IoT-Vision Enabled Assistant For Epileptic Patients

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***Abstract* - Health facilities have increased life expectancy, a key factor for the growth of the population. World Health Organization (WHO) states around 50 million people with epilepsy live on the earth. Seizures are sudden and cause severe injuries if not managed. This forces the constant presence of a caretaker with the patient, causing an increase in burden on the nursing sector and caretakers of epileptic patients. This research aims to develop and implement an IoT-Vision Enabled Assistant to assist epileptic patients before and during seizure events. Seizures occur rarely compared to other activities of daily living. So, the seizure detection problem is treated as anomaly detection under the activity recognition domain. This handles the ictal stage of the seizure. For pre-ictal management forecasting algorithms are required. Every patient has their own habits and life patterns. So general forecasting is not applicable. The solution to this problem is personalization. Every patient is assigned a new model that trains on his/her activities resulting in personalized forecasting. This improves the accuracy and time horizon of forecasted activities. The caretaker could be notified when the patient faces a seizure or is near to face a seizure using activity and forecasting methodology. This improves life expectancy and makes them independent.**

Keywords *- Computer Vision, IoT, Seizure detection, Seizure forecasting, Epilepsy, Assistive Living*

I. INTRODUCTION

Epilepsy is a neurological disorder that causes recurrent, indefensible and unpredictable seizures. According to the World Health Organization (WHO) [7], epilepsy is the most prevalent neurological disorder that has affected approximately 50 million people worldwide. Around 80% of these individuals reside in low or middle-income countries where access to advanced medical assistance is often limited. The general proportion of active cases, which means people having continuous seizure attacks or need urgent treatment, is estimated to be between 4 to 10 individuals per 1000. Around 70% of people could be cured if they are properly treated.

It is estimated that 5 million people are diagnosed with epilepsy every year. In high-income countries, 49 per 100,000 people get positive for epilepsy each year. Pakistan [8] has 1.5% of its total population which is about 3.3 million people, bearing epilepsy. According to the research conducted by the National Library of Medicine [9], epilepsy has quite severe consequences including lifespan shortening, excessive body injury, psychological and psychiatric impairment, and social disability. These consequences separate the population of epilepsy from the rest of the world, emphasizing the urgency for improved healthcare solutions.
Meticulous approach of monitoring and timely intervention is required to manage the daily lives of elderly epileptic patients. In response to the critical need for enhanced assistance this research project proposes the development of an innovative solution which is “IoT Vision Enabled Assistance for Epileptic Patients”.

Existing solutions often fall short in providing real-time monitoring and personalized care tailored to the unique needs of elderly individuals. They are impractical and insufficient especially for elderly patients because they rely on manual monitoring of EEG signals and patients, and interventions. The existing gap in efficient, real-time monitoring, and personalized assistance which includes detection and forecasting of seizures for elderly epileptic patients necessitates the exploration of cutting-edge technologies. It is crucial to address this gap not only for the safety of the patients but also for providing caregivers with timely information and alerts to facilitate effective interventions.

Our proposed system aims to revolutionize epilepsy management by offering an integrated and intelligent assistance system through the usage of the Internet of Things (IoT), advanced computer vision and deep learning technologies. It acknowledges the limitations of existing technologies and uses an IoT-enabled system that provides real-time data streams from strategically placed cameras within the living space of the patient. These cameras, which are integrated with advanced computer vision and machine learning algorithms, enable continuous monitoring of activities that help in timely identification and forecasting of

seizures.It also provides personalized insights into the patient's daily activities and overall well-being.
It has potential to improve the quality of life for elderly epileptic patients and lessen the difficulties faced by their caretakers. A successful implementation of the proposed system helps to reduce the response time to seizures, improve patient safety, and provide caregivers with intelligent insights for better decision-making.

II. Literature REVIEW

Epilepsy is a widespread neurological disorder that researchers have extensively studied and researched in terms of its symptoms and preventive measures. According to the research in the past decade, it is analyzed that many studies have been published on detecting epilepsy using EEG(electroencephalogram) signal classification and sensor based methods. However, they all require some sort of device to be attached with the human body. Wearing a device on the human body is visible and looks intrusive and may disclose the conditions of the patients to others. Now there is a swing of research to video recording of patient through CV (Computer Vision). The major division for research on epilepsy is supervised and unsupervised learning. Major researches of both categories of the last 5 years are outlined below in the following section.

Ahmedt-Aristizabal et al. [1], developed approaches to automatically extract and classify semiological patterns from facial expressions, two deep learning models, landmark-based and region-based were used, to quantitatively identify changes in facial semiology in patients with mesial temporal lobe epilepsy (MTLE) from spontaneous expressions during phase I monitoring. They created custom dataset of about 55 video clips, 24 clips of seizures and 31 clips of non-seizure, using 16 patients.The models used are LSTM with accuracy 95.19 percent and face detector model with accuracy 92 percent. Better results were achieved using landmark-based approach. This approach works for ictal phase of seizure.
Sayeed et al. [2] in 2019 proposed an Edge-Device for Accurate Seizure Detection for Smart Healthcare. It works on Internet of Medical Things (IoMT)-based automated seizure detection system which will detect a seizure from electroencephalography (EEG) signals using a voltage level detector (VLD) and a signal rejection algorithm (SRA). The proposed system analyzes neural signals continuously and extracts the hyper-synchronous pulses for the detection of seizure onset. Within a time frame, if the number of pulses exceeds a predefined threshold value, a seizure is declared.. The sensitivity recorded was 96.9\% , specificity 97.5\%, with the latency of 3.6 sec. This approach also works for the ictal phase of the seizure.

Shamim Hussain et al.[3] 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 and this approach works for ictal phase of seizure.

Ahmedt-Aristizabal et al. [4] 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 [5] 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\%. They introduced a Transformer-based approach called Multi-channel Vision Transformer (MViT) for automated and simultaneous learning of the spatio-temporal-spectral features in multi-channel EEG data.This would work on Preictal and Ictal phase of seizures and its a wearable device.

In 2019 Choi et al. [6] presented a wearable device for Epileptic Seizure Forecasting using Generative Adversarial Networks. They used short-time Fourier transform on 28-s EEG windows as a pre-processing step. A generative adversarial network (GAN) is trained in an unsupervised manner where information of seizure onset is disregarded. The trained Discriminator of the GAN is then used as a feature extractor. Features generated by the feature extractor are classified by two fully-connected layers for the labeled EEG signals. This semi-supervised patient-specific seizure forecasting method achieves an out-of-sample testing area under the operating characteristic curve (AUC) of 77.68%, 75.47% and 65.05% for the CHB-MIT scalp EEG dataset, the Freiburg Hospital intracranial EEG dataset and the EPILEPSIAE dataset, respectively. 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.

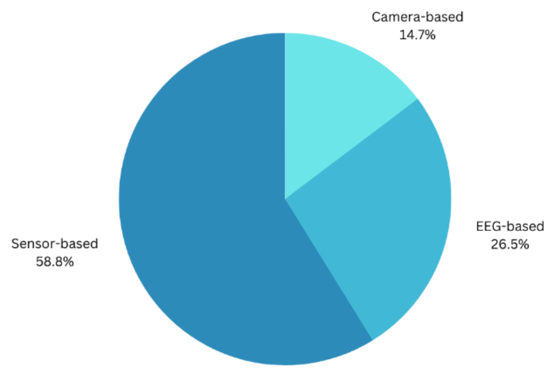

Figure 1: Ratio of available devices for epileptic seizure detection

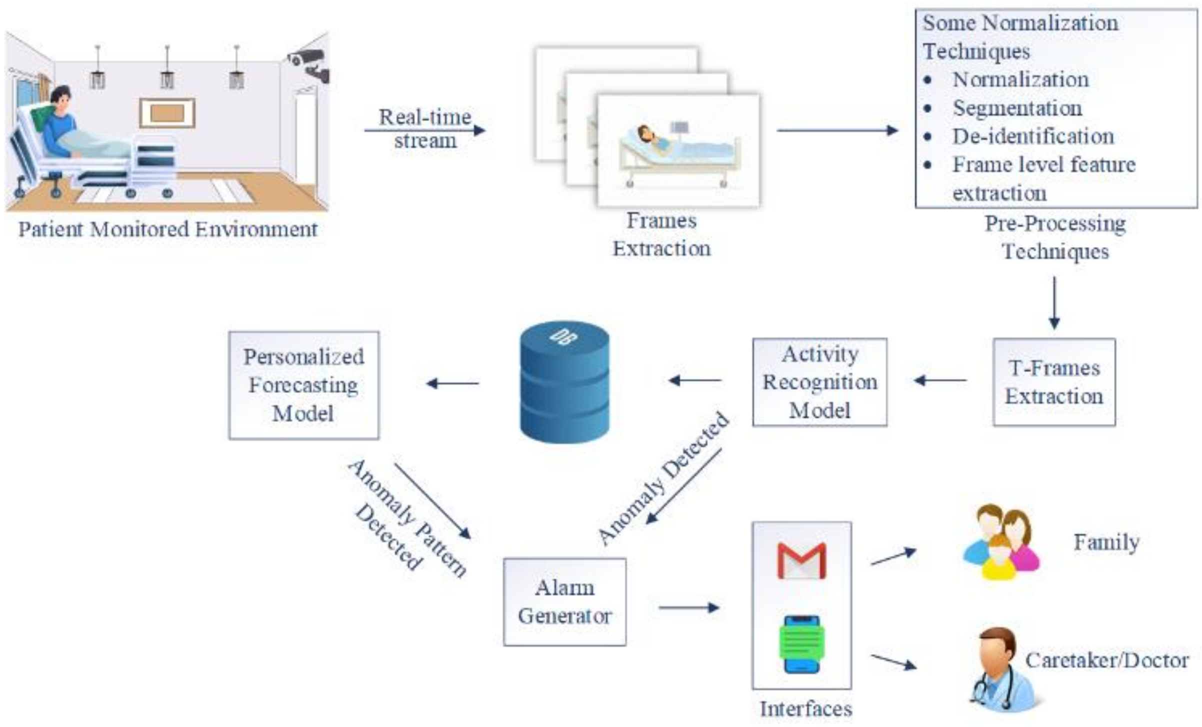

Figure 2: Methodology for Epilepsy Detection

III. METHODOLOGY

Epilepsy, a neurological disorder, presents a challenge for immediate care and post-seizure management. For elderly patients, a lack of post-seizure management may cause severe injuries or sudden death. Current solutions in the world often lack real-time monitoring and timely assistance for patients. This lack brings up a life risk and affects the privacy of patients in constant need of caretakers.

The methodology of this project aims to outline the approach in designing and implementing an IoT-Vision Enabled Assistant system for elderly epileptic patients during seizure and pre-seizure events. By integrating IoT technology with computer vision algorithms, this project aims to detect and respond to seizure (anomaly) events effectively. Seizure is treated as an activity for the patient. And activity logs monitored by the system can be used in forecasting techniques. These forecasting techniques will lead to pre-seizure events management. This whole methodology can be visualized through figure 2.

Every patient has its own way of living that defines his patterns and habits of life. So general forecasting for all patient is not applicable. Here the concept of personalization raises. Personalization allows to adopt patterns and habits of individual without considering their gender, age, religion or region, etc. This ensures the accuracy in future activity prediction that leads to effective pre-seizure management. Caretaker or family member can be notified with the current or near future activity of the patient.

A. *Implemented Method*

The implementation methodology elucidates the architectural blueprint that underpins the functionality and operations of the proposed assistant. The core components of the architecture are:

- Camera
- Personal Computer
- Server
- Database

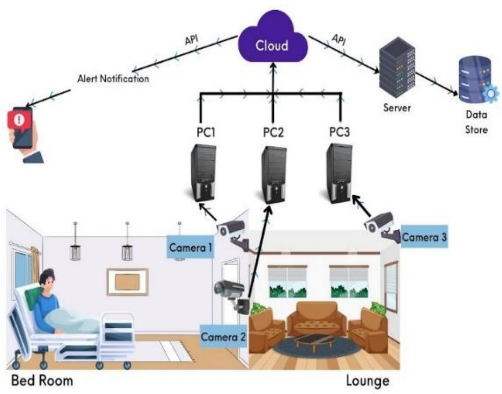

Figure 3: Implementation Architecture Diagram

Cameras act as an IoT device and tool for capturing real-time stream of the patient. Single patient can have more than one camera according to his/her need. These cameras send the real-time stream to personal computers attached with the cameras using internet connection. Every single camera is attached to separate computer. These personal computers have desktop application installed for analysis of the stream. Personal computers are supposed to be capable to run computer vision algorithms and models. The analysis includes all operations like frame extraction, normalization of frames, features extraction from frames, etc. After all pre-processing steps, specific frames or specific count of frame features are sent to activity recognition model. Model will evaluate features and output an activity label like patient x is doing activity and other details like this activity starts at a time a and ends at b time.

These results of the model are sent to server through API to store in database. These results are collectively called activity logs of the patient. Here come the forecasting techniques. Forecasting algorithm now uses these activity logs for future activity prediction. This future prediction is called forecasting of the activities. Forecasting results improves with the passage of time as patient spent more time under monitoring of the project. Forecasting model has more logs and more patterns of the patient to learn. This increases the correctness of the activity for the patient and time limit for future expected activity. As every patient is assigned with its own forecasting model for their personal activities, so that model is personalized to him/her.

Both stages of the patient during seizure and pre-seizure, pillars of the project, can be notified to caretaker and registered family member on the system. Activity recognition module can trigger an alarm or notification when caretaker specified activities like seizure or eat are detected. And forecasting module can trigger notification when patient pattern that leads to emergency situation are detected.

This methodology outlines a comprehensive architecture for the implementation of the IoT-Vision Enabled Assistant, highlighting the interplay between various components crucial for the accurate detection, forecasting, and support for epileptic patients during seizure events.

IV. CONCLUSION

By continuously monitoring the epileptic patients with a camera and sending the collected data to the cloud or server where it will be analyzed, this project is expected to produce an accurate IoT-Vision-enabled assistant that can detect seizures or predict its happening before it actually happens. This allows seizures, if they occur, to be detected and prevented. If the system notices any seizure activity or symptoms of a seizure, it will produce an alarm that will be sent to the patient’s caretaker, who will then respond by rescuing the patient. Moreover, the system will be capable of managing nursing records like sleep, food and medicines routines, and vitals which will help in extracting detailed patterns that trigger seizure. Our system will primarily use personalized model techniques, which will enhance the system’s prediction and accuracy, and lower false-positive responses. Abnormal physiological activities differ from person to person. The personalized model technique will be highly helpful since it will enable learning models to learn specific physiological symptoms of each individual patient, improving the user’s outcome with epileptic disease. The generated alarm will be sent to caretakers by an alert feature of the Web and Mobile application of our system. These applications will be handy, simple to use, interactive, and will give caretakers and guardians constant access to real-time patient monitoring. Our proposed solution will be cost-effective as it will lift the financial burden of guardians, which will ul- timately lead the epileptic patient living an independent, comfy and healthy life, as well as lessen the burden on caretakers.

V. AUTHOR CONTRIBUTIONS

All authors contributed to the study conception and design. Data collection, analysis, and experiments were performed by everyone equally.

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