IoT-Vision Enabled Assistance for Epileptic Patients

Project Proposal

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1 Introduction

1.1 Purpose

The purpose of this project is to provide better nursing care for elderly people bearing epilepsy so that they can live their life to the fullest and enjoy a happier life by not worrying about their epileptic condition. This will thus reduce the load on our nursing sector and improve the life of epileptic patients.

1.2 Intended Audience and Reading Suggestions

The intended audience are the elderly people bearing epilepsy who require assistance for their epileptic condition, caregivers who interact with the system which will help them in caring and it will ease their lives, and healthcare professionals to analyze the patient's data.

1.3 Product 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

in recognizing these patterns:

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

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

1.3.1 Objectives

1.3.1.1 *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 latest devices such as smartphones and laptops.

1.3.1.2 *Research Objectives*

The following research objectives will be achieved:

- To determine and analyze existing mechanisms/solutions for managing seizures in epileptic patients
- To examine the viability of using the 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.

1.3.1.3 *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.

1.3.2 Business Strategies

The business strategy is to market it and sell it on subscription-based packages. By using this approach, it provides advantages to both, our customers and business.

- Firstly, by using this subscription approach, we are able to offer a flexible and affordable way to access the system. We can limitize the system according to the specific needs of our customers and offer it at different prices based on the level of support and features they need
- Secondly, it generates a stream of revenue which helps in the ongoing development and continuous improvements of the system. This ensures that our system is up-to-date and compatible with the latest market trends and technologies.
- Thirdly, selling the system on a monthly/yearly subscription basis creates a long-term relationship with the customer and it also builds customer loyalty, which helps in expanding our business to new customers and retaining the existing ones.

To implement this approach, we provide our customers with an easy-to-use interface to manage all the subscriptions accordingly.

2 Overall Description

2.1 Product Perspective

The IoT-Vision enabled assistant for epileptic patients is a system that utilizes cameras for real time monitoring of activities and behavior of patients. By sending data to the cloud server where machine learning models do analysis, the system is able to accurately detect and prevent epileptic seizures with minimal delay. Over a period of time system establishes behavioral patterns that help in forecasting the seizures earlier which improves the accuracy of seizure detection and reducing false positive rates. Personalized model techniques are used to enhance the accuracy of seizure detection and improve the user's outcome with the epileptic disorder. The system has user-friendly and accessible mobile, desktop, and web applications that are used by patients and caregivers. These applications provide a high degree of flexibility and convenience to potential users. The system helps to provide round-the-clock safety and comfort and assistance when epileptic patients need it. Thus it reduces the burden on caretakers and nursing sector.

2.2 Product Functions

Product functions of IoT-Vision enabled Assistant for Epileptic Patients are:

- **Real-Time Monitoring:** System continuously monitors the patients using cameras and provides streaming to their caretakers.
- **Analysis:** System analyze the patient's activities and extract the behavioral patterns.
- **Seizure Detection:** System accurately detects seizures and prevent it with minimal delay possible.
- **Forecasting:** By doing analysis on pre and post-activities of epileptic having seizures, system extracts behavioral patterns which helps in forecasting the upcoming seizure.
- **Alarm Generation:** System generates alarm immediately based on seizure detection or observing any abnormal activities.
- **Nursing Record:** System manages the nursing records such as food, sleep and medicine routines which ultimately helps in understanding the living pattern of patients in detail.

2.3 User Classes and Characteristics

2.3.1 Caretaker

Caretakers are responsible to provide support and assistance to patients and are primary user of a system.

Characteristics:

- System should provide them with concise information to help them understand the patient's condition.
- System should be designed to be time-efficient and not require excessive effort on their part.

2.3.2 Medical Professional

Medical professionals are responsible for treating the patients condition and are secondary user of system.

Characteristics:

- System provide them with accurate and relevant data to assist in diagnosis and treatment.

2.3.3 Family Member

Family members are responsible to provide support in absence of caretaker and are tertiary user of system.

Characteristics:

- Monitor the patient health and respond to alarms generated by the system.
- View patient's nursing records which includes medication, sleep, and food routines.

2.4 Design and Implementation Constraints

2.4.1 Hardware Constraints

System must be able to operate with variety of hardware platforms such as camera. This system ensures that it is designed to meet hardware platform's maximum requirements.

2.4.2 Security Constraints

Patient's data is sensitive and needs to be private or secret so system ensures that data is kept secure by providing multiple security features such as encryption and authorization.

2.4.3 Performance Constraints

Cameras are capturing video round a clock so data is much bigger in size but system ensures that it handles data without compromising the performance.

2.4.4 Usability Constraints

System is intuitive, flexible, easy to use for all the targeted audience such as caretakers, doctors and family members.

2.4.5 Regulatory Constraints

The system is designed to compliant the regulatory requirements such as Health Insurance Portability and Accountability Act (HIPAA) and General Data Protection Regulation (GDPR).

2.5 User Documentation

2.5.1 User Manual

This document provides step by step guidance on how to use to use the system efficiently. This document includes detailed instructions and screenshots top help out the potenial users from installation of system to managing nursing record.

2.5.2 FAQs

Frequently Asked Questions (FAQs) provides answers about commonly asked questions which helps out in troubleshooting and frequently encountered problems.

2.6 Assumptions and Dependencies

Assumptions for IoT-Vision Enabled Assistant for epileptic patients are:

- Cameras are reliable and accurate.
- Internet connection is stable and reliable for data transmission to and from cloud server.
- Personalized model technique reduces the false positive rate and increases accuracy of seizure detection.

Dependencies of system are:

- Compatibility of hardware and software.
- Availability of internet.
- Availability of cloud server for data storage and analysis
- Accuracy and reliability of cameras

3 External Interface Requirements

3.1 User Interfaces

User interfaces are a critical component of the IoT-Vision enabled assistant for epileptic patients. System includes user-friendly, flexible and accessible mobile, desktop and web application that can be used by caretakers, doctors and family members to interact with system.

The web application is accessible from any web browser and it is designed to provide real time monitoring of patients. Caretaker can monitor his patients from anywhere. During monitoring, application generates alert in case of detection or forecasting of any abnormal activity or seizure. Web application provides comprehensive view of patient's data which includes activities logs, seizures history and nursing records. Nursing record involves sleep routine, medicines intake routine, food routine and vitals such as blood pressure, oxygen concentration and diabetes level. Nursing record is represented with info graphics for better visualization and understanding of patient's living style.

Desktop application is for windows and mac platforms and is used as an entry point of input video stream of patient captured through single or multiple cameras. Pre-processing of videos which includes extractions of facial expressions and de-identifying the patient's face is done on desktop application and then it gets transfer to cloud platform where machine learning models work on it to detect or forecast seizures.

Mobile application is available for both iOS and Android platform and is easy to use. It is used by family member, caretaker and doctor so they can receive alert in case of seizure detection or forecasting and can respond promptly. Mobile application also provides activity logs and nursing records so family members and doctors can keep check on their epileptic family member and patients respectively. All the user interfaces are highly flexible, easy to use, interactive and according to industry-standard design practices. We also gather feedback from users to improve user interfaces.

3.2 Software Interface

Software interfaces are essential aspect of system. System has to interact with multiple software interfaces which includes cloud servers and cameras. Firstly, system interacts with cloud server to store data for advance analysis on it. System uses HTTPS and RESTful APIs to communicate with server and exchange data in defined data formats. Secondly system interacts with camera devices through

standard camera APIs such as DirectShow, V4L or GStreamer to capture data and transmit to cloud server. Then system interact with database management system and machine learning models for final output in term of learning and detection or forecasting of seizures. So, system has various software interfaces to which it has to interact seamlessly.

4 System Features

4.1 Seizure Detection

The main feature of the system is to detect the seizure timely and accurately using the techniques of computer vision and the methods of machine learning. This feature is the most fundamental and critical because it saves from any serious injury and improve the health of elderly people bearing epilepsy.

4.2 Forecasting Using Behavioural Modeling

The system uses the technique of behavioral modeling to predict potential seizures beforehand and provide early warning to the caregiver. The system observes activities of daily living including abnormal activities and maintains nursing records such as medication routine, sleep routine, and food routine. By using this data, the system builds a predictive model that foresees the likelihood of seizure and generates the alert so that proper actions should be taken in order to bypass the seizure safely.

4.3 Real Time Monitoring

The system is capable to monitor the condition of elderly people in real-time and provide continuous support to the caregivers on their devices.

4.4 Alerts and Notifications

When a potential seizure is detected or forecasted by the system, an immediate alert and notification are sent to the patient's caregiver on their smartphones. This feature is most helpful as it provides timely intervention so that the patient can be saved from any accident and it reduces the risk of injury. This feature also provides peace of mind to the caretaker who are concerned about their patient's health.

4.5 User Friendly Interface

The system has an easy-to-use interface that provides all the functionalities to be executed easily. A person with little technical knowledge can also use the system in an efficient way.

5 Functional Requirements

The following are some functional requirements of the project:

5.1 User Login and Authentication

- System must provide login and authentication mechanism to its users to access data.
- User must be forced to choose a string password.
- User must have forget password or update password facility.
- For the case of forget password and update password, a confirmation mail must be sent to its inbox and user must need to click provided button for the sake of confirmation.

5.2 User Role Level Access

- System must be designed with different layers of data access according to the role of the user like doctor, caretaker, etc.
- Every stakeholder must be shown their respective screens that show their respective actions i.e. Caretakers can add and edit reports data of patients and doctors just view these reports.

5.3 User Interface and Experience

- Screens must be designed to make a user-friendly interface for the user.
- Clear navigations and labels must be used on the screen as different technology background users will use.
- Graphical way must be used to show the activity data of the patient.

5.4 Input and Output Requirement

- System must be designed to provide real-time monitoring through Camera.
- System should provide the interface for the caretaker to add reports and vital data of the patient.
- Abnormal activities of the patient must be notified to the caretaker through notifications or by an alarm system in the patient room.

5.5 Data Management

- System must follow the data management protocols that are accepted world-wide like General Data Protection Regulation (GDPR).
- Data must be encrypted before any transmission.
- Stored data in the database must be encrypted.
- Database must contain specific data for every patient like its daily monitored activities.

5.6 Functionality

- Every registered patient must be monitored through a camera 24/7.
- Camera monitoring must be sent to the local processing unit to detect activities through a lightweight model.
- If any abnormality is detected by the machine, the alarming or notifying module to the caretaker must be activated.
- Detected activities of the patient must be sent to the server in encrypted form.
- Then the Forecasting model on the server must process received activities to forecast future possible abnormal activities with time.
- System must inform the caretaker if any confident abnormality in the near future.
- Sysetm must provide the interface for forecasted future activities.

5.7 System integration

- System must be integrated if more than one camera is installed in the environment of the patient.
- Integrated system of the camera must act as a single monitoring system.
- Cameras must be integrated with the server with encryption decryption transmission protocols.

5.8 Compliance

- System must follow personal data protection guidelines provided by General Data Protection Regulation (GDPR).

5.9 Reporting and Analysis

- System must have a graphical interface to show the progress of patient with past and present data.
- Patient reports generated by the system must be in encrypted codes that provide information to the caretaker and doctor but are meaningless for any other person.

6 Other Nonfunctional Requirements

6.1 Performance Requirements

The following are some performance requirements for the project:

- System must have a camera resolution of 480p per frame and 30 frames per second.
- Camera should be fit to the roof and declined with 45 degrees. The camera must be at the place where all activities of the patient are covered.
- System must have a reliable internet connection with a bandwidth of 2 MBps.
- Server response time must be not more than 3000 milliseconds.
- System must provide real-time seizure detection with a maximum 2 to 5 seconds delay.
- System must store complete clinical data of the patient irrespective of time.
- System must be capable to forecast real abnormal activity of the patient after 5-day installation.
- System must provide real-time activities of the patient like today at this time patient did this.

6.2 Safety Requirements

The following are the safety requirements of the project:

- System must meet the safety requirements of the General Data Protection Regulation (GDPR) regardings patient data.
- System must be deployed in a manner that a complete electricity cut never happens. System must support continuous monitoring of patients.
- System must be designed to prevent data loss or data corruption.
- System must support reliable alarming mechanisms to notify caretaker on time.
- System should be capable to learn new behavioral patterns of the patient.
- System must provide real-time activity logs and live room camera view from a remote location to the authorized person.

6.3 Security Requirements

The following are the security requirements of the project:

- System must support strong user authentication mechanisms like string password, notifying on the same password, notifying to login to other devices, etc.
- System must support data protection protocols like encryption before transmission and data storage.
- System must provide access to data with respect to the role of the person. Caretakers have the access to enter and edit data and doctors have the access just to view the data.
- Reporting mechanism regarding patient disease must follow the rules of WHO (World Health Organization).

6.4 Software Quality Attributes

Following are some software quality attributes:

- System must provide the functionality of monitoring the patient in real-time with consistency and reliability.
- System must be easy and comfortable for the caretaker and other stakeholders to use.
- System must be usable for patients having different activities in daily living.
- System must be adaptive for the patient so that it could model the personal activities of the patient.
- System should learn abnormal activities of a particular patient during the first five-day installation with minimum false alarms.
- System must have secured data collection and storage setup and must follow secure and reliable protocols of encryption before data transmission.
- System must reach the accuracy threshold during day and night time before deployment in the patient environment.
- System must have the predefined behavior in unexpected circumstances like server down, internet connectivity issues, etc.

- System must be available to caretakers and doctors all the time with minimal downtime and interruption.