or symptoms that can lead to seizure. The system generates an alert notification if any seizure or its symptoms are detected and send it to its caretakers or family members through mobile and web application. The main objective is to detect and forecast seizures by utilizing a personalized model technique which improves the accuracy of seizure detection and forecast and reduce false positive rate. System uses machine learning algorithms to learn activities and symptoms of each patient. This personalized model technique enables learning models to identify and understand unique behavioral patterns and triggering activities of each individual patient, which helps in forecasting and improving user's outcome with epileptic disease.
The system has user-friendly and accessible mobile, web and desktop application which provides a high level of flexibility and convenience to patients, their family members and caretakers. The applications are simple to use, interactive and provides real time monitoring which makes it easier for caretakers to give response in case of any emergency. The system is designed to be cost-effective. It provides round -the-clock safety and comfort and assistance only when epileptic patient needs it. Hence, it reduces the burden on caretakers and nursing sector and maintains an independent, comfortable, healthy and private life of epileptic patients.
In conclusion, it is revolutionary system that uses cameras and machine learning algorithms to detect and forecast the seizures. Personalized model technique used in this system helps in improving the accuracy of seizure detection and reduce false positives. The user-friendly and accessible mobile, desktop, and web applications provide a high degree of flexibility and convenience to patients, their family members and caretakers, making it easier for them to respond in case of any emergency hence improves the quality of life of patients and caretakers. Overall this project has potential to make significant impact on the lives of millions of people suffering with epilepsy.

2 Previous Research

Epilepsy is a neurological disorder or condition that causes repeated and indefensible seizures. A person can be declared epileptic if he has had at least two unprovoked seizures. According to World Health Organization (WHO) [16], around 50 million people with epilepsy live on the earth, making it the most common neurological disorder globally. Around 80% of the patients reside in low or middle-income countries. The past 5 year research on epilepsy under the domain of Computer Vision could be summarized into two categories. It could further be divided as Video based or EEG based.

2.1 Supervised Learning

In 2018 Ahmedt-Aristizabal [10], David with 5 other authors, presented a video-based epilepsy detection system. They created their custom dataset of about 55 video clips, 24 clips of seizures and 31 clips of non-seizure, using 16 patients. They used the technique of LSTM and CNN. This approach works for ictal phase of seizure.

Ahmedt-Aristizabal [1] with 7 others in 2018 proposed deep facial analysis using using computer vision. Video recordings were used, the dataset involved consisted of 55 video clips having 24 seizure and 31 non-seizure videos. This approach also works for ictal phase of seizure. The models used are LSTM with accuracy 95.19 percent and face detector model with accuracy 92 percent.

In 2019, sayeed [11]published a study in IEEE Transactions on Consumer Electronics journal, An Edge-Device for Accurate Seizure Detection for Smart Healthcare. SRA (Signal Rejection Algorithm) an algorithm that predicts the result based on voltage level threashold using no AI. The Sensitivity recorded was 96.9% , Specificity 97.5%, with the latency of 3.6 sec. This approach works for the ictal phase of the seizure.

Shamim hussain [8]along with 5 others applied deep learning for epilepsy seizure detection and brain mapping visualization using 24 Channel EEG Recording Fed into CNN Architecture. They used the datset CHB-MIT EEG (EEG Recordings) including 969 hours of Recording and has 173 seizure samples.There were total of 23 patients including 18 females and 5 males aged between 18 and 22. It is a wearable device anfd this approach works for ictal phase of seizure.

Ahmedt-Aristizabal [2]and David used Supervised (MTLE , ETLE) learning approach for Aberrant epileptic seizure identification using the computer vision perspective. Video Video Recordings involved consective 25 frames. CNN-LSTM methodology was used with an accuracy of 97.03%. The videos were of 1 to 2 minute length and this approach also works for ictal phase of seizure.

Hussein and Ramy [9]in 2022 proposed Multi-Channel Vision Transformer for Epileptic Seizure Prediction with the help of EEG recordings and the transformers were used in methdology. The recorded accuracy was 99.8% Specificity recorded was 99.7% and Sensitivity was 99.8%. The dataset used was CHB–MIT Scalp EEG Dataset, Kaggle/American Epilepsy Society (AES) Invasive EEG Dataset, Kaggle/Melbourne University Invasive EEG Dataset. The supervised approach was used including 22 patients(5 males and 17 females) with age ranging from 15 to 19. This would work on Preictal and Ictal phase of seizures and its a wearable device.

2.2 Unsupervised Learning

Choi with 7 others [14]in 2019 presented a wearable device for Epileptic Seizure Forecasting using Generative Adversarial Networks. It was based on video EEG Monitoring. The evaluation matrices indicated an accuracy above 80 percent. The datasets used in this study were CHB-MIT dataset, Freiburg Hospital dataset, EPILEPSIAE dataset. The GAN technique was used in this study.

3 Comparison with State of Art

3.1 Existing Projects

Many devices are commercially available in markets for the detection of epileptic seizures. Most of them are sensor-based which uses sensors like accelerometer, a gyroscope, a thermometer, and electrodermal activity which detect many such activities that can help to detect seizures. EEG and Camera-based devices are also available such as Epihunter EEG headcaps, SAMi, etc.

3.1.1 Epihunter

Used to detect absence seizures [7]. Absence seizure is characterized by a brief, sudden loss of consciousness, often lasting only a few seconds, during which the person may appear to be staring blankly into space.

Cost: $825.91 – $1,515.91 inc GST

Detector Location: Scalp

FIGURE 1: Epihunter

3.1.2 Embrace 2

This device [6] utilizes accelerometer, a gyroscope, a thermometer, and electrodermal activity to detect convulsive seizure activity and communicates it to a paired wireless device which alerts designated caregivers.

Cost: The watch costs $249 and the monitoring service requires a monthly subscription, which costs either $9.90 per month, $19.90 per month, or $44.90 per month, depending on several features such as the number of caregivers to be notified.

FIGURE 2: Embrace 2

3.1.3 SAMi

SAMi [3] (Sleep Activity Monitor) is a device that is primarily designed to monitor sleep patterns and detect movements during sleep, including movements that may be associated with seizures. SAMi uses a small infrared camera that is placed near the individual's bed to monitor their movements during sleep.

Cost: Rs.114,700.00 PKR or above for different available packages.

FIGURE 3: SAMi

3.1.4 Epi-Care Mobile

Epi-Care Mobile [13] consists of sensors placed on the wrist of epileptic patients. it can easily be worn by patients both inside and outside. the sensor device is connected to an app on smartphones that can send alarms by automatically calling the caretakers of a patient for immediate assistance and also forwarding their GPS location through direct message.

Cost: £1,005.00 around 350,545 in PKR

Detector Location: Wrist

FIGURE 4: Epi-Care

3.1.5 Emfit

Emfit is a bed sensor [5], a thin-sheet device placed under the mattress that can detect GTC (Generalized tonic-clonic seizure) only.

Cost: $249.00 around 80000 in PKR

Detector Location: Under the mattress

FIGURE 5: Emfit

3.1.6 Brain Sentinel SPEAC

SPEAC [12] is used to detect GTC seizures only and can be used in the home or health-care facilities during periods of rest (designed to detect seizures during sleep or rest).

Cost: Not Available

Detector Location: Arm (over the biceps muscle)

FIGURE 6: SPEAC

3.1.7 MedPage

It can detect tonic-clonic seizures with the help of prolonged unusual movements and will inform the caretaker for early assistance . [17]

Cost: £246.00 around 90000 PKR

Detector Location: Under the mattress

FIGURE 7: MedPage

3.1.8 AlertIt Companion by AlertIt

The Alert-iT Companion Mini is designed to detect tonic-clonic seizures and is placed between the mattress and bed base. It detects the seizure's movements and abnormal physiological symptoms that occur during seizures. It generates an alarm that can alert the caretakers by using radio pager, which has a 450m range. [15]

Cost:£248.33 around 90000 in PKR

Detector Location: Between mattress and Bed base

FIGURE 8: AlterIt

3.2 Comparison and Need of New System

So, why we still need something that can help epileptic patients to detect and prevent seizures even though these devices are available? Although these devices are available, there are many issues that can insist to propose something that can actually help patients while considering all the factors.

In [5], the results showed that users indicate that a device should be socially acceptable, as wearing a device that looks unfamiliar, visible, and intrusive may disclose their condition to others. Most of the EEG-based devices are not comfortable and also refer to instances where the device detects a seizure when no seizure is actually occurring (generate false alarms). This can happen for a number of reasons such as stress, hormonal imbalances, trauma, changes in sleep patterns etc during which changes in brain activity are not even related to seizures.

Epihunter headcap device is expensive EEG based seizure detection device compared to other devices. **Embrace2** is also expensive. It is necessary to have an active subscription to the monitoring and alerting service. There are several different epilepsy types for which the Embrace watch is not indicated, such as complex partial seizures and absence seizures. Complex partial seizures are characterized by a decreased level of awareness, with possible movements of the body, usually lasting for a few seconds. Absence seizures are characterized by a decreased level of awareness and staring spells but without involuntary physical movements.

In addition, **SAMi-like** devices have a high rate of false detection for seizures as they can detect simple movements like the movement of limbs because of restlessness may also detect as an epileptic seizure. This product is not affordable for the average person because it is more expensive than others in the market.

Other devices, like **Epi-Care Mobile**, **Emfit**, **Brain Sentinel SPEAC**, **MedPage**, and **AlertIt Companion by AlertIt**, all have some limitations. They can detect tonic-clonic or convulsive seizures by observing unusual movements using different sensors, which may generate false alarms by considering normal movements as seizure-jerking movements. This may result in disruption for patients and their caregivers. Most of them are not available in all countries, have battery limitations, and may have premium features that are not financially suitable for all epileptic patients, which can also burden their caregivers.
Many other devices with similar services and limitations are also available [4].

Table 1: Do currently marketed devices match the needs of users?

Devices	Modality	Comfort	Placement	Seizure Type	Affordable
Epihunter	EEG	×	Scalp	Absence Seizures	Expensive
Embrace 2	Sensors	✓	Wrist	Tonic-clonic Seizures	Moderate
SAMi	Camera	✓		Tonic-clonic Seizures	Affordable
Epi-Care	Sensors	✓	Wrist	Tonic-clonic Seizures	Expensive
Emfit	Sensors	✓	Under the mattress	Tonic-clonic Seizures	Moderate
SPEAC	Sensors	×	Arm	Tonic-clonic Seizures	
N/A heightMedPage	Sensors	✓	Under the mattress	Tonic-clonic Seizures	Moderate
AlertIt	Sensors	✓	Between mattress and Bed base	Tonic-clonic Seizures	Moderate

It is important to note that some devices require different subscription plans to enable premium features which can also include in the overall cost of devices.
A rough estimate of the ratio of available devices for epileptic seizure detection based on EEG, Camera, and Sensors:

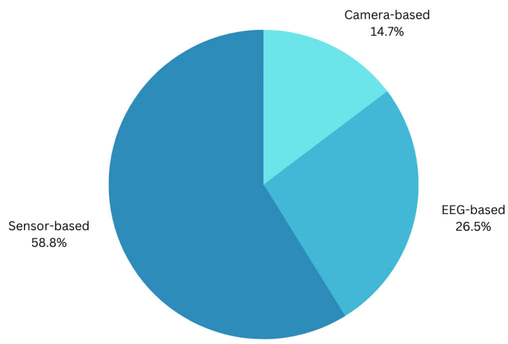

Figure 9: ratio of available devices for epileptic seizure detection

Most devices are available for people with epilepsy to monitor seizures associated with convulsive movements only. No single device exists that can forecast or prevent upcoming seizures or detects all types of seizures since different types present varying physiological and external symptoms.
Our focus is using sensor and camera-based technologies instead of relying on only one type like EEG-based or accelerometer-based devices. Sensors capture physiological signals like electrodermal activity, heart rate, and breathing patterns while cameras capture visible changes in facial expressions, body movements, etc., providing a comprehensive picture of normal and abnormal activities to forecast seizures as well as detect seizures more accurately.
Machine learning algorithms personalize the seizure forecasting and detection process considering the unique physiological characteristics of each individual user. This feature sets our project apart from others that rely on a one-size-fits-all approach resulting in a higher accuracy rate and reliable seizure detection.

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