AI-Driven Epilepsy Support: Patient Chatbots

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Abstract

Epilepsy is a chronic neurological disorder marked by recurrent and unpredictable seizures that significantly affect patients' quality of life. While EEG-based detection remains the clinical gold standard, emerging non-EEG wearable technologies and AI-based solutions offer more accessible and continuous monitoring alternatives. This paper presents an AI-powered chatbot based on a a hybrid AI architecture combining large language models with external knowledge retrieval, designed to deliver personalized and empathetic information to epilepsy patients and caregivers. By integrating large language models with curated medical knowledge, the chatbot promotes better patient education, supports medication adherence, and assists in lifestyle management. It thus complements traditional seizure detection methods and contributes to more comprehensive and patient-centered care.

1 Introduction

Epilepsy is a chronic neurological disorder characterized by recurrent seizures, affecting millions of individuals worldwide. Effective management involves not only accurate seizure detection but also the provision of clear, accessible information and ongoing support for patients.

While electroencephalography (EEG) remains the clinical gold standard for seizure monitoring, it is often impractical for continuous, everyday use outside medical settings. Recent advances in AI, including conversational agents, have introduced new possibilities for providing flexible, patient-centered support alongside traditional clinical management.

AI-powered chatbots can offer real-time, personalized education, medication reminders, and lifestyle guidance, empowering patients to better understand and manage their condition. This project introduces an AI chatbot specifically designed for individuals with epilepsy and their caregivers, aiming to enhance patient engagement and complement traditional clinical care through accessible and empathetic interaction.

2 Background: Understanding Seizures

2.1 What is a Seizure?

A seizure is a temporary neurological event characterized by signs and symptoms resulting from abnormal, excessive, or synchronous neuronal activity in the brain.

2.2 Types of Seizures

Seizures are typically classified into two major categories:

- **Generalized Seizures:** Generalized seizures involve simultaneous electrical disturbances across both cerebral hemispheres and present in various forms. Tonic-clonic seizures begin with sudden muscle stiffening, followed by rhythmic jerking. Tonic seizures involve only sustained muscle contraction, while clonic seizures are marked by repetitive jerks. Myoclonic seizures cause brief, shock-like muscle spasms. Absence seizures result in short lapses of awareness, often with a blank stare. Atonic seizures lead to sudden loss of muscle tone, frequently causing falls. These subtypes illustrate the diverse manifestations of generalized epilepsy, with implications for detection and personalized intervention.

- **Focal Seizures:** Focal seizures originate in a specific region of one cerebral hemisphere. When awareness is maintained, they are termed focal aware seizures; when consciousness is impaired, they are classified as focal impaired awareness seizures. These episodes may involve motor symptoms such as twitching, or non-motor manifestations including sensory disturbances, emotional changes, or cognitive alterations.

- **Focal to Bilateral Seizures:** Initially begin in one hemisphere and subsequently spread to both hemispheres, often evolving into generalized seizures.

2.3 Who Gets Seizures?

Seizures can affect individuals of all ages. Common risk factors include vascular events (e.g., stroke), infections (e.g., meningitis), exposure to toxins, structural brain abnormalities, metabolic imbalances, autoimmune disorders, idiopathic (unknown) causes, and psychological or physical stress.

3 Why Non-EEG Approaches for Seizure Detection?

Effective seizure detection is essential for individuals affected by this diverse neurological condition. While the electroencephalogram (EEG) has long been considered the gold standard, its practical limitations for continuous, real-life monitoring highlight the need for alternative solutions. Non-EEG methods leveraging various physiological and motion sensors combined with machine learning, deep learning, and AI offer compelling advantages. These benefits, spanning both user-centric and technological factors, are outlined below.

3.1 Human Factors (User-Centric Considerations)

- **Comfort and Usability:** EEG systems require scalp electrode placement, which is uncomfortable and impractical for daily or long-term use. Non-EEG solutions—such as smartwatches and wearable sensors—are lightweight, discreet, and non-intrusive, making them more suitable for continuous monitoring.

- **Social Acceptance and Privacy:** Wearing an EEG cap in public may lead to social stigma or discomfort. Non-EEG devices, such as wristbands or smartphone-based systems, are more socially acceptable and preserve user privacy.

- **Accessibility and Affordability:** EEG-based systems are expensive and require trained professionals for setup and interpretation. Non-EEG alternatives, including consumer wearables and ECG patches, are more affordable, widely available, and user-friendly without specialized training.

- **Continuous Monitoring in Daily Life:** Continuous EEG monitoring is challenging outside clinical settings. Non-EEG solutions enable 24/7 seizure detection at home or on the go, supporting long-term care and timely interventions.

- **Reduced Stress and Care Burden:** Non-EEG methods minimize the need for frequent hospital visits, reducing the emotional and logistical burden on both patients and caregivers. Remote monitoring also contributes to improved mental well-being.

3.2 Technological Factors (Sensor and AI-Driven Advantages)

- **Portability and Integration with Wearables:** EEG systems are typically restricted to clinical or laboratory environments. Non-EEG approaches integrate with portable, wearable, and IoT devices such as smartwatches and fitness trackers, enabling real-world monitoring.

- **Robustness to Motion Artifacts:** EEG signals are highly susceptible to motion artifacts. Non-EEG biosignals such as ECG, accelerometry, and PPG are more stable and reliable in daily-life scenarios.

- **Multimodal Sensor Fusion:** AI models can integrate data from multiple non-EEG sources (e.g., heart rate, electrodermal activity, movement) to enhance detection accuracy.

- **AI and Deep Learning Capabilities:** Deep learning algorithms can process real-time biosignals from non-EEG devices with high accuracy, tailored to individual patients.

- **Remote Monitoring and Telemedicine Integration:** Cloud-based AI systems enable real-time detection and instant alerts for caregivers and healthcare professionals.

4 AI Chatbot for Epilepsy Support

While non-EEG approaches and wearable devices have improved accessibility and comfort of seizure detection, there remains a critical need for continuous, personalized support and reliable information for individuals living with epilepsy. To address this gap, AI chatbots are emerging as valuable tools for patient education and daily assistance.

4.1 Retrieval-Augmented Generation (RAG) Chatbot Architecture

Our solution adopts a RAG architecture, strategically combining the generative capabilities of large language models (LLMs) with the precision of a domain-specific medical knowledge base. This hybrid setup enables the system to generate responses that are not only linguistically coherent but also grounded in validated medical content, thereby enhancing the reliability and contextual relevance of its outputs.

- **Data Processing Pipeline:** Medical texts, including clinical guidelines, peer-reviewed articles, and patient education materials, are subjected to a preprocessing workflow involving document parsing, segmentation into semantically coherent chunks, and transformation into high-dimensional vector embeddings suitable for efficient similarity search.
- **Vector Database Integration:** We utilize the Pinecone vector database in conjunction with the `all-mpnet-base-v2` sentence embedding model. This setup enables rapid retrieval of semantically relevant chunks in response to user queries, thereby enhancing the factual consistency of generated responses.
- **RAG Implementation:** The core generation engine is based on the Mistral-7B-Instruct-v0.3 model, which integrates retrieved context passages into its prompt space. This facilitates the generation of outputs that are both conversationally fluent and aligned with the retrieved medical evidence.
- **Web Interface:** The system is deployed through an interactive web platform that supports real-time dialogue, maintains contextual memory across turns, and adheres to accessibility and usability standards to ensure inclusivity.
- **Evaluation Framework:** To assess system performance, we employ a dual evaluation scheme: (1) automatic metrics such as BLEU and ROUGE to quantify linguistic fidelity, and (2) expert driven qualitative analysis to ensure clinical validity and informational integrity.

4.2 Development Methodology

- **Literature Review:** Compilation of peer-reviewed epilepsy research and clinical guidelines to ensure medical relevance and model alignment.
- **Iterative Model Refinement:** Prompt engineering and embedding evaluation were applied iteratively to improve contextual accuracy and reduce hallucinations.
- **Hyperparameter Tuning:** Key parameters (e.g., top-k, chunk size, temperature) were optimized to balance informativeness and reliability.
- **Clinical Validation:** Outputs were tested on real-world patient queries and reviewed by clinical experts to assess safety and accuracy.
- **User Experience Optimization:** Interface usability was refined through user testing, focusing on accessibility for both patients and caregivers.

4.3 Benefits and Impact

The RAG-based chatbot provides reliable access to up-to-date, evidence-based information on epilepsy and seizure management. It generates personalized and empathetic responses tailored to individual user needs, offering everyday assistance such as medication reminders, lifestyle recommendations, and guidance on device use. By supporting continuity of care beyond clinical settings, the chatbot significantly enhances patient autonomy and empowerment.

5 Conclusion

Epilepsy management is undergoing significant transformation through digital health technologies and intelligent systems. While EEG remains essential in clinical settings, non-EEG wearable solutions provide continuous, accessible monitoring that better suits patients' daily lives.

This paper has examined the rationale and benefits of non-EEG approaches and introduced an intelligent conversational agent designed to offer personalized support and information. These innovations pave the way for integrated, patient-centered care, enabling more proactive and comprehensive epilepsy management.