IoT-Vision Enabled Assistant for Epileptic Patients

Feasibility Study Report

Session: 2020 – 2024

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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 patient's activities in real time then send it 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.

1.2 Objectives

1.2.1 Industry Objectives

The following industry objectives will be achieved:

- To make a contribution to the advancing field of healthcare technology
- To develop ways to integrate our system with the existing healthcare systems to improve nursing care for epileptic patients
- To ensure the compatibility of the system with the devices such as smartphones and laptops.

1.2.2 Research Objectives

- To determine and analyze existing mechanisms/solutions for managing seizures in epileptic patients
- To examine the viability of system in the detection and prevention of seizures.
- To explore and identify research gaps in the management of epilepsy.
- To publish the findings in journals and present them at the international level.

1.2.3 Academic Objectives

The following academic objectives will be achieved:

- To get a deep understanding of various computer vision and machine learning algorithms used in the management of epilepsy.
- To practically implement the algorithms and analyze the results.
- To provide an opportunity for the students to explore the area of healthcare technology.

1.3 Scope

The project uses a Bullet 2C 4mp camera installed on the ceiling of the patient's room. The number of cameras varies from patient to patient but a minimum of one camera is required.

These activities are examined:

- Drinking
- Eating
- Stand Up
- Stand Down
- Walking
- Lying
- Sit Up
- Sit Down
- Watch Screen
- Use Smartphone
- Reading
- Take Pills
- Enter
- Leave

These activities will help in recognizing these patterns:

- Eating Pattern
- Medicine Pattern
- Fall Pattern
- Sleep Pattern

Activities of elderly are usually limited to a room or within a house so environment of project ranges from single room to area covered by a house, hospital or care center.

1.4 Overview of Existing Systems

Many devices are commercially available in markets for epileptic seizure detection. 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.

1.4.1 Epihunter

Used to detect absence seizures [3]. 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

1.4.2 Embrace 2

This device [4] 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.

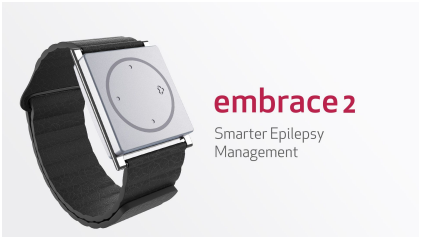

FIGURE 2: Embrace 2

1.4.3 SAMi

SAMi [5] (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.

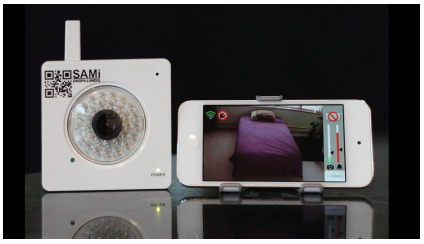

FIGURE 3: SAMi

1.4.4 Epi-Care Mobile

Epi-Care Mobile [1] 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

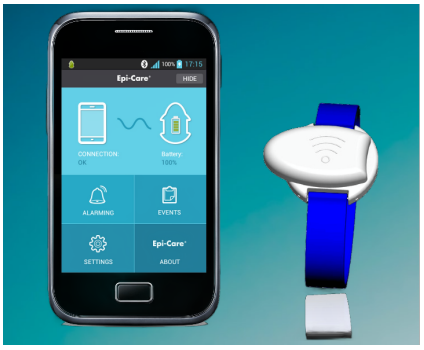

FIGURE 4: Epi-Care

1.4.5 Emfit

Emfit is a bed sensor [2], 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

2 Feasibility Study

2.1 Technical Feasibility

2.1.1 Technology Requirements

The end product of the project will be a desktop and web-based application. So, keeping in view these deliverables, we can classify our technology requirements into hardware and software components used in the project.

2.1.2 Hardware Requirements

The project involves IoT which means that hardware will also be involved. To ensure real-time monitoring and data collection of patients, some hardware components will be required. High-resolution cameras will be required to seamlessly monitor the patient in real-time. Secondly, to process the stream and manage the data, high computational power will be required which will be in the form of a system installed in the environment. Hardware requirements involve:

- Camera 1080p (1920 x 1080 pixels) [Minimum 1 Required]
- A multi-core processor (2.5 GHz or higher), 8 GB RAM (16 GB recommended), dedicated GPU, sufficient storage space, compatible operating system, and stable high-speed internet connection.

2.1.3 Software Requirements

The software components are required to carry out various functionalities of the project. In our case, there are two major software components including a desktop and web-based application. To ensure the smooth integration of both applications, the common language Python is used in both of them.

The following tools and technologies are involved in developing the web application. HTML, CSS, Javascript, React for frontend and Django for backend development.

On the other hand, the desktop application is also developed in PyQT which is a cross-platform GUI toolkit. It's free software used to design and develop powerful desktop applications.

Lastly, the following machine-learning models will be required:

- Face Recognition
- Face de-identification
- Activity Recognition
- Seizure forecasting

Computer Vision libraries such as OpenCV and Python libraries such as PyTorch for image and video processing are used. All these technologies and libraries are freely avaialble and ready to use. There integration with the above hardware is also feasible . Therefore all the software requirements can be met.

2.1.4 Network and Connectivity

Firstly, for the project to run smoothly and generate alerts and send them to caretakers after the seizure detection and secondly to process the stream on cloud server for the sake of forecasting, a stable internet connection is required. A minimum bandwidth of 10 Mbps and a reliable internet connection with a download speed and upload speed of at least 5 Mbps for seamless real-time data transmission and remote access functionalities is required.

2.1.5 Technical Skills and Resources

The successful completion of the project depends upon the technical skills of the developers working on this project. Fortunately, all the skills required for the development are acquired by the development team and they also have enough resources to do so.

2.1.6 Technical Risks

2.1.6.1 Inaccurate AI algorithms

The seizures are detected/forecasted using certain artificial intelligence algorithms. If these algorithms do not perform up to the mark by providing inaccurate results they may generate false alarms causing unnecessary tension and anxiety for the caregivers and epileptic patients.

2.1.6.2 Hardware/Software Failures

The hardware components which is used in the system includes IoT devices such as a camera in order to monitor the patient and a computer system that provides an interface used for the management of patient data. There are chances that these devices may malfunction or fail to function properly which could lead to the breakdown of the system and loss of important data. Similarly, the software may crash due to anonymous bugs in the system.

2.1.6.3 Power Outage

Electric power is the fundamental component of the system, short/long-term power outrage may lead to loss of important information and this may lead to a delay in notifying the caregiver.

2.1.6.4 Data Storage Failure

The data storage devices such as disk drives may fail and stop functioning properly causing potential loss of data and leaving the system worthless. This may occur due to insufficient storage or disk corruption.

2.1.6.5 Connectivity Issues

The system requires continuous connectivity to the Internet with specific bandwidth in order to function properly. But if there are network outrages or weak strength of signals, there are high chances of inaccurate data recording.

2.2 Financial Feasibility

2.2.1 Cost Estimation

After the analysis, the estimated costs for each of the components including hardware and software are given below:

2.2.1.1 Hardware Components

- The cost of high-resolution cameras is estimated to be around 12K PKR.
- The multi-core processor (2.5 GHz or higher), 8 GB RAM (16 GB recommended), dedicated GPU, and storage space are estimated to cost approximately 200K PKR.

2.2.1.2 Software Components

- The cost of software development, including the desktop and web-based applications, is estimated to be around 150K PKR.
- The cost to train machine learning models using cloud services can cost up to 50K.

- Miscellaneous costs such as any legal licenses, permits,travel and marketing are also considered and they can cost up to 100K PKR.

2.2.2 Cost of Operations

The estimated cost of operations performed in the project is also given below:

2.2.2.1 Maintenance and Support

The cost of monthly maintenance including any updates, technical faults, or bug fixing is estimated to be 10K.

2.2.2.2 Internet Connection

For a high-speed and stable internet connection, the cost can be up to 5k to 10k PKR.

2.2.2.3 Hosting/Cloud Services

To process the data and train the models on it, the cost associated with it is 10K PKR.

2.2.3 Revenue Projections

The project generates revenue from a subscription-based approach. Different plans are offered to the customers to choose from including a variety of features. All the features are divided into plans.

2.2.3.1 Subscription Fees

The revenue projection is based on three plans.

- Freemium:
  The Freemium plan is considered as an entry-level option for all customers. All the basic functionalities are accessed by the users. Revenue will be generated based on plan upgradation to higher tiers. The important thing of Freemium plan is conversion rate to higher plans.
- Premium:
  The premium plan will offer all the things included in the freemium and some enhanced features and capabilities other than the freemium plan.

- Platinum
  This is the last tier of our subscription plan, this tier is the most important as it will offer all the features of the system.

2.2.4 Financial Risks

2.2.4.1 Lack of Funds

The cost required in the development of the system may exceed the budget due to any reasons such as change in scope may lead to a financial crisis for the manufacturer of the product.

2.2.4.2 Reduced Market demand

This is somehow a low-level risk that the market demand may reduce due to a lack of awareness or strong competition between the existing devices.

2.3 Operational Feasibility

2.3.1 Operational Requirements

The operational requirements for the project include a dedicated room for the setup to be installed. The environment where the system is installed should be constrained. In the case of a single camera, the camera is set up facing the epileptic patient's bed so that it can easily monitor the activities of patients. But in case of multiple cameras installed in the house, they are set up in a way that they can be synchronized afterward.

The lightning conditions of the room should be maintained for the camera to capture the activities seamlessly without any interruption or blurriness. The room is organized in such a way that it is comfortable for the patients by all means. For better functioning and connectivity, a stable power and internet connection is required in the dedicated room.

2.3.2 Staff and skills

In order for the system to function properly, a properly trained team is required to set up the initial system in the room. A team with proper knowledge of camera installation, system configuration, and integration is required.

Once the initial setup has been done, then only a single caretaker is required to lookup the patient, basically, his 24/7 presence is not mandatory, when the system will detect the seizure it will generate an alarm that will send the notification to the caretaker so that he can come up and look over the patient.

2.3.3 Training

The user guide will be provided with the system to manage the software and hardware. Moreover, training will be given to the team responsible for the system installation.

A user guide will also be provided to the caretaker so that he can easily understand the system, know how to operate the system, and navigate through the web and desktop applications.

2.3.4 Data Security and Management

Data security is the major concern for the operability of the system in the environment. To address this concern, a consent form will be provided to the patient's caretaker so that we can assure the integrity and privacy of the data collected by epileptic patients. Moreover, when the data is collected, the first operation done on the data is de-identifying the faces of the patients so that their identity could be hidden in this way, the caretaker's trust is obtained and then we can process the data accordingly.

2.3.5 User Acceptance

The project is totally compatible with the daily environment of elderly people who are bearing seizures in this case. The system is much capable to protect the confidential and sensitive health data of the patient and also assure privacy. However, still, some elderly people may not like that they are being constantly monitored by a camera and they may find it uncomfortable. We can assure their privacy by blurring their face and we will use the type of cameras in which the body is not completely visible. So, we can say that makes our solution is operationally feasible and acceptable to our targeted customers.

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