Mini Project Report On

Epileptic Seizure Detection from EEG Signals

Submitted in partial fulfillment of the requirements for the award of the degree of

Bachelor of Technology

in

Computer Science & Engineering

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CERTIFICATE

This is to certify that the mini project report entitled ***"Epileptic Seizure Detection from EEG Signals"*** *is a bonafide record of the work done by* ***Nandana S Pillai (U2103147)****,* ***Niyatha V S (U2103163)****,* ***Rose Jacob (U2103185)****,* ***Shreya Veeraraghav (U2103198)****, submitted to the APJ Abdul Kalam Technological University in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology (B. Tech.) in Computer Science and Engineering during the academic year 2023-2024.*

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Abstract

Epilepsy is a neurological disorder that affects children as well as adults. It is characterised by sudden recurrent epileptic seizures. This seizure disorder is basically a temporary, brief disturbance in the electrical activity of a set of brain cells. The excessive electrical activity inside the networks of neurons in the brain will cause epileptic seizures. These seizures can be detected by the use of EEG or ElectroEncepheloGram. Signals monitor the brain's electrical activity through the available 16 electrodes and 256 channels. EEG's high temporal resolution (in milliseconds) allows researchers to track real-time neural activity, proving invaluable in studying cognitive processes and neural dynamics. This allows us to study the dynamics of brain processes and how they relate to different stimuli and tasks. A lot of current neurotech initiatives try to use EEG data to capture user intention.

The EEG data helps in identifying the occurence of a seizure much before the visual changes that could be noticed in the patients. Normally an EEG recording could take upto 10 to 15 hours. Of this each minute can be divided in almost 256 sampling parts. Medical practitioners hence could find it time consuming to analyse this vast amount of data. Our aim is to aid them in identifying the important points in the EEG dataset while highlighting points where onset of seizure has been recognised. Our tool is not going to be a substitute for any medical practitioner rather focuses on helping in early detection hence decreasing the time consumed in this process. The aid identifies the pattern and marking the areas where unusual brain activity takes place.

Our project in epileptic seizure detection from EEG signals offers several key advantages over existing methods. First and foremost, it significantly enhances accuracy, ensuring precise identification of seizure events with greater reliability. This improvement in accuracy is complemented by higher efficiency, achieved through the utilization of advanced algorithms and techniques, resulting in faster processing of EEG signals and more

responsive seizure detection. Additionally, the adaptability of our framework allows it to accommodate variations in EEG signals across different individuals, making it suitable for a diverse range of patients in clinical settings. Lastly, our solution is designed for scalability, facilitating seamless integration with existing healthcare systems and enabling widespread adoption in hospitals and medical facilities.

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List of Abbreviations

Here are the full forms for the provided acronyms:

EEG - ElectroEncephaloGram

EDF - European Data Format

CSV - Comma Separated Values

GUI - Graphical User Interface

MNE - Minimum Norm Estimation

OS - Operating System

CNN - Convolutional Neural Network

HIPAA - Health Insurance Portability and Accountability Act

GDPR - General Data Protection Regulation

ML - Machine Learning

DL - Deep Learning

API - Application Programming Interface

FTT - Fast Fourier Transform

PyEEG - Python Electroencephalography

USB HID - Universal Serial Bus Human Interface Device

SSP - Signal Space Projection

REQ - Requirement

HTTPS - Hypertext Transfer Protocol Secure

Numpy - Numerical Python

Pandas - Python Data Analysis Library

Chapter 1

Introduction

1.1 Background

Epilepsy is a neurological disorder that affects children as well as adults. It is characterised by sudden recurrent epileptic seizures. The excessive electrical activity inside the networks of neurons in the brain will cause epileptic seizures. These seizures can be detected by the use of EEG or ElectroEncepheloGram. Signals monitor the brain's electrical activity through the available 16 electrodes and 256 channels. EEG's high temporal resolution (in milliseconds) allows researchers to track real-time neural activity, proving invaluable in studying cognitive processes and neural dynamics. This allows us to study the dynamics of brain processes and how they relate to different stimuli and tasks. A lot of current neurotech initiatives try to use EEG data to capture user intention.

The EEG data helps in identifying the occurence of a seizure much before the visual changes that could be noticed in the patients. Normally an EEG recording could take upto 10 to 15 hours. Of this each minute can be divided in almost 256 sampling parts. It is time consuming for the medical practitioners to manually traverse through this vast amount of EEG signals and then identify the onset of a seizure. Our aim is to aid them in identifying the important points in the EEG dataset while highlighting points where onset of seizure has been recognised. The aid identifies the pattern and marking the areas where unusual brain activity takes place. This involves dividing the EEG files into separate ictal as well preictal signal files. The relative power spectral density is then determined for both the ictal and preictal stages hence helping in understanding the variations that could suggest the onset of an epileptic seizure.

1.2 Problem Definition

Epileptic seizures are usually observed using the help of EEG signals. These EEG signals could include 10 - 15 hours of data. Each second is further divided into numerous parts based on the sampling rate of the dataset. Medical practitioners normally take huge amount of time to manually traverse through this vast amount of data and to detect the occurence of the seizure. Our aim is to aid them in identifying the onset of the epileptic seizures by identifying the important regions and points of variations in the EEG file.

1.3 Scope and Motivation

Scope:

The scope of seizure detection from EEG signals encompasses the development and implementation of algorithms and methodologies aimed at accurately identifying epileptic seizures from electroencephalogram (EEG) data. This includes preprocessing EEG signals to remove noise, extracting relevant features that characterize seizure activity, and utilizing machine learning or signal processing techniques for classification. Additionally, the scope may involve the design of real-time monitoring systems that can detect seizures promptly to provide timely medical intervention. Furthermore, the scope extends to the evaluation and validation of seizure detection methods using diverse datasets to ensure their reliability and generalizability across different patient populations and conditions.

Motivation:

The motivation behind seizure detection from EEG signals lies in the urgent need to improve the management and treatment of epilepsy, a neurological disorder characterized by recurrent seizures. Early and accurate detection of seizures is crucial for timely medical intervention, which can prevent potential injury and improve patient outcomes. By leveraging advances in computational techniques and signal processing, researchers aim to develop reliable and efficient seizure detection systems that can assist healthcare providers in diagnosing and treating epilepsy more effectively. Furthermore, such systems can enhance the quality of life for individuals with epilepsy by providing timely alerts and interventions, thereby reducing the burden of living with unpredictable seizure episodes.

1.4 Objectives

- To divide the given EEG file into separate ictal and preictal files.
- To identify features showing noticeable variations during ictal and preictal stages.
- To highlight the region of ictal period in the EEG files.

1.5 Challenges

The challenges in seizure detection from EEG signals include dealing with high-dimensional and noisy data, variability in seizure patterns across individuals, and the need for real-time processing capabilities. Additionally, ensuring robustness and generalizability of the detection algorithms across diverse patient populations and conditions poses a significant challenge.

1.6 Assumptions

- The assumption that EEG signals contain distinct patterns indicative of seizure activity.
- The assumption that preprocessing techniques can effectively mitigate noise and artifacts in EEG recordings.
- The assumption that the relative concentration of brain waves could vary with the physiology of each patient.

1.7 Societal / Industrial Relevance

The project holds significant societal relevance as it directly impacts the quality of life for individuals living with epilepsy. Accurate seizure detection systems can provide timely alerts and interventions, reducing the risk of injury and improving overall patient outcomes. Furthermore, in the industrial context, such systems can find applications in medical device development, healthcare monitoring solutions, and telemedicine platforms, catering to the growing demand for remote healthcare services and personalized medical interventions.

1.8 Organization of the Report

The report contains an introduction part, the Software Requirements Specification and the System Architecture and Design part. The introduction gives an idea about the background of the project.It defines the problem as well as the scope and motivation. The objectives, challenges, assumptions and societal/industrial relevance is explained here. The Software Requirements Specification provides an overall description, external interface requirements, system and other non functional requirements for the project. The last section explains the system overview and the architectural design containing the UML diagram and the Sequence diagram. The proposed methodology, user interface design, database design and module division are also explained in this section. The Gantt chart gives an overall idea about the time line of the work being done by the team.

Chapter 2

Software Requirements Specification

2.1 Introduction

2.1.1 Purpose

Epilepsy is a persistent neurological condition characterized by erratic signals from groups of neurons in the brain, leading to seizures. The primary objective of obtaining an Electroencephalogram (EEG) is to assess patients with known seizures, enabling an accurate diagnosis of seizure types and epilepsy syndromes. This diagnostic clarity facilitates targeted therapy. Additionally, EEGs are crucial for identifying unknown paroxysmal spells that may indicate seizures. However, analyzing the extensive 10 to 15 hours of EEG data is time-consuming. Our software tool streamlines this process for neurologists, assisting them in evaluating EEG data. Our self-contained product aids in identifying preictal, ictal, and interictal time frames associated with suspected seizures. With this idea about the time frames of the suspected epileptic activity, the frequency with which seizures are occuring in the patient can be determined hence helping the neurologists in understanding the severity of the disorder.

2.1.2 Product Scope

In the Electroencephalogram (EEG) procedure, electrodes, composed of small metal discs connected by thin wires, are applied to the scalp. These electrodes function as sensors, detecting minute electrical charges generated by the neural activity within the brain. The utility of EEG extends to the evaluation of patients exhibiting symptoms suggestive of seizures, epilepsy, and unusual spells, providing a comprehensive understanding of neurological functions. However, the current diagnostic approach entails a labor-intensive and time-consuming manual analysis of extensive long-term EEG signals by dedicated neurophysiologists. Taking into consideration this challenge, our software introduces an automated seizure detection system. By automating the seizure detection process, we mitigate the challenges associated with manual analysis, significantly improving operational efficiency. This system ensures seizure quantification, providing neurophysiologists with an objective basis for tailoring treatments.

2.2 Overall Description

2.2.1 Product Perspective

In order to detect seizures, neurologists need to examine an extensive amount of long-hours EEG signals through visual analysis, which is a time consuming process. Therefore, there is a need for a tool to help neurologists to efficiently pinpoint key moments of unusual brain activity.This software tool helps neurologists to analyze the EEG data obtained by placing electrodes on the scalp to monitor brain waves activity in the event of a seizure and before the seizure has occurred.This is a new self contained product that aims in aiding the doctors to identify the preictal, ictal and interictal time frames of a suspected epileptic activity that is occuring in the brain.

2.2.2 Product Functions

1. Authenticate users by verifying login credentials to ensure secure access to the EEG file upload functionality

2. Facilitate users in uploading EEG files, allowing them to securely transfer their data to the system for analysis.

3. Assist users in pinpointing seizure activity by implementing algorithms to highlight the ictal (seizure) and preictal (pre-seizure) stages within the EEG data.

4. Provide the user with the option to visualise the EDF graphs of selected electrodes.

5. Provide the functionality of visualising and highlighting a time frame.

6. Provides the functionality of letting the user add comments to the CSV file maintained for each patient and also retrieve the existing comments.

2.2.3 Operating Environment

The software being developed for seizure detection must be compatible with the hardware and software platforms commonly used in healthcare settings, which should include desktop computers, servers, etc. The application must also take into consideration the processing power and memory of the target system. The software should be designed to operate on operating system environments and related versions of Windows, Linux or macOS. Compatibility must be ensured with relevant third-party libraries or frameworks used for signal processing , machine learning and other components of seizure detection algorithms. Network protocols and requirements take into consideration both online and offline scenarios , and must be specified for ensuring compatibility with common networking standards. The application must comply with security protocols and standards that are relevant to healthcare for secure data transmissions.

2.2.4 Design and Implementation Constraints

The developers might face regulatory policy constraints from the healthcare system due to the need for protecting the privacy of the patients by following the HIPAA (Health Insurance Portability and Accountability Act) and other such regulations. The hardware limitations might include constraints with respect to memory constraints while processing and dealing with EEG data of high volume. This could lead to the need for efficient memory optimisation techniques that should be implemented. While integrating to external applications, care should be taken to ensure seamless integration as well as data transfer across the platforms while ensuring that proper data exchange protocols with other medical systems have been met. The developer has to take in consideration the processing capability and memory availability in the target environment which increases the complexity of the development process. The security considerations of the application requires the implementation of robust data encryption to ensure that there is no unauthorized access to the EEG files.

2.2.5 Assumptions and Dependencies

The developmental process assumes that the software will comply with relevant healthcare regulations such as HIPAA (Health Insurance Portability and Accountability Act) and GDPR (General Data Protection Regulation) . The process also assumes that the software will have access to accurate data of the patient. The software may need to integrate with other healthcare systems such as management systems for the laboratory. The project depends on third-party libraries and frameworks for data extraction and visualization and hence any changes or limitations in these frameworks could affect the software functionality. The software is developed for specified operating systems and platforms. The software may also rely on specific database systems for storing and managing data and therefore dependencies on these database systems must be addressed.

2.3 External Interface Requirements

2.3.1 User Interfaces

Raw EEG signal is non-stationary and has a low spatial resolution. EEG signals are susceptible and highly affected by artifacts and noise. Most of the practical applications of EEG are often needed for real-time signal processing to be robust to artifacts. Designing a user interface for EEG seizure detection using machine learning (ML) involves considering several important requirements to ensure usability, effectiveness, and efficiency.
Data Visualization

- Provide visualizations such as time-series plots, spectrograms to help in understanding brain activity.
- In GUI it highlights the inputted time frame with the colour of choice.
- A comment box is maintained for each patient which retrieves all previous comments as well add new comments with the current system date and time.

Error Messages

- Messages will be displayed in a clear and concise manner, indicating the nature of the error and possible solutions.
- Error messages will follow a consistent format and style across the platform.

2.3.2 Hardware Interfaces

The system uses open source dataset - CHB-MIT dataset that was collected at the Children's Hospital Boston, consisting of EEG recordings from pediatric subjects with intractable seizures.

2.3.3 Software Interfaces

Seizure detection systems employed machine learning techniques.
Operating System Compatibility:

- Windows 10 or 11

Software Dependencies:

- Python (version 3.7 or later) with necessary packages for data processing, machine learning, and visualization(e.g., NumPy, SciPy, Pandas, matplotlib).

Graphical user interface (GUI) framework:

- Python-based applications.

Machine learning framework:

- In conventional machine learning algorithms, most simulations were executed in the Matlab software environment, but the DL (Deep Learning) models are usually developed using Python programming language with numerous open-source toolboxes.
- PyTorch, TensorFlow and one of its high-level APIs, Keras, are widely used for epileptic seizure detection using DL in reviewed works due to their versatility and applicability.
- CNN (Convolutional Neural Network) is the widely used machine learning model for epileptic seizure detection.

Data Processing and Visualization Tools:

- Libraries for signal processing- e.g., FFT (Fast Fourier Transform), wavelet transforms.

- Python Libraries for EEG Image Analysis: Python offers a range of libraries commonly used for EEG image analysis. Three notable examples are MNE (Minimum Norm Estimation)-Python, PyEEG, and Brainstorm.

2.3.4 Communication Interfaces

The communication interface specification outlined below is crucial for establishing reliable communication between the EEG acquisition device and the software application. Data Acquisition Interface:

- Standard communication protocols such as USB HID (Human Interface Device) or Bluetooth SPP (Serial Port Profile), depending on the connectivity options supported by the EEG device.

Data Transmission Protocols:

- For USB connectivity, data will be transmitted using USB HID protocol, enabling communication from the device to the software application.
- For Bluetooth connectivity, data will be transmitted using Bluetooth SPP, providing a serial communication channel for transferring EEG data wirelessly.

2.4 System Features

2.4.1 User Authentication

Description and Priority

The application has a user authentication which verifies the identity of the user trying to access the system, account, or device. This is accomplished by verifying the password entered. This feature is of high priority. This protects the sensitive information from security breaches to ensure patient privacy.

Stimulus/Response Sequences

- The user enters username and password.
- On successful authentication, the system redirects the user to the page where the file can be uploaded.

- In the event of unsuccessful login, an error message of invalid credentials is displayed, and the user can try again.

Functional Requirements

REQ-1: The software should provide the user with a facility to enter their credentials.
REQ-2: In case of invalid authentication, the user must be notified about the error in the entered credentials, and enable them to try again minimum for a number of times.

2.4.2 File Upload Facility

Description and Priority

The software enables the user to upload EEG data files. The uploaded file is then converted into a .csv format. It is of high priority as the conversion of the file to csv format aids in its efficient usage for implementation of machine learning models.

Stimulus/Response Sequences

- The user uploads the EEG file in the given field.
- If the file is in the specified format, it is converted to .csv extension and the user is notified on successful conversion.
- If the file uploaded is not in a valid format, an error message is displayed to inform the user.
- After the conversion, the user must be redirected to the next page.

Functional Requirements

REQ-1: The software enables the user to upload the input data in a valid format.
REQ-2: The uploaded file must be converted to .csv extension.
REQ-3: If file is not uploaded in a valid format, an error message should be displayed to indicate the user of the invalid format.
REQ-4: The user must also be notified in case of a conversion failure.

2.4.3 Highlighting Channels under variation

Description and Priority

The channel values in the .csv file are analyzed through various techniques and those that indicate suspicious brain activity are highlighted. Features are extracted based on the patterns seen in the values to detect epileptic seizures. Power spectrum analysis is one of the standard methods used for quantification of the EEG signals. This feature is of high importance since it aids the medical practitioner to pinpoint those areas of the brain where there is a change.

Stimulus/Response Sequences

- After conversion to the csv file, the user can view the channels showing variation.
- The areas where there is a change are highlighted in the csv file.

Functional Requirements

REQ-1: The software should perform necessary analysis of the EEG to highlight areas of suspected seizure activity.
REQ-2: Quantification of the EEG signals must be done through power spectrum analysis.

2.4.4 Returning the Time-Frame of the suspected epileptic activity

Description and Priority

The files in .csv format are scrutinized channel-by-channel to identify the focal or generalized epileptic activity that is occurring. This is done by traversing the time frames and dividing the file into preictal, ictal and interictal periods. This is of high priority as it helps in pinpointing the onset of the epileptic seizure.

Stimulus/Response Sequences

- After pinpointing the preictal period, the software returns the value of the time frame of the onset of the seizure.

Functional Requirements

REQ-1: The software should perform necessary analysis of the EEG to highlight areas of suspected seizure activity.
REQ-2: The time frame must be displayed by the system.

2.5 Other Nonfunctional Requirements

2.5.1 Performance Requirements

The software must respond to user interactions within a period of 5 to 10 seconds. It should also perform well under varying workloads , increased user interactions which could include high volumes of data, multiple users and other performance degrading factors. The main rationale behind these performance requirements is the fact that seizure detections systems from EEG signals must be accurate for critical medical interventions. It is also crucial to detect and respond to seizures within a certain timeframe. The different features or functions of the software have different performance requirements with regards to the speed at which the system responds in response to the inputs made by the user.

2.5.2 Safety Requirements

The system must prioritize user safety and implement mechanisms to minimize false positives and false negatives to ensure that unnecessary alarms or interventions are not made. Proper warning systems must be defined in the event of a seizure being detected. Recovery systems in the case of failure of the software must be implemented. The software must comply with relevant healthcare regulations and standards.

2.5.3 Security Requirements

The system must implement strong encryption mechanisms to ensure confidentiality and to prevent unauthorized access. This must include protecting the sensitive information from security breaches to ensure patient privacy. The system must adhere to relevant data protection regulations and medical industry standards such as HIPAA (Health Insurance Portability and Accountability Act) and GDPR (General Data Protection Regulation) .

The system must be under strict access control allowing access to authorized persons only. Integrity checks for EEG data to detect and prevent unauthorized modifications must be implemented. Secure communication protocols such as HTTPS (Hypertext Transfer Protocol Secure) must be used to transmit data between the system components and external entities.

2.5.4 Software Quality Attributes

The software must achieve a minimum accuracy in detecting the seizures by analyzing the EEG data. False positive and False Negative rates must be minimized. This can ensure that software minimizes the risk of mis-diagnosis or missed seizures. The mean time between failures must be low with a low average recovery time. This ensures the high reliability of the system. The system must handle unexpected crashes and erroneous behavior. The system must be user-friendly, easily accessible and understandable. It should be designed with well documented code for easy updations and maintainability of the software. The system will be designed with in-built testing capabilities such as unit tests and integration tests. Testability verifies the correctness and reliability of the software.

Chapter 3

System Architecture and Design

3.1 System Overview

The project aims at developing a comprehensive system for analyzing EEG (Electroencephalography) data to identify seizure events and extract relevant features for further analysis. The system is designed to handle EEG recordings stored in EDF (European Data Format) and CSV (Comma-Separated Values) formats, providing a user-friendly interface for visualization and analysis.

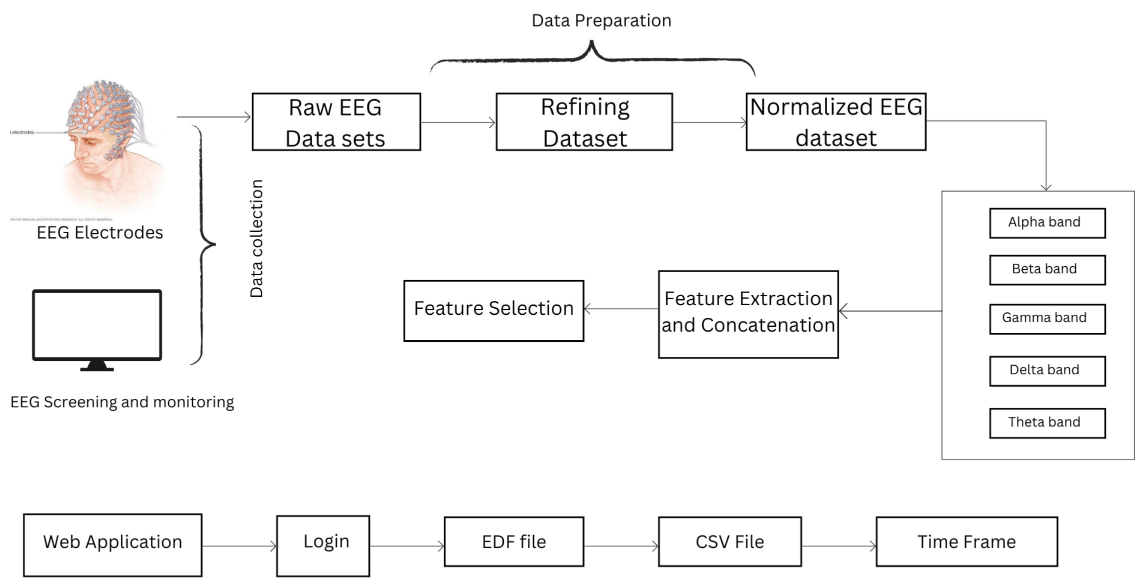


Figure 3.1: System Architecture Diagram

The primary objective of the project is to develop a robust system capable of processing large volumes of EEG data efficiently. The project makes use of a dataset comprising of EEG recordings that are grouped into 23 cases obtained from 22 subjects from the

Children's Hospital, Boston. Key goals of the project include:
(i) Conversion of EDF files to CSV format
(ii) Seizure event detection
(iii) Feature extraction
(iv) Visualization and analysis
(v) Performance evaluation

The GUI focuses on providing a user-friendly interface for visualizing the written data and analyzing them easily with robust error handling and a modular structure for maintainability and extensibility. It consists of different parts:
(i) Login
First the login credentials are given. These credentials are cross-checked with the database consisting of passwords and usernames. If it is matched, the user is directed from the login page to the file upload window.
(ii) File upload
The file in EDF or CSV format is uploaded. If it is of EDF format, then each channel can be visualized in the form of graphs. Additionally, the EDF files can be converted to CSV format, and the CSV file can be visualized in the form of graphs by giving the start time, end time and the sampling frequency as inputs. If the input file is of CSV format, then the file can be directly visualized without the conversion.

Subsequently, the CSV data files are separated into ictal and preictal periods as different files for each seizure, by the backend module. This is achieved by the execution of Python scripts on the uploaded or converted CSV file. After the preictal and ictal data files have been extracted, the relative power of the brain waves are computed. The Welch Method for Power Spectral Density is used for the relative power calculation. The values of relative power during the ictal and the preictal periods for each of the brain waves(alpha, beta, theta, delta & gamma) are analyzed to determine and understand the variations occurring. These variations are highlighted in the graph when the CSV data files are visualized in the GUI, to indicate possibilities of unusual activity in those areas of the brain.

3.2 Architectural Design

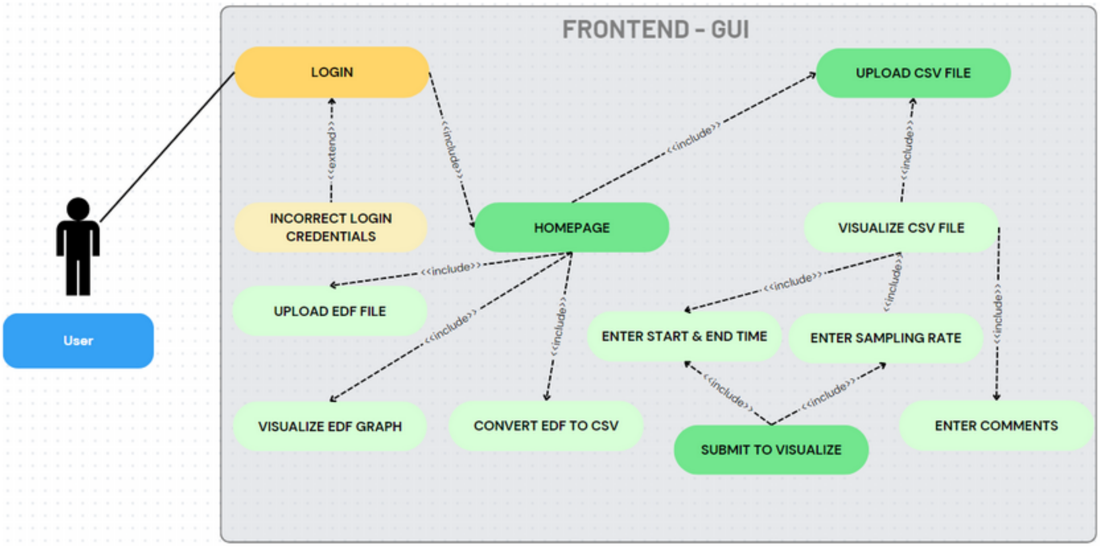


Figure 3.2: Use Case Diagram

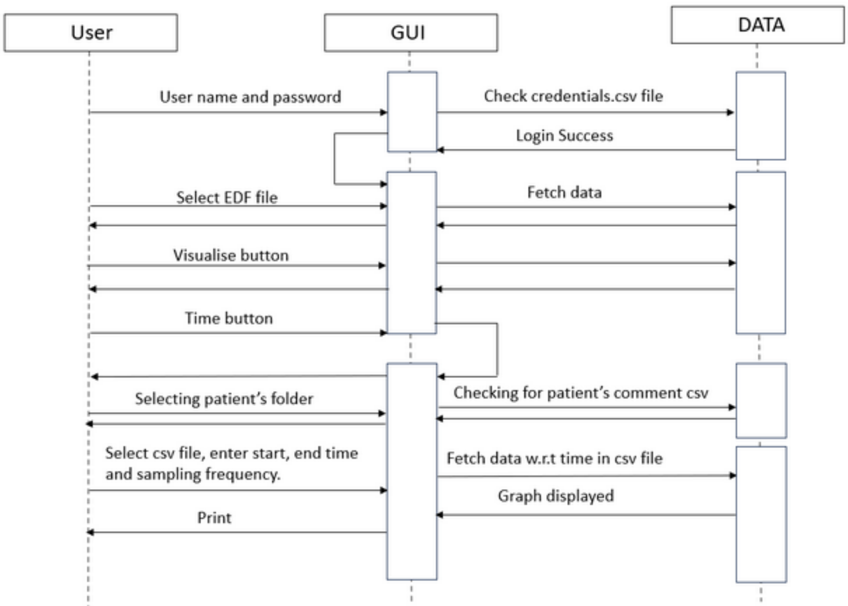


Figure 3.3: Sequence Diagram

3.3 Dataset identified

The project utilizes the CHB-MIT dataset collected from the Children's Hospital at Boston, consisting of EEG recordings from pediatric subjects with intractable seizures. The EEG recordings, grouped into 23 cases(chb01, chb02,..chb23), were collected from 22 subjects (5 males, ages 3–22; and 17 females, ages 1.5–19), where one of the patients has 2 recordings that were taken 1.5 years apart (Case chb21 was obtained 1.5 years later after case chb01 from the same female subject) . The .edf files contain exactly one hour of digitized EEG signals for most of the cases, although those belonging to case chb10 are two hours long, and those belonging to cases chb04, chb06, chb07, chb09, and chb23 are four hours long. Due to hardware limitations, the recordings resulted in gaps between consecutively numbered .edf files, during which no signals were recorded. The sampling rate of the signals is 256 Hz (ie. 256 samples per second). Most of the cases contain 23 EEG channels, where an EEG channel is formed by taking the difference between potentials measured at two electrodes (bi-polar montage). The International 10-20 system of EEG electrode positions and nomenclature was used for these recordings. The mentioned dataset can be downloaded from : https://physionet.org/content/chbmit/1.0.0/

3.4 Proposed Methodology/Algorithms

The project involves algorithms for: (i) conversion of EDF files to CSV files, (ii) extraction of ictal and preictal data from the CSV files for each of the cases, (iii) computing the relative power of the various brain waves (alpha, beta, gamma, delta and theta) for ictal and preictal data for all the cases using the Welch Method.

ALGORITHM: EXTRACTION OF DATA DURING ICTAL PERIODS

STEP 1: Start

STEP 2: Import the Python modules - os and pandas.

STEP 3: Define the folder path containing the CSV files for the case

STEP 4: Define file_list as a list of dictionaries containing file names along with the respective seizure window information (i.e., the seizure start time and seizure end time)

STEP 5: Repeat steps 5.1 to 5.7 for each file name in the file_list

STEP 5.1: Define the path of the output CSV file for each seizure occurring.

STEP 5.2: Construct the full file path for the input CSV file.

STEP 5.3: Read the CSV file pointed to by the file path into a pandas DataFrame.

STEP 5.4: Assign the corresponding start time & end time of the current file name to variables "start_time" and "end_time" respectively (i.e., select the ictal time window in seconds).

STEP 5.5: Create a boolean mask (time_stamps) such that each value in the 'time' column of the DataFrame (df) should be greater than or equal to start_time and less than or equal to end_time.

STEP 5.6: Use the boolean mask to filter the rows within the seizure window and store in a DataFrame df_windowed.

STEP 5.7: Write the filtered rows to the output CSV file using the function df_windowed.to_csv() to the same folder path.

STEP 6: Stop

ALGORITHM: EXTRACTION OF DATA DURING PREICTAL PERIODS

STEP 1: Start

STEP 2: Import the Python modules - `os` and `pandas`

STEP 3: Define the folder path containing the CSV files for the case.

STEP 4: Define `file_list` as a list of dictionaries containing file names along with the respective seizure window information.

STEP 5: Repeat steps 5.1 to 5.14 for each file name in the `file_list`

STEP 5.1: Access the `file_name` and `start` keys from the current dictionary in `file_list`.

STEP 5.2: Update the count of occurrences for the current file name in the `file_counts` dictionary.

STEP 5.3: Define the output file paths for three frames of the preictal window.

STEP 5.4: Construct the full file path for the input CSV file.

STEP 5.5: Read the CSV file pointed to by the file path into a pandas DataFrame `df`.

STEP 5.6: Convert the `time` column to numeric values using `pd.to_numeric()`.

STEP 5.7: Calculate the `gap_start_time` as `start_time` minus 10 seconds.

STEP 5.8: Calculate the `frame1_start_time` as `gap_start_time` minus 10 seconds.

STEP 5.9: Calculate the `frame2_start_time` as `frame1_start_time` minus 10 seconds.

STEP 5.10: Calculate the `frame3_start_time` as `frame2_start_time` minus 10 seconds.

STEP 5.11: Filter data for each frame based on the calculated start times and the `gap_start_time`.

STEP 5.12: Save each frame to a separate CSV file using the `to_csv()` function.

STEP 5.13: Print the status of each frame written to the CSV files.

STEP 5.14: Print the completion message for the current file processing.

STEP 6: Stop

ALGORITHM: CALCULATION OF RELATIVE POWER USING THE WELCH METHOD

STEP 1: Start

STEP 2: Import the Python libraries csv, welch from scipy.signal, and datetime.

STEP 3: Define the function calculate_relative_band_power, with parameters:

STEP 3.1: Initialize the variables - total_power to 0, band_power to 0, signal to an empty list, start_time, end_time to the seizure start time and end time of the seizure for which the relative power is to be calculated.

STEP 3.2: Repeat steps 3.2.1 to 3.2.4 for each row in data (the dictionary list).

STEP 3.2.1: Extract the current timestamp from the row into variable current_time.

STEP 3.2.2: Check whether current_time is within the window time frame defined by the start_time and end_time.

STEP 3.2.2.1: Convert the signal value to float and append it to the signal list.

STEP 3.2.3: If the signal data is available then, STEP 3.2.3.1: Apply Welch's method to estimate the Power Spectral Density (relative power) of the signal within the specified frequency range.

STEP 3.2.3.2: Calculate band_power and total_power by integrating the PSD value of the signals.

STEP 3.2.3.3: Calculate relative power as the ratio of the band_power to total_power.

STEP 3.2.3.4: Return the value of relative power.

STEP 3.2.4: Otherwise, if signal is not available, then

STEP 3.2.4.1: Return None to indicate that there is no data within the seizure period for this electrode.

STEP 4: Define the main function

STEP 4.1: Define the path to the EEG data files directory.

STEP 4.2: Open and process the file containing the seizure period.

STEP 4.3: Extract the column names except the column named 'time' into a list electrode_columns, which represents the electrodes in the file.

STEP 4.4: Define the frequency range of the interested brain wave.

STEP 4.5: Repeat steps for each column in electrode_columns.

STEP 4.5.1: Calculate the relative power for the brain wave using the function - calculate_relative_band_power.

STEP 4.5.2: Print the calculated relative power.

STEP 5: Execute the main function

STEP 6: Stop

ALGORITHM: CONVERSION FROM .EDF TO .CSV FORMAT

STEP 1: Start

STEP 2: Import the module os, Python libraries mne and pandas (aliasing it as pd).

STEP 3: Function convert_edf_to_csv is defined with 2 parameters: edf_folder and csv_folder.

STEP 3.1: If csv_folder directory does not exist then, STEP 3.1.1: New directory using os.makedirs(csv_folder) is created.

STEP 4: Create a list of edf files in the specified edf_folder that end with '.edf' or '.edf.seizures' and store it in edf_files.

STEP 5: Repeat the steps to iterate through each edf file in edf_files.

STEP 5.1: The filename (edf_file) is split into its base name (base) and extension (ext)

STEP 5.2: If the extension is of '.seizures' format then,

STEP 5.2.1: Modify the csv_file name by removing the last 4 characters ('.edf') from base, add -1, and append '.csv'.

STEP 5.3: Otherwise

STEP 5.3.1: Set csv_file to base by appending '.csv'.

STEP 5.4: Display name of the csv file that will be created from the current edf file.

STEP 5.5: Try:

STEP 5.5.1: if the current file is a standard edf file then,

STEP 5.5.1.1: The edf file is read using mne-Python's read_raw_edf function and stores the data in raw.

STEP 5.5.2: Convert the EEG data (raw) to a pandas DataFrame (df) using mne-Python's to_data_frame method.

STEP 5.5.3: Save the DataFrame (df) as a csv file in the csv_folder.

STEP 5.5.4: Display a message indicating that the conversion from edf to csv is successful.

STEP 5.6: Except:

STEP 5.6.1: Display an error message if there is an exception during the conversion process, including the specific error (e) that occurs.

STEP 6: The edf_folder and csv_folder variables are defined with the paths to the edf files and the destination folder for the csv files.

STEP 7: The convert_edf_to_csv function is then called with these parameters to perform the conversion.

STEP 8: Stop

3.5 User Interface Design

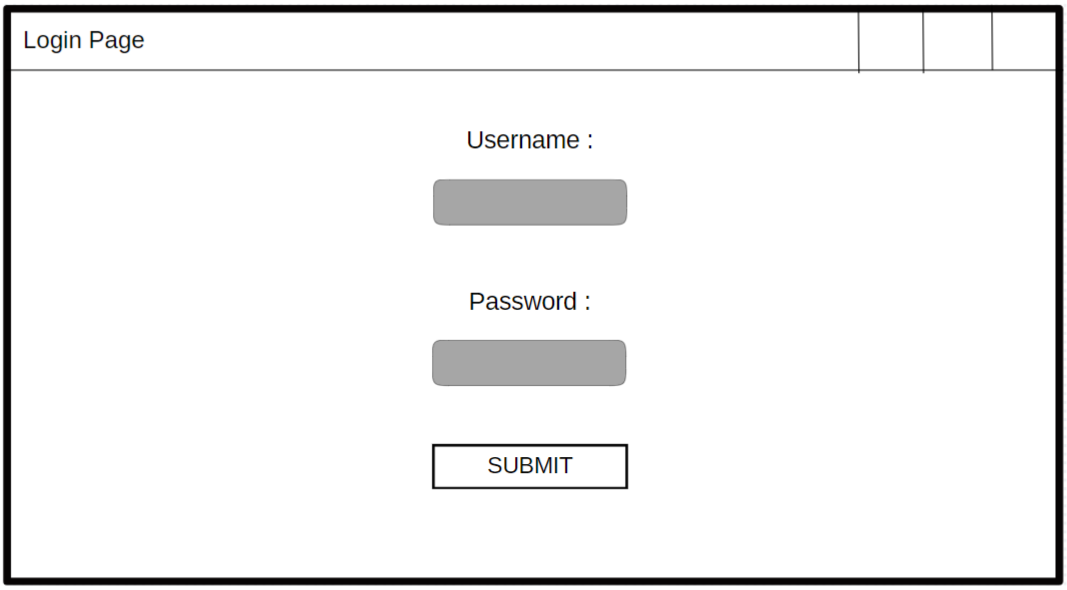


Figure 3.4: Login Window UI Design

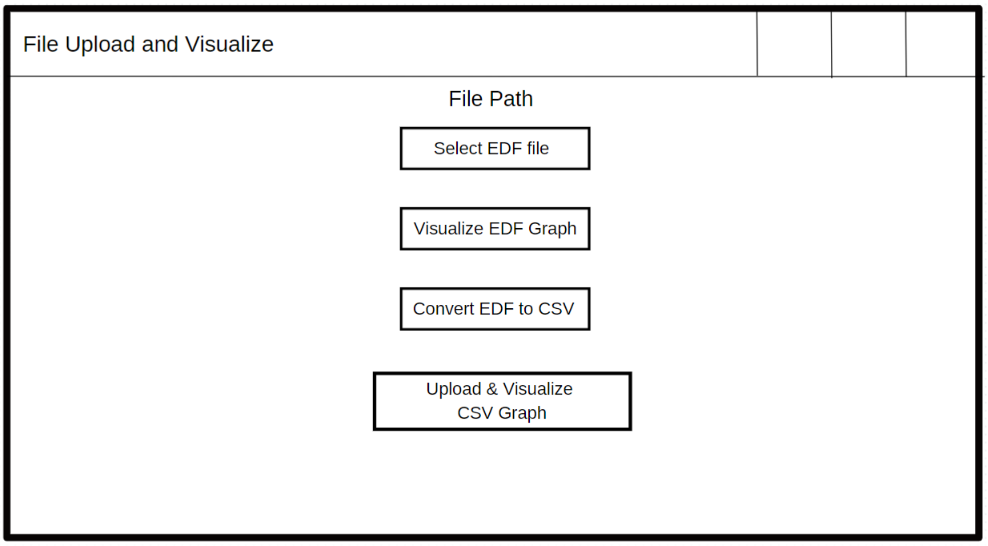


Figure 3.5: File Upload Window UI Design

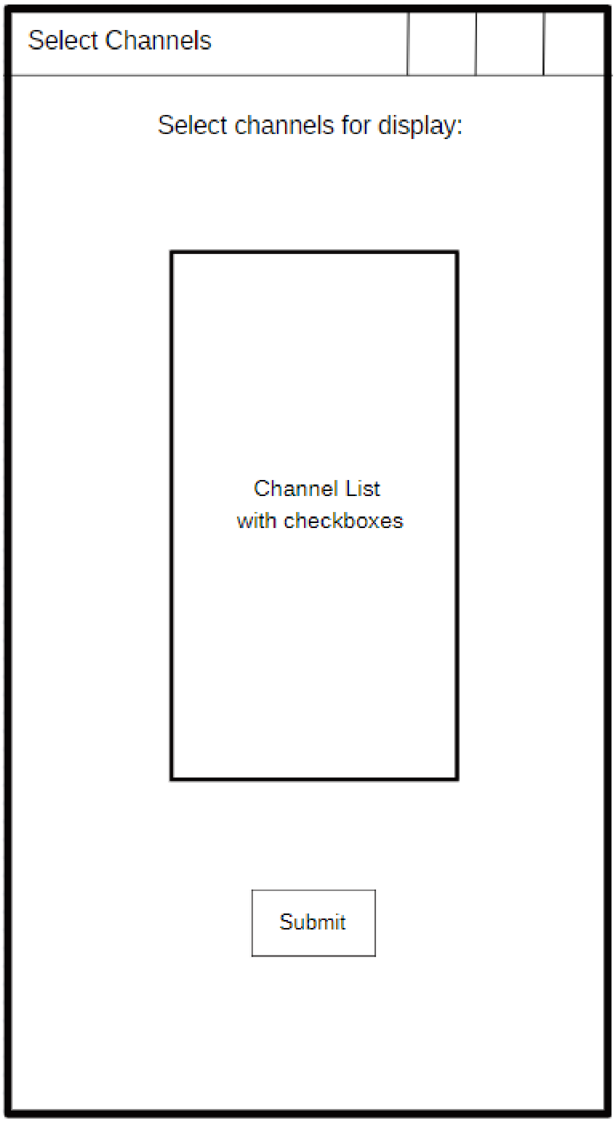


Figure 3.6: Channel Selection Window UI Design

Figure 3.7: EEG Data Visualizer Window UI Design

3.6 Database Design

A database is used in this project to store the credentials of the authenticated users who are permitted to login to the EDF Visualizer App. Only those users who have their usernames and passwords stored in the database can login successfully in the GUI. In the case of an unsuccessful login due to a mismatch between the entered details and the stored credentials, an error is reported to the user. The project's database usage is limited to storing login credentials and does not extend to other functionalities or purposes.

3.7 Description of Implementation Strategies

The frontend of the project is Graphical User Interface (GUI) designed using the Python programming language.
The various libraries and modules used in the development of the GUI are:

- tkinter : used for the construction of the GUI
- csv : used for reading and writing csv files
- os : utilized for Operating System related functionalities

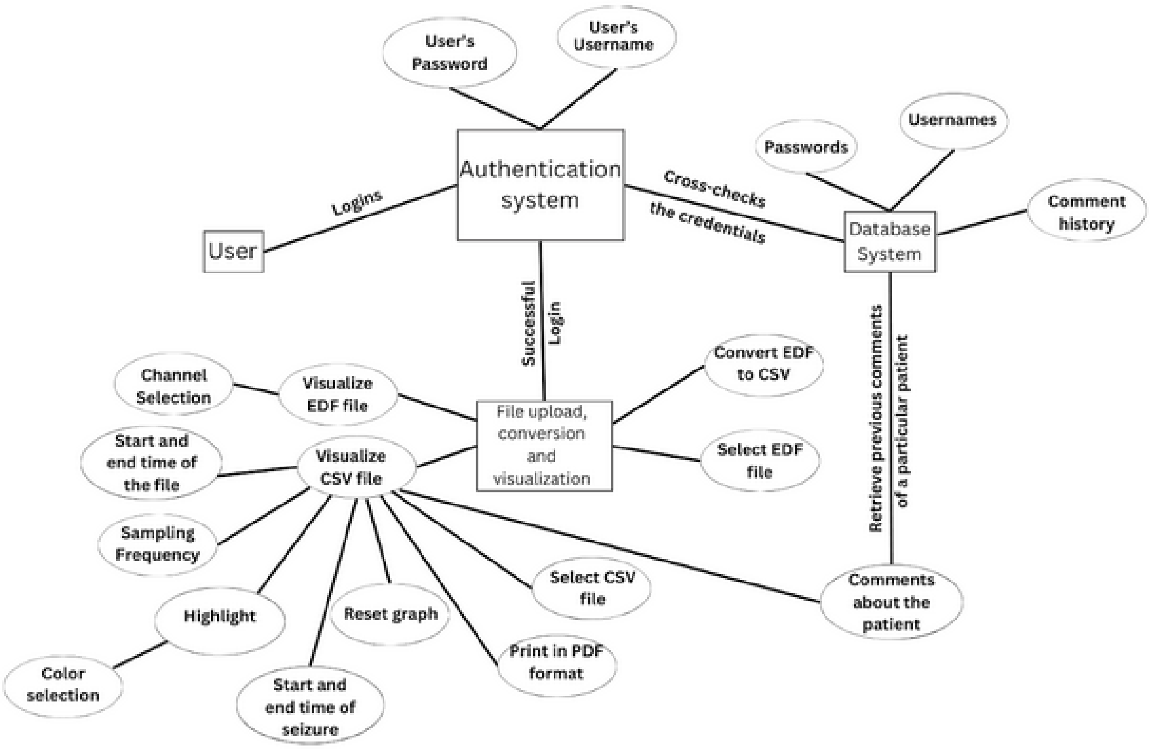


Figure 3.8: ER Diagram

- matplotlib.pyplot : used for plotting graphs
- mne : used for the processing, analysis and visualisation of EEG data
- matplotlib.backends.backend_tkagg.FigureCanvasTkAgg : used to integrate matplotlib plots and figures into tkinter
- filedialog, ,messagebox, ttk : are specific modules from tkinter for file dialogs, message boxes and themed widgets.

The specific classes used in the implementation of the GUI are:

- LoginPage class :

  It initializes the login page which validates the login credentials. On successful login, it redirects the user to the EDF Visualizer App.

- EDFVisualizerApp class:

  This class initializes the EDF visualizer. It opens a file dialog to select an EDF file. The selected EDF file is then converted to CSV format. The selected EDF file's data can be visualozed as a line grpah and also provides a facility to the user to select the specific EEG channels to be displayed. The line grpah is plotted based on the selected channels from the EDF file. In the event where a CSV file is uploaded, the user is directed to the 'EEG Data Visualizer'.

- EEGDataVisualizer class :

  This class initializes the 'EEG Data Visualizer'. A file dialog box is provided to select a CSV file. It parses the time string in the format - 'hh:mm:ss' , to seconds and results in the visualization of the data in the uploaded CSV file.

3.8 Module Division

The project is divided into two main modules: the frontend GUI and the backend.
In the front end, Python along with various libraries is utilized to craft a user-friendly interface for visualizing EEG data stored in EDF and CSV formats. The login process involves retrieving and validating user credentials from a CSV file.Once successfully logged in, users are presented with a GUI for EDF file selection, offering four main functionalities: selecting an EDF file, visualizing EDF graphs, converting EDF files to CSV format, and accessing specific time segments within the EDF files. Upon clicking the "Select EDF file" button, users can choose the desired EDF file. Subsequently, clicking on the "Visualize EDF graph" button opens another GUI featuring checkboxes corresponding to each channel, allowing users to select individual channels for graph visualization. Similarly, clicking on the "Convert EDF to CSV" button initiates the conversion process, generating a CSV file from the selected EDF data.
Lastly, the "Access Time Segments" button leads users to a separate GUI where they can select a CSV file, specify start and end times, and set the sampling frequency to visualize specific time segments of the EEG data, enhancing the overall usability and functionality of the EEG data analysis tool.
The backend module is responsible for processing the seizure dataset. The initial EEG data stored in the EDF format, is transformed into CSV format using Python scripts. Subsequently, the backend module extracts data corresponding to seizure periods (ictal time frames) into individual CSV output files for each seizure for all the cases. Similarly, data during preictal periods for each patient is isolated into separate output files for each

seizure. Both of these tasks involve executing Python scripts on the CSV files obtained after the EDF-to-CSV conversion. After the data has been separated into preictal and ictal data files, the relative power of the brain waves (alpha, beta, theta, delta, gamma) are computed for each patient. The relative power calculation is performed using the Welch Method for Power Spectral Density.

The frontend module is designed and developed by Nandana S Pillai and Rose Jacob, while the backend module is managed by Niyatha V S and Shreya Veeraraghav.

3.9 Work Schedule - Gantt Chart

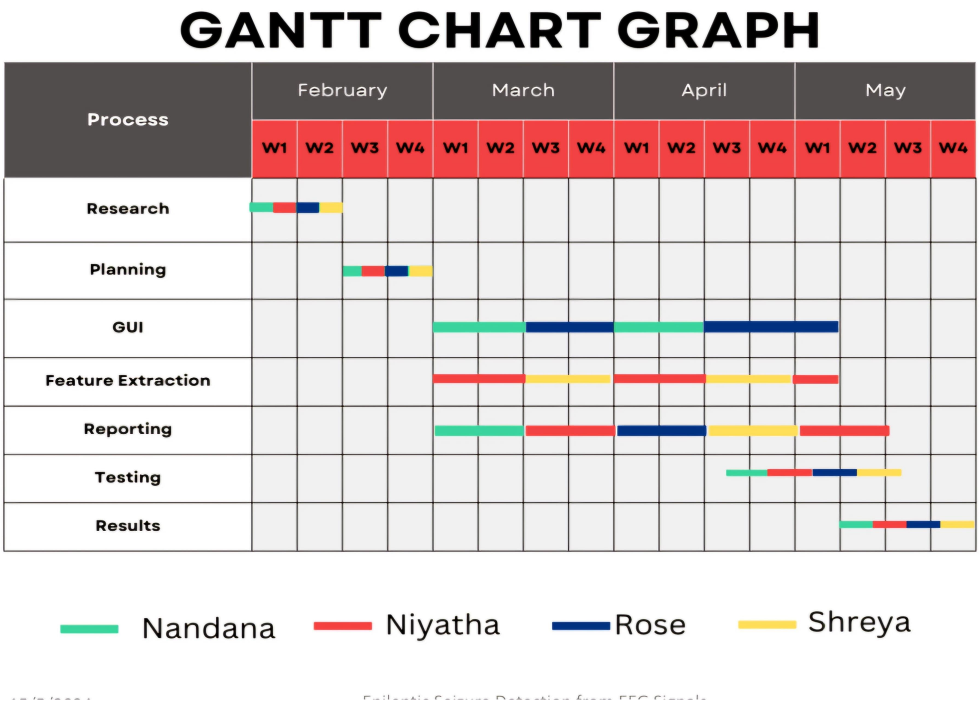


Figure 3.9: Work Division

Chapter 4

Results and Discussions

4.1 Overview

Users are provided with a login page where authentication is done using their entered credentials. On successful login, the user is taken to a file uploading GUI with four different choices: select the EDF file to visualize, visualize the EDF file as a line graph, convert the selected EDF file to a CSV file, and upload and visualize the generated CSV file.

When selecting the option to visualize the EDF file, users are presented with a new GUI window where they can choose one or multiple electrodes to visualize as line graphs. If they choose to upload and visualize a CSV file, users are taken to a new GUI window where they can browse and select the CSV file from their system. They must also enter the start and end time in hours, minutes, and seconds format along with the sampling frequency. The line graph for the selected time frame can then be viewed. Users can enter the seizure start and end time to highlight the relevant points in the line graph with a color of their choice.

The GUI also provides a feature to extract existing comments on the patient's EDF graph from their respective folders. Previously added comments are listed in a provided text box, and users can add a new comment with the current system time and date.

In the feature extraction stage of the project, the EDF files are first converted to CSV files. For each seizure, corresponding files are created, including an ictal file consisting of all data points between the start and end time of the seizure, and three preictal frame files. A gap of 10 seconds is left between the start of the ictal stage and the end of preictal frame 1 to avoid any crossovers in brain wave behavior during the ictal and preictal stages. Preictal frame 1 includes the 10 seconds before the start of the earlier gap. Frame 2 includes the 10 seconds before the start of frame 1, and frame 3 includes the 10 seconds before the start of frame 2. Further calculations were done based on these generated files.

The relative alpha, beta, delta, and theta powers are calculated for the ictal stage as well as for all frames in the preictal stage. The average relative delta power is observed to be significantly higher than the relative alpha power in the ictal stage. The interframe difference in relative concentrations of alpha and delta for each seizure is calculated, followed by the percentage increase in delta relative to alpha for each seizure. For a group of randomly selected seven patients, alpha slowing could be detected numerically. Alpha slowing is characterized by brain waves initially categorized in the alpha frequency range gradually shifting to the delta frequency range at the onset of a seizure. Although scientific analysis is yet to be completed, numerical analysis suggests the occurrence of this slowing tendency in alpha waves.

4.2 Testing

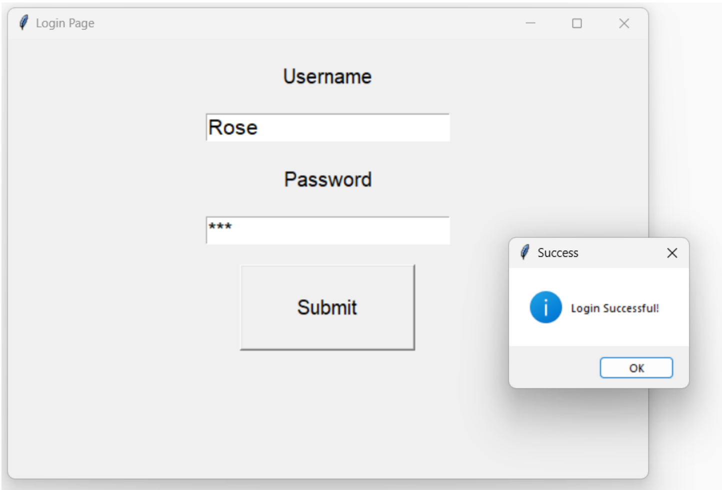


Figure 4.1: login page

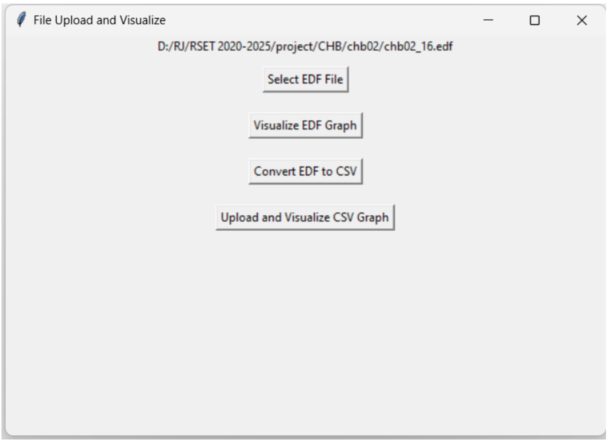


Figure 4.2: file uploading

Figure 4.3: channel selection

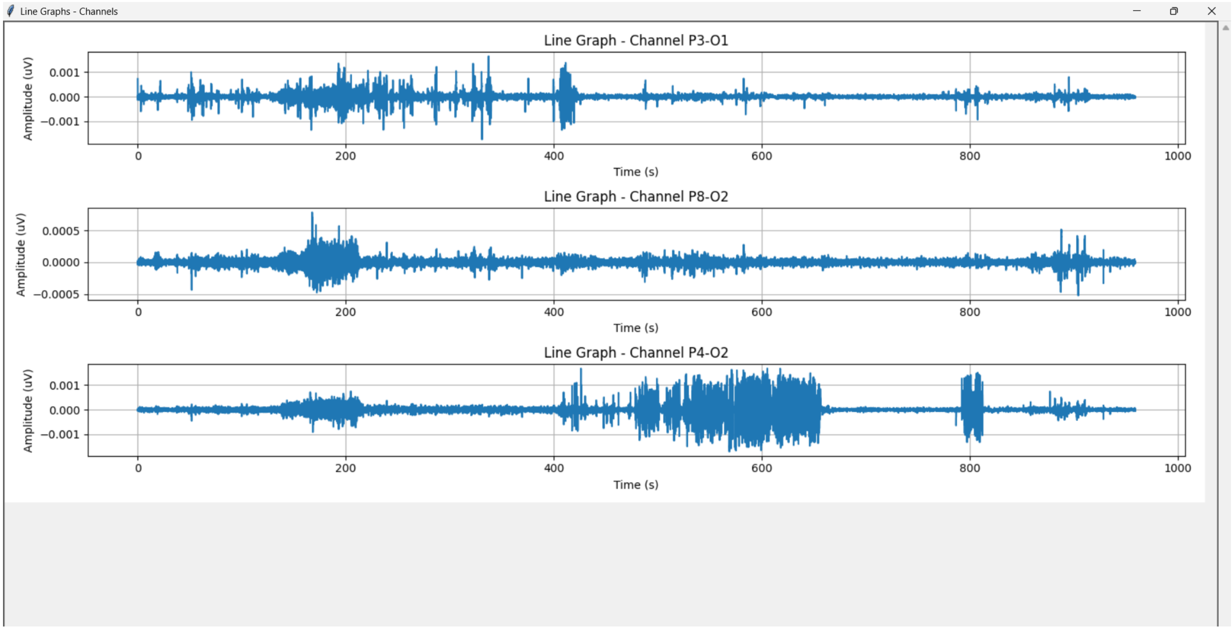


Figure 4.4: EDF graph representation

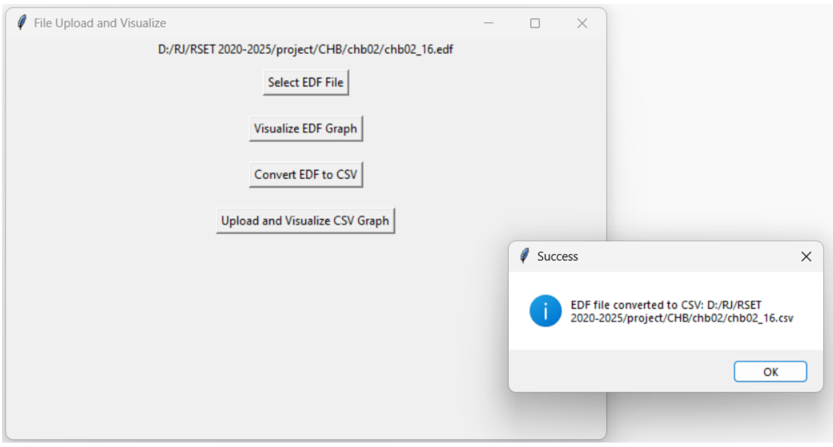


Figure 4.5: EDF to CSV file conversion

Figure 4.6: Visualising CSV file

Figure 4.7: Highlighting seizure time frame and entering comment

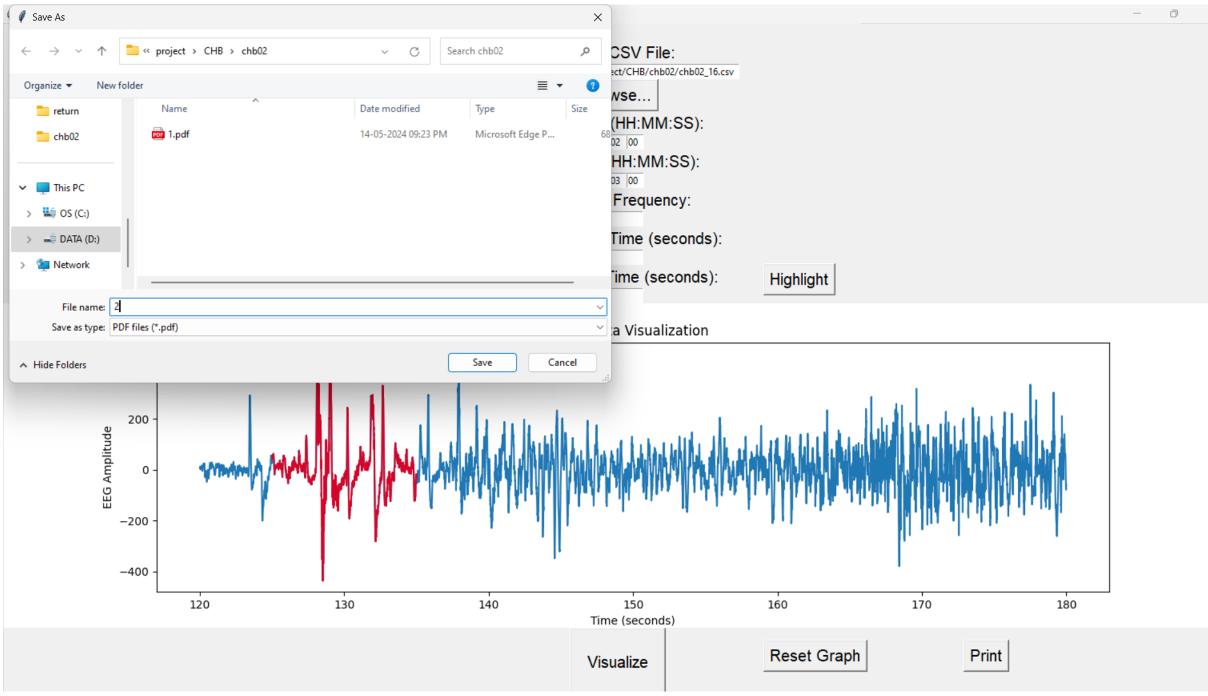


Figure 4.8: Saving as PDF file

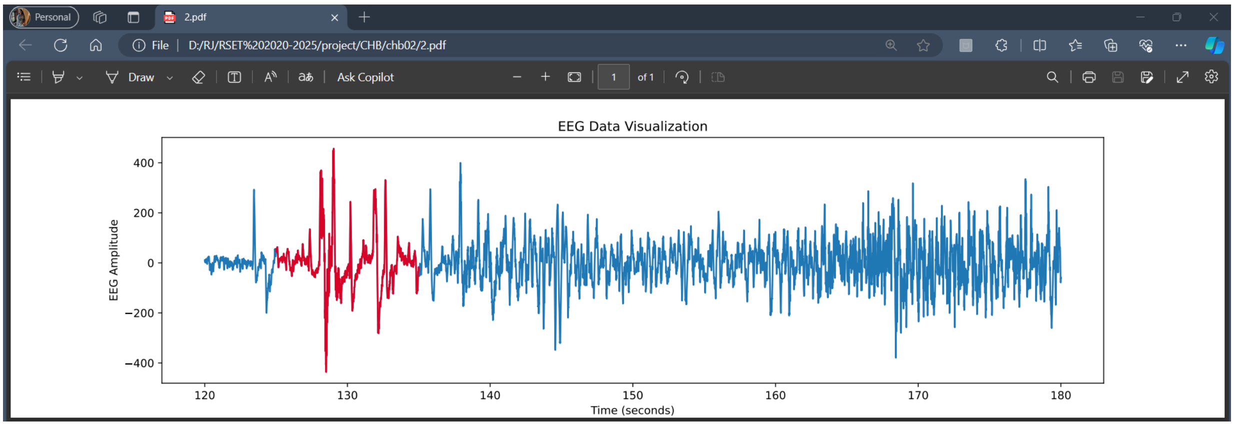


Figure 4.9: PDF file

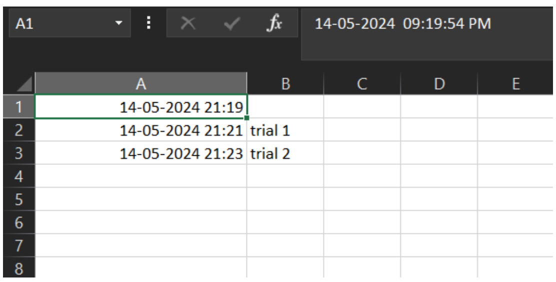


Figure 4.10: Entered comments into CSV file

4.3 Quantitative Results

For each seizure an ictal file consisting of all data points between the start and end time of the seizure, and three preictal frame files were generated. A gap of 10 seconds is left between the start of the ictal stage and the end of preictal frame 1 to avoid any crossovers in brain wave behavior during the ictal and preictal stages. Preictal frame 1 includes the 10 seconds before the start of the earlier gap. Frame 2 includes the 10 seconds before the start of frame 1, and frame 3 includes the 10 seconds before the start of frame 2. Further calculations were done based on these generated files.

The relative alpha, beta, delta, and theta powers are calculated for the ictal stage as well as for all frames in the preictal stage. The average relative delta power is observed to be significantly higher than the relative alpha power in the ictal stage. The inter-frame difference in relative concentrations of alpha and delta for each seizure is calculated, followed by the percentage increase in delta relative to alpha for each seizure. For a group of randomly selected seven patients, alpha slowing could be detected numerically. Alpha slowing is characterized by brain waves initially categorized in the alpha frequency range gradually shifting to the delta frequency range at the onset of a seizure. Although scientific analysis is yet to be completed, numerical analysis suggests the occurrence of this slowing tendency in alpha waves.

A	B	C	D	E	F	G	H	I
RESULTS								
PATIENT CH02								
SEIZURE FILE	**START TIME**	**END TIME**	**SEIZURE LENGTH**	**ELECTRODE**	**FRAME 3 & 2**	**FRAME 2 & 1**	**FRAME 1 & ICTAL**	**PERCENTAGE INCREASE**
CHB_16	130	212	82	F4 - C4	-33.33	14.29	75.00	144.44
CHB_16+	2972	3053	81	CZ - PZ	50.00	100.00	100.00	50.00
CHB_19	3369	3378	9	F3 - C3	70.00	77.78	88.89	21.25
					RELATIVE ALPHA	0.0516	**RELATIVE DELTA**	0.5793
PATIENT CH04								
SEIZURE FILE	**START TIME**	**END TIME**	**SEIZURE LENGTH**	**ELECTRODE**	**FRAME 3 & 2**	**FRAME 2 & 1**	**FRAME 1 & ICTAL**	**PERCENTAGE INCREASE**
CHB_05	7804	7853	49	F3 - C3	28.57	55.56	90.91	68.57
CHB_08	6446	6557	111	P4 - O2	-300.00	58.82	100.00	400.00
CHB_28	1679	1781	102	FT10 - T8	-50.00	0.00	56.52	188.46
CHB_28	3782	3898	116	T7 - P7	84.21	90.00	93.62	10.05
					RELATIVE ALPHA	0.0475	**RELATIVE DELTA**	0.4218
PATIENT CH07								
SEIZURE FILE	**START TIME**	**END TIME**	**SEIZURE LENGTH**	**ELECTRODE**	**FRAME 3 & 2**	**FRAME 2 & 1**	**FRAME 1 & ICTAL**	**PERCENTAGE INCREASE**
CHB_12	4920	5006	86	P3 - O1	-75.00	66.67	88.24	185.00
CHB_13	3285	3381	96	P7 - O1	-400.00	88.89	91.43	537.49
CHB_19	13688	13831	143	FZ - CZ	78.57	92.00	100.00	21.43
					RELATIVE ALPHA	0.065	**RELATIVE DELTA**	0.5616

Figure 4.11: Numerical detection of possible alpha slowing

A	B	C	D	E	F	G	H	I
PATIENT CH09								
SEIZURE FILE	**START TIME**	**END TIME**	**SEIZURE LENGTH**	**ELECTRODE**	**FRAME 3 & 2**	**FRAME 2 & 1**	**FRAME 1 & ICTAL**	**PERCENTAGE INCREASE**
CHB_06	12231	12295	64	FP1 - F7	-250.00	47.37	92.00	371.74
CHB_08	2951	3030	79	C4 - P4	-200.00	12.50	95.45	309.53
CHB_08	9196	9267	71	C4 - P4	50.00	53.33	76.09	34.29
CHB_19	5299	5361	62					
					RELATIVE ALPHA	0.1075	**RELATIVE DELTA**	0.3355
PATIENT CH11								
SEIZURE FILE	**START TIME**	**END TIME**	**SEIZURE LENGTH**	**ELECTRODE**	**FRAME 3 & 2**	**FRAME 2 & 1**	**FRAME 1 & ICTAL**	**PERCENTAGE INCREASE**
CHB_82	298	320	22	P7 - O1	-100.00	60.00	81.82	222.22
CHB_92	2695	2727	32	P8 - O2				
CHB_99	1454	2206	752	F3 - C3	42.86	80.00	96.43	55.55
					RELATIVE ALPHA	0.0564	**RELATIVE DELTA**	0.5033
PATIENT CH17								
SEIZURE FILE	**START TIME**	**END TIME**	**SEIZURE LENGTH**	**ELECTRODE**	**FRAME 3 & 2**	**FRAME 2 & 1**	**FRAME 1 & ICTAL**	**PERCENTAGE INCREASE**
CHB_03	2282	2372	90	F8 - T8	50.00	50.00	98.16	49.06
CHB_04	3025	3140	115	T7 - P7	0.00	76.92	93.33	100.00
CHB_63	3136	3224	88	FP2 - F4	-16.67	66.67	71.43	123.34
					RELATIVE ALPHA	0.043	**RELATIVE DELTA**	0.5938
PATIENT CH19								
SEIZURE FILE	**START TIME**	**END TIME**	**SEIZURE LENGTH**	**ELECTRODE**	**FRAME 3 & 2**	**FRAME 2 & 1**	**FRAME 1 & ICTAL**	**PERCENTAGE INCREASE**
CHB_28	299	377	78	C4 - P4	-100.00	22.22	76.00	231.58
CHB_29	2964	3041	77	F3 - C3	0.00	76.92	100.00	100.00
CHB_30	3159	3240	81	FP1 - F3	-33.33	50.00	92.31	136.11
					RELATIVE ALPHA	0.0922	**RELATIVE DELTA**	0.3928

Figure 4.12: Numerical detection of possible alpha slowing

PATIENT	ALPHA	DELTA	PERCENTAGE CHANGE
CH01	0.0139	0.7892	98.24%
CH02	0.0516	0.5793	91.09%
CH03	0.0336	0.544	93.82%
CH04	0.0475	0.4218	88.74%
CH05	0.0134	0.4459	96.99%
CH06	0.0305	0.657	95.36%
CH07	0.065	0.5616	88.43%
CH08	0.011	0.8283	98.67%
CH09	0.1075	0.3551	69.73%
CH10	0.0379	0.5776	93.44%
CH11	0.0564	0.5033	88.79%
CH14	0.0514	0.6376	91.94%
CH16	0.0653	0.5359	87.81%
CH17	0.043	0.5938	92.76%
CH18	0.046	0.6045	92.39%
CH19	0.0922	0.3928	76.53%
CH20	0.0463	0.8696	94.68%
CH21	0.035	0.6552	94.66%
CH22	0.04	0.5288	92.44%

Figure 4.13: Detection of relative delta being higher than relative alpha during ictal stage

4.4 Discussion

The preictal stages are not usually considered by neurologists during the detection of epileptic seizure onset while examining the EDF files. The major challenge was to identify and define a possible time frame for the preictal stage so that studies could be conducted on the brain waves during this period. Research on brain waves in the preictal stage could potentially help identify important uniform variations that suggest seizure onset. Since research typically does not focus on the preictal stage, it was difficult to pinpoint the time frame for this stage. According to studies by the University of Alabama, the preictal stage was considered to be 40 minutes before the onset of the ictal stage. Further analysis of the relative brain powers within this time frame showed that relative delta power was higher than relative alpha power for patients ch_01 and ch_02 alone. Therefore, the preictal stage was adjusted according to a study by J. Prasanna, M. S. P. Subathra, Mazin Abed Mohammed, Robertas Damaševičius, Nanjappan Jothiraj Sairamya, and S. Thomas George, published in the National Library of Medicine, titled *Automated Epileptic Seizure Detection in Pediatric Subjects of CHB-MIT EEG Database—A Survey*, which suggested that the preictal stage could be 1–15 minutes before the onset of the seizure. This adjustment held for four patients.

The preictal stage was later refined further to include interframe dependencies. In this calculation, three preictal frames were considered. A gap of 10 seconds was left between the start of the ictal stage and the end of preictal frame 1 to avoid any crossovers in brain wave behavior between the ictal and preictal stages. Preictal frame 1 included the 10 seconds before the start of the earlier gap. Frame 2 included the 10 seconds before the start of frame 1, and frame 3 included the 10 seconds before the start of frame 2. With this new selection for preictal time frames, the finding held for 19 out of the 24 patients considered.

Discussions with neurologists suggested the occurrence of alpha slowing, indicating that alpha brain waves gradually change into delta and theta waves as the seizure occurs. This transition could be localized to one electrode. The relative alpha and delta powers were calculated for each of the three preictal frames as well as the ictal stage for each seizure of the patient. The difference in concentration of the waves was calculated in groups: Frame 3 and Frame 2, Frame 2 and Frame 1, and Frame 1 and the ictal stage for each corresponding seizure. The percentage difference between the delta and alpha waves for these groups was considered. A significant increase in the percentage difference was observed moving from Frame 3, which is furthest from the ictal stage, to the ictal stage. This suggested possible numerical evidence for alpha slowing. This finding was observed in 7 randomly selected patients for calculation purposes. Each of these 7 patients had at least 3 seizures that lasted from a minimum of 9 seconds to a maximum of 752 seconds.

Chapter 5

Conclusion

5.1 Conclusion

The primary objective of this project was to explore the preictal stage of epileptic seizures to identify potential early indicators of seizure onset. Through extensive analysis of EEG data, particularly the relative power of alpha and delta brain waves, significant findings were made that could enhance early detection methods. Initially, studies suggested a preictal window of 40 minutes before the ictal stage, but further analysis showed this timeframe was only partially effective for a limited number of patients. By adjusting the preictal stage to 1–15 minutes before seizure onset, as recommended by recent studies, a more accurate correlation was found in a broader patient group.

The refined method yielded robust results, which involved breaking down the preictal period into three 10-second frames with a 10-second buffer before the ictal stage. This approach demonstrated that the transition from alpha to delta and theta waves, known as alpha slowing, occurs consistently across the majority of patients analyzed. These findings suggest that a shorter, more immediate preictal window is critical for developing reliable predictive models for epileptic seizures. This study underscores the importance of focusing on the preictal stage and paves the way for future research and the development of advanced seizure prediction technologies.

5.2 Future Scope

The current project can be extended to implement a Convolutional Neural Network (CNN) model that accurately pinpoints the onset of an epileptic seizure using the existing extracted features. Additionally, further feature extraction techniques, such as computing the mean power of the brain waves, can be incorporated to enhance the model's performance. Furthermore, there is potential for exploring new correlations between the brain waves in different frames of the preictal stage, which could provide deeper insights into the underlying mechanisms of epileptic seizures. Such extensions can contribute to the development of more precise and reliable seizure prediction and detection systems.

Bibliography

[1] Goldberger, A., Amaral, L., Glass, L., Hausdorff, J., Ivanov, P. C., Mark, R., ... & Stanley, H. E. (2000). PhysioBank, PhysioToolkit, and PhysioNet: Components of a new research resource for complex physiologic signals. Circulation [Online]. 101 (23), pp. e215–e220.

[2] Guttag, J. (2010). CHB-MIT Scalp EEG Database (version 1.0.0). PhysioNet. https://doi.org/10.13026/C2K01R.

[3] Epileptic seizure detection combining power spectral density and highfrequency oscillations, https://dergipark.org.tr/en/download/article-file/2874211

[4] A.T. Tzallas, M.G. Tsipouras and D.I. Fotiadis, "Epileptic Seizure Detection in EEGs Using Time–Frequency Analysis," in IEEE Transactions on Information Technology in Biomedicine, vol. 13, pp. 703-710, Sept. 2009, doi: 10.1109/TITB.2009.2017939.

[5] J Gotman, "Automatic recognition of epileptic seizures in the EEG, Electroencephalography and Clinical Neurophysiology", Volume 54, Issue 5,1982, pp. 530-540,https://doi.org/10.1016/0013-4694(82)90038-4.

[6] L. Boubchir, B. Daachi and V. Pangracious, "A review of feature extraction for EEG epileptic seizure detection and classification," 2017 40th International Conference on Telecommunications and Signal Processing (TSP), Barcelona, Spain, 2017, pp. 456-460, doi: 10.1109/TSP.2017.8076027.

Appendix A: Presentation

Epileptic Seizure Detection from EEG Signals

Dr. Sminu Izudheen

Nandana S Pillai
Niyatha V S
Rose Jacob
Shreya Veeraraghav

Contents

Introduction

- Epilepsy is a neurological condition characterized by erratic signals from groups of neurons in the brain, leading to seizures, assessed using EEG.
- Examining the 10 to 15 hours of EEG data through visual analysis is time-consuming
- Our software tool streamlines this process for neurologists
- Enables automated detection of seizure

Introduction

- 1 hour EEG data = 1 * 60 * 60 * 256
  =9,21,600 data points
- 10 hours EEG data = 9,21,600 * 10
  = 92,16,000 data points

Problem Definition

- To develop a software to extract features of brain waves that are suggestive of epileptic seizure activity from EEG signals by identifying and highlighting the time frame of ictal period of an epileptic seizure.

Objectives

- To divide the given EEG file into separate ictal and preictal files.
- To identify features showing noticeable variations during ictal and preictal stages.
- To highlight the region of ictal period in the EEG files.

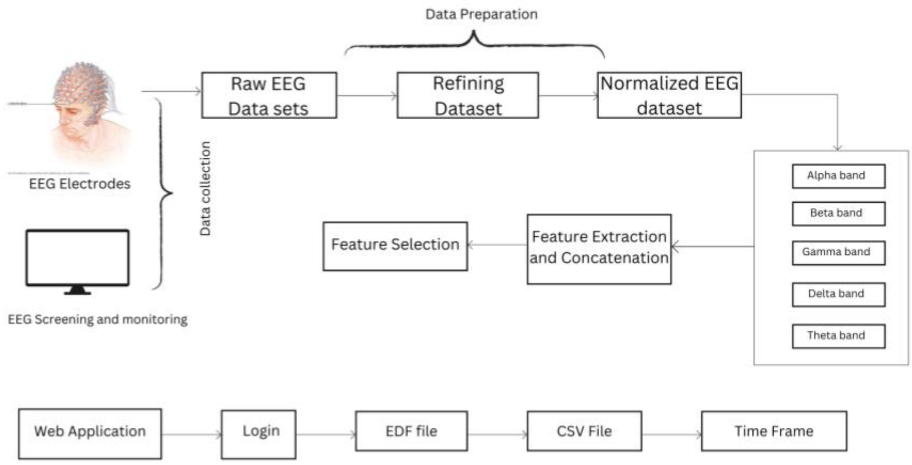
Scope and Relevance

- Gives the time frames of ictal and preictal stages of the seizure as the output.
- Identifies the power spectral density of alpha, beta, theta and delta waves.

System Design

- Comprehensive system to analyze EEG data
- Identifies seizure events and extracts relevant features for further analysis
- Provides a user-friendly interface for visualization and analysis.

Architectural Diagram



System Modules - Frontend

1. User Interface Design
  - Interface designed using Python libraries such as mne, tkinter, matplotlib, etc.
2. User Authentication
  - matches the entered details with the credentials stored in the database

System Modules - Frontend

3. File uploading and Visualisation

- allow users to upload EDF files
- selecting specific channels for visualisation
- Visualisation of EDF files as line graphs
- utilizing plotting libraries to display data in graphical format

System Modules - Frontend

4. User Interaction

- selection of patient's folder and retrieval of selected patient's comment csv
- on entering the start and end time of the seizure, the respective time frame is highlighted with colour of choice in the line graph
- option to print the line graph in pdf format

System Modules - Backend

1. Data Processing
   - separating the data into ictal and preictal files as frames of 10 seconds each

2. Feature Extraction
   - extract features from ictal and preictal data
   - compute relative power of the brain wave

Algorithms Used

ALGORITHM FOR EXTRACTION OF DATA DURING ICTAL PERIODS

STEP 1: Import the python modules - os and pandas
STEP 2: Define the folder path containing the CSV files
STEP 4: Define file_list as a list of dictionaries containing files names along with seizure window information
STEP 5: Repeat steps 5.1 to 5.6 for each file name in the file_list
  STEP 5.1: Define the path of the output CSV file
  STEP 5.2: Construct the file path for the input CSV file.
  STEP 5.3: Read the CSV file into a pandas DataFrame.

STEP 5.4: Assign the corresponding start time & end time of the current file name to variables “start_time” and “end_time” respectively

STEP 5.5: Create a boolean mask(time_stamps) such that each value in the ‘time” column of the DataFrame (df) is within the window time frame.

STEP 5.6: Use the boolean mask to filter the rows within seizure window and store in a DataFrame df_windowed.

STEP 5.7: Write the filtered rows to the output CSV file using the function df_windowed.to_csv() to the same folder path

Algorithms Used

ALGORITHM FOR CALCULATION OF RELATIVE POWER USING THE WELCH METHOD

STEP 1: Import necessary python libraries

STEP 2: Define the function calculate_relative_band_power, with parameters - data, column,window, overlap

STEP 2.1: Initialize the variables - total_power band_power, signal start_time, end_time

STEP 2.2: Repeat steps 3.2.1 to 3.2.4 for each row in data

STEP 2.2.1: Extract current timestamp into current_time

STEP 2.2.2: If current_time is within window time frame

STEP 2.2.2.1: Append it to the signal list

STEP 2.2.3: If signal data is available then,

STEP 2.2.3.1: Apply Welch's method

STEP 2.2.3.2: Calculate band_power and total_power

STEP 2.2.3.3: Calculate relative power

STEP 2.2.3.4: Return relative power

STEP 2.2.4: Otherwise if signal is not available, then

STEP 2.2.4.1: Return none

STEP 3: Define the main function

STEP 3.1: Define the path to the EEG data files directory.

STEP 3.2: Open and process file containing the seizure period

STEP 3.3: Extract column names into a list electrode_columns

STEP 3.4: Define frequency range of interested brain wave

STEP 3.5: Repeat steps for each column in electrode_columns.

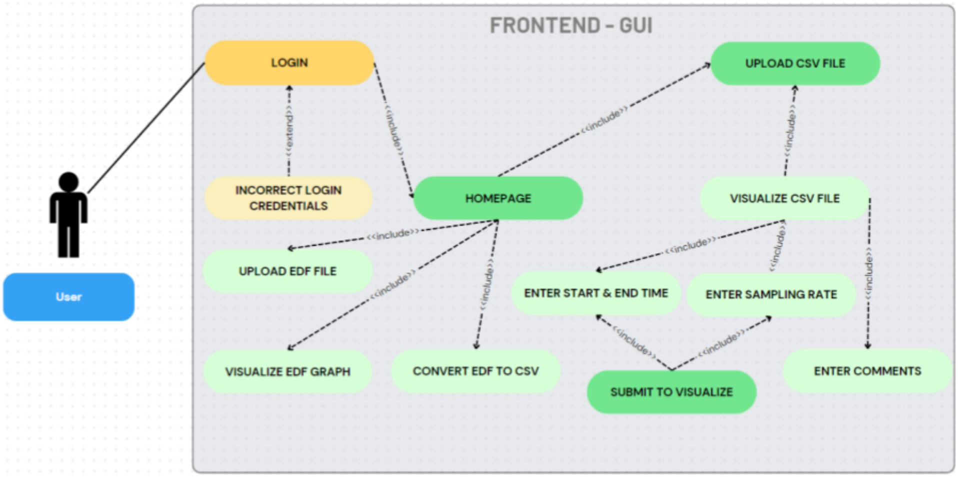
STEP 3.5.1: Calculate relative power for the brain wave using the function - calculate_relative_band_power

STEP 3.5.2: Print the calculated relative power

STEP 4: Execute the main function

Design Models

1. Use case Diagram



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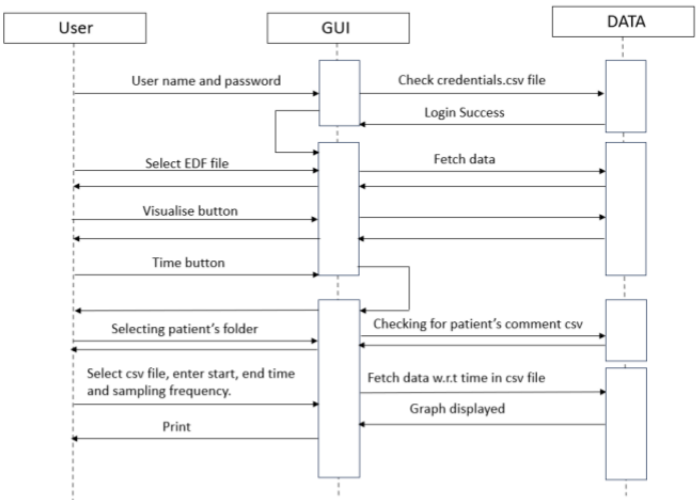
Design Models

2. Sequence Diagram



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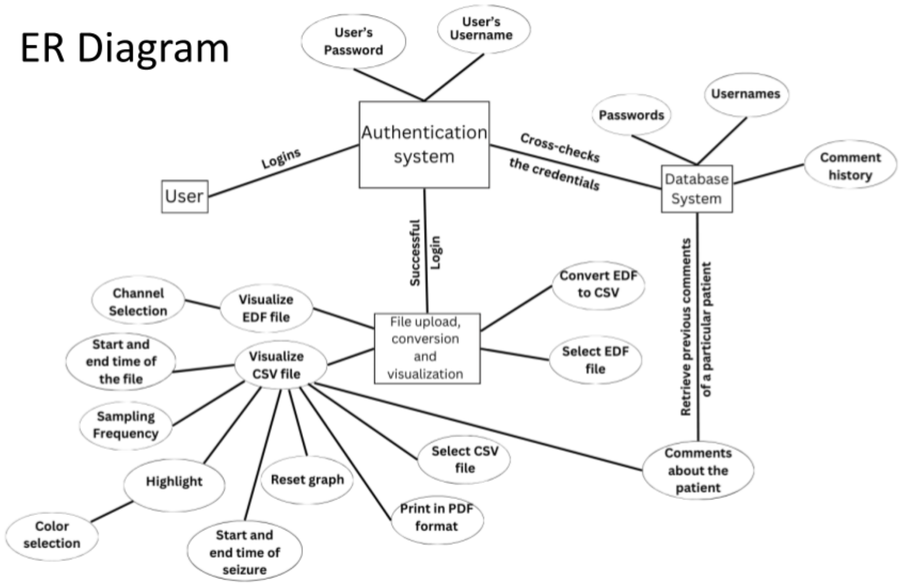
Database Design

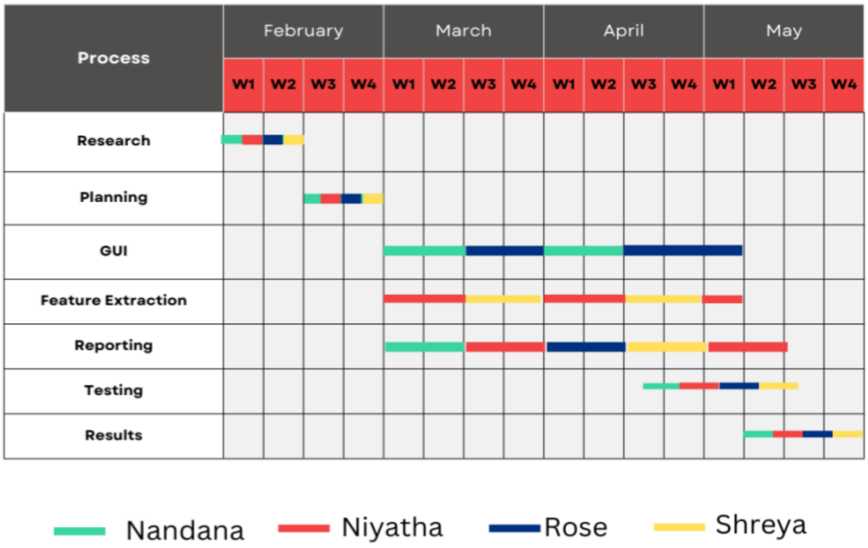
ER Diagram



Datasets

- Utilizes the CHB-MIT dataset, collected from the Children's Hospital at Boston, which consists of EEG recordings.
- The EEG recordings are grouped into 23 cases, collected from 22 subjects (5 males, ages 3–22; and 17 females, ages 1.5–19) and it includes pediatric subjects with intractable seizures.
- The sampling rate of the signals is 256 Hz . For most of the cases, 23 EEG channels are present and the .edf files contain exactly one hour of digitized EEG signals.
- The International 10-20 system of EEG electrode positions and nomenclature was used for these recordings.
- Source: https://physionet.org/content/chbmit/1.0.0/

GANTT CHART GRAPH

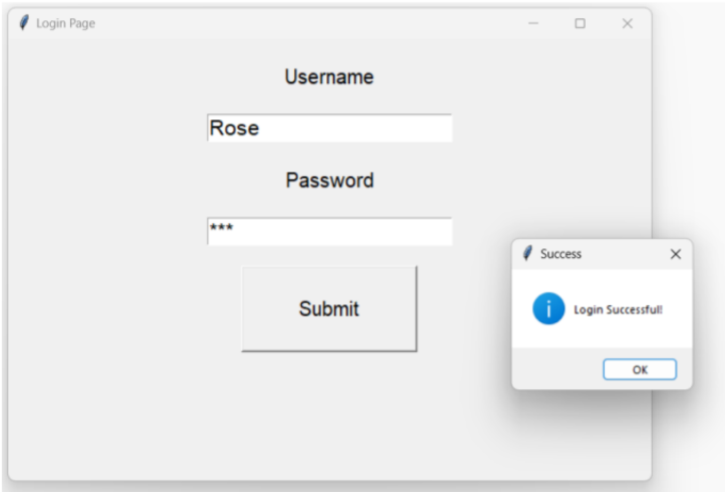


Software/ Hardware Requirements

- Software requirements: Python (version 3.7 or later)
- Hardware requirements: Windows 10 or 11, intel core i5 or equivalent, 8GB RAM or higher, 256GB SSD

Results

Login Page



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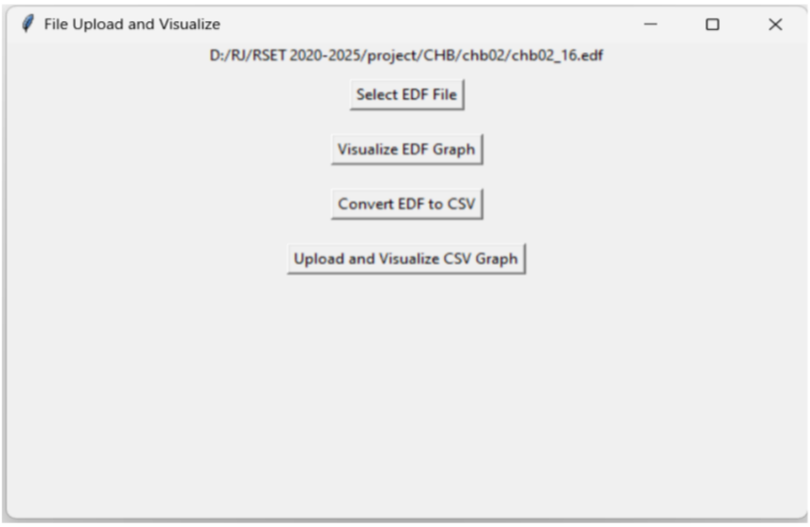
File uploading



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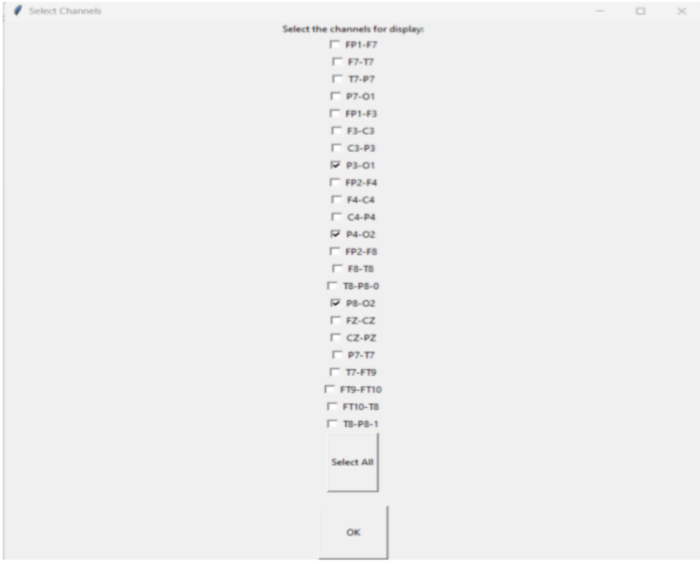
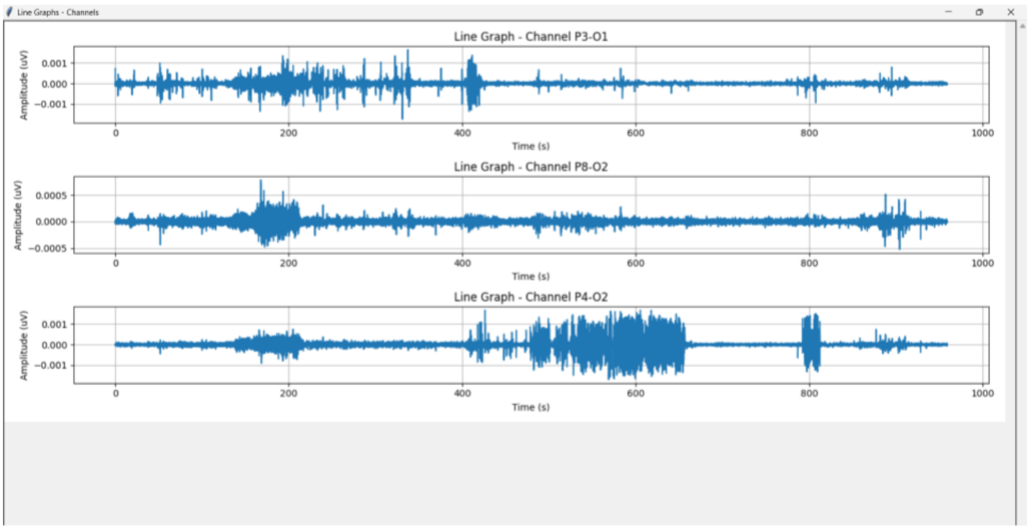
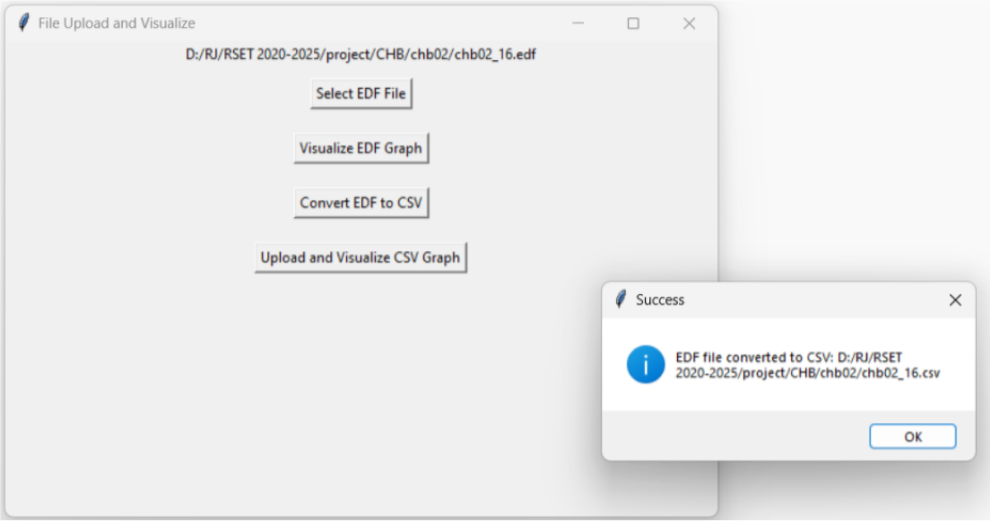
Channel selecting



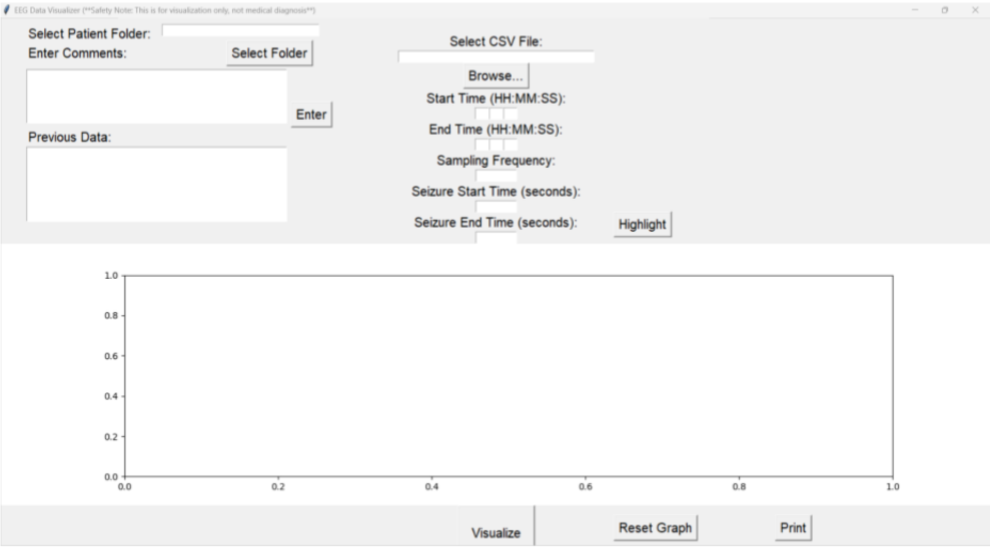
EDF graph representation



EDF to CSV file conversion



Visualising CSV file



Highlighting seizure time frame and entering comment

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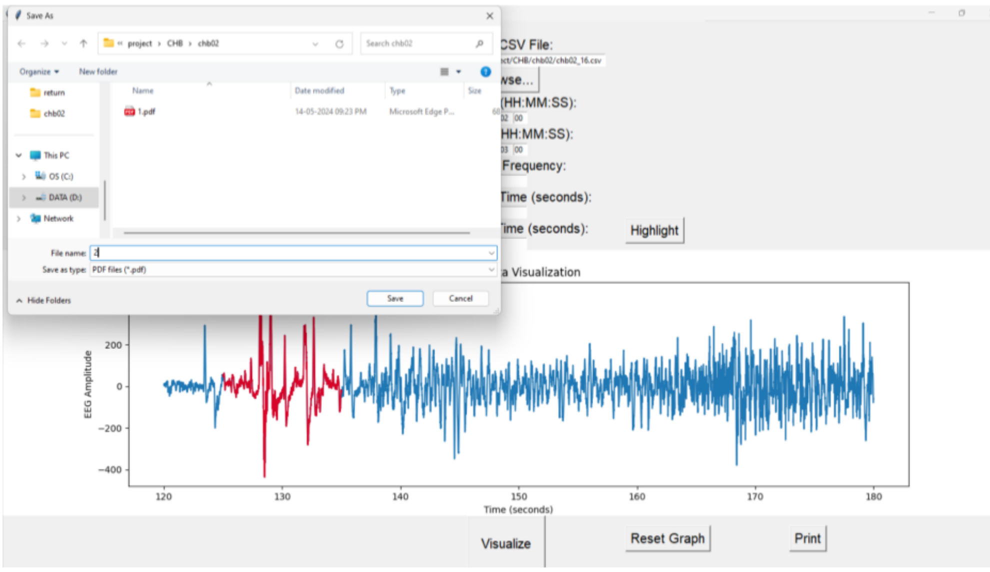
Saving as PDF



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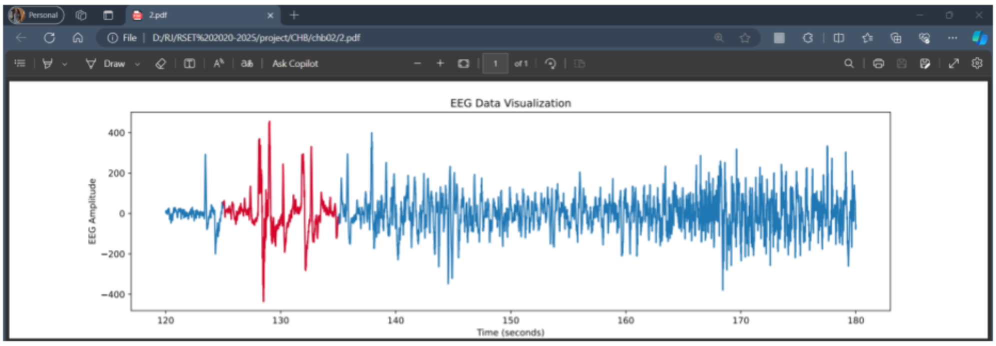
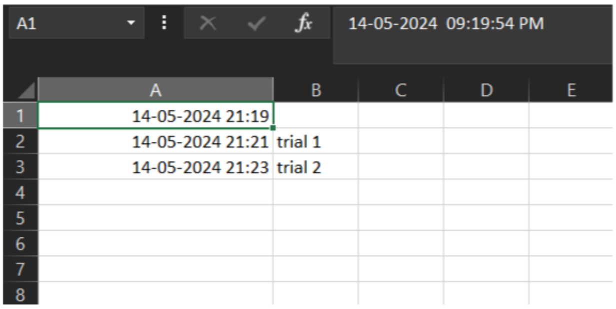
PDF file



Entered comments into CSV file



	A	B	C	D	E
1	14-05-2024 21:19				
2	14-05-2024 21:21	trial 1			
3	14-05-2024 21:23	trial 2			
4					
5					
6					
7					
8					

RELATIVE POWER CALCULATION FOR PATIENT CHB_02

RELATIVE POWER

ICTAL CONVERSION

	FP1 - F7	F7 - T7	T7 - P7	P7 - O1	FP1 - F3	F3 - C3	C3 - P3	P3 - O1	FP2 - F4	F4 - C4	C4 - P4	P4 - O2	FP2 - F8	F8 - T8	T8 - P8	P8 - O2	FZ - CZ	CZ - PZ	P7 - T7	T7 - FT9	FT9 - FT10	FT10 - T8	T8 - P8	
130 - 212	0.0300	0.0400	0.1400	0.0900	0.0300	0.0400	0.0700	0.1200	0.0400	0.0400	0.0800	0.1200	0.0300	0.0600	0.0700	0.1200	0.0400	0.0800	0.1400	0.0600	0.0500	0.0600	0.0700	
2972 - 3053	0.0400	0.0400	0.1200	0.0800	0.0600	0.0500	0.1100	0.0900	0.1000	0.0700	0.1000	0.0900	0.0400	0.0800	0.0900	0.0900	0.0500	0.0800	0.1200	0.0700	0.0400	0.0800	0.0900	
3369 - 3378	0.0200	0.0600	0.1400	0.0800	0.0200	0.0600	0.1100	0.1300	0.0100	0.0600	0.0900	0.0600	0.0000	0.0500	0.0600	0.1200	0.0400	0.0900	0.1400	0.0600	0.0400	0.0400	0.0600	
	0.03	0.04666666	0.1333333	0.08333	0.036666	0.05	0.09666	0.11333	0.05	0.05666	0.09	0.09	0.0233333	0.063333	0.073333	0.11	0.043333	0.083333	0.13333	0.06333	0.0433333	0.06	0.0733333	0.05166666667

FRAME 1 CONVERSION

	FP1 - F7	F7 - T7	T7 - P7	P7 - O1	FP1 - F3	F3 - C3	C3 - P3	P3 - O1	FP2 - F4	F4 - C4	C4 - P4	P4 - O2	FP2 - F8	F8 - T8	T8 - P8	P8 - O2	FZ - CZ	CZ - PZ	P7 - T7	T7 - FT9	FT9 - FT10	FT10 - T8	T8 - P8	
110 - 119.996094	0.0100	0.0100	0.0200	0.0700	0.0000	0.0500	0.0600	0.0800	0.0000	0.0600	0.0600	0.0700	0.0100	0.0100	0.0200	0.0600	0.0200	0.0500	0.0200	0.0100	0.0100	0.0100	0.0200	
2952 - 2961.996094	0.0100	0.0300	0.0300	0.0600	0.0100	0.1100	0.0500	0.0500	0.0100	0.1200	0.0900	0.0500	0.0200	0.0200	0.0300	0.0400	0.0500	0.0800	0.0300	0.0200	0.0100	0.0200	0.0300	
3349 - 3358.996094	0.0200	0.0300	0.0200	0.0600	0.0300	0.0500	0.0400	0.0400	0.0000	0.0900	0.0600	0.0400	0.0000	0.0400	0.0200	0.0700	0.0600	0.0400	0.0200	0.0200	0.0300	0.0200	0.0200	
	0.0133	0.0233	0.0233	0.0633	0.0133	0.0700	0.0500	0.0567	0.0033	0.0900	0.0700	0.0533	0.0100	0.0233	0.0233	0.0567	0.0433	0.0567	0.0233	0.0167	0.0167	0.0167	0.0233	0.0365

FRAME 2 CONVERSION

	FP1 - F7	F7 - T7	T7 - P7	P7 - O1	FP1 - F3	F3 - C3	C3 - P3	P3 - O1	FP2 - F4	F4 - C4	C4 - P4	P4 - O2	FP2 - F8	F8 - T8	T8 - P8	P8 - O2	FZ - CZ	CZ - PZ	P7 - T7	T7 - FT9	FT9 - FT10	FT10 - T8	T8 - P8	
100 - 109.996094	0.0100	0.0200	0.0200	0.0600	0.0300	0.1100	0.0300	0.0400	0.0300	0.1200	0.1000	0.0800	0.0300	0.0200	0.0300	0.0700	0.1200	0.0100	0.0200	0.0100	0.0300	0.0200	0.0300	
2942 - 2951.996094	0.0100	0.0200	0.0200	0.0300	0.0200	0.0300	0.0600	0.0300	0.0100	0.0200	0.0300	0.0300	0.0200	0.0100	0.0300	0.0300	0.0600	0.0800	0.0200	0.0100	0.0200	0.0100	0.0300	
3339 - 3348.996094	0.0200	0.0200	0.0300	0.0200	0.0200	0.0700	0.0900	0.0300	0.0100	0.0400	0.0300	0.0200	0.0100	0.0100	0.0300	0.0200	0.0900	0.0400	0.0300	0.0100	0.0200	0.0100	0.0300	
	0.0133	0.0200	0.0233	0.0367	0.0233	0.0700	0.0600	0.0333	0.0167	0.0600	0.0533	0.0433	0.0200	0.0133	0.0300	0.0400	0.0900	0.0433	0.0233	0.0100	0.0233	0.0133	0.0300	0.0343

FRAME 3 CONVERSION

	FP1 - F7	F7 - T7	T7 - P7	P7 - O1	FP1 - F3	F3 - C3	C3 - P3	P3 - O1	FP2 - F4	F4 - C4	C4 - P4	P4 - O2	FP2 - F8	F8 - T8	T8 - P8	P8 - O2	FZ - CZ	CZ - PZ	P7 - T7	T7 - FT9	FT9 - FT10	FT10 - T8	T8 - P8	
90 - 99.996094	0.0300	0.0300	0.0300	0.0400	0.0400	0.1000	0.0300	0.0300	0.0300	0.0800	0.0500	0.0900	0.0200	0.0300	0.0400	0.0700	0.0700	0.0400	0.0300	0.0200	0.0300	0.0500	0.0400	
2932 - 2941.996094	0.0100	0.0200	0.0200	0.0500	0.0200	0.0600	0.0400	0.0400	0.0200	0.1300	0.0400	0.0600	0.0100	0.0100	0.0100	0.0600	0.0400	0.0700	0.0200	0.0100	0.0200	0.0100	0.0100	
3329 - 3338.996094	0.0200	0.0200	0.0100	0.0400	0.0200	0.0400	0.0900	0.0300	0.0100	0.0400	0.0400	0.0200	0.0100	0.0200	0.0300	0.0300	0.1700	0.3400	0.0100	0.0100	0.0100	0.0100	0.0300	
	0.0200	0.0233	0.0200	0.0433	0.0267	0.0667	0.0533	0.0333	0.0200	0.0833	0.0433	0.0567	0.0133	0.0200	0.0267	0.0533	0.0933	0.1500	0.0200	0.0133	0.0200	0.0233	0.0267	0.0413
																								0.0374

INTERFRAME CALCULATION BASED ON ALPHA & DELTA

			FP1 - F7	F7 - T7	T7 - P7	P7 - O1	FP1 - F3	F3 - C3	C3 - P3	P3 - O1	FP2 - F4	F4 - C4	C4 - P4	P4 - O2	FP2 - F8	F8 - T8	T8 - P8	P8 - O2	FZ - CZ	CZ - PZ	P7 - T7	T7 - FT9	FT9 - FT10	FT10 - T8	T8 - P8
ICTAL & FRAME 1	ALPHA	SEIZURE 1	0.02	0.03	0.12	0.02	0.03	0.01	0.01	0.04	0.04	0.02	0.02	0.05	0.02	0.05	0.05	0.06	0.02	0.03	0.12	0.05	0.04	0.05	0.05
		SEIZURE 2	0.03	0.01	0.09	0.02	0.05	0.06	0.06	0.04	0.09	0.05	0.01	0.04	0.02	0.06	0.06	0.05	0	0	0.09	0.05	0.03	0.06	0.06
		SEIZURE 3	0	0.03	0.12	0.02	0.01	0.01	0.07	0.09	0.01	0.03	0.03	0.02	0	0.01	0.04	0.05	0.02	0.05	0.12	0.04	0.01	0.02	0.04
	DELTA	SEIZURE 1	0.14	0.36	0.32	0.03	0.07	0.06	0.04	0.13	0.2	0.08	0.11	0.17	0.08	0.31	0.5	0.14	0.05	0.13	0.32	0.49	0.21	0.42	0.5
		SEIZURE 2	0.03	0.41	0.1	0.12	0.05	0.27	0.2	0.01	0.21	0.03	0.1	0.02	0.06	0.03	0.23	0.25	0.08	0.02	0.1	0.18	0.05	0.05	0.23
		SEIZURE 3	0.1	0.32	0.01	0.04	0.09	0.09	0.11	0.1	0.01	0.22	0.03	0.39	0.1	0.35	0.35	0.17	0.02	0.05	0.01	0.01	0.04	0.17	0.35
	PERCENT DIFFERENCE OF ALPHA AND DELTA	SEIZURE 1	85.71	91.67	62.50	33.33	57.14	83.33	75.00	69.23	80.00	75.00	81.82	70.59	75.00	83.87	90.00	57.14	60.00	76.92	62.50	89.80	80.95	88.10	90.00
		SEIZURE 2	0.00	97.56	10.00	83.33	0.00	77.78	70.00	-300.00	57.14	-66.67	90.00	-100.00	66.67	-100.00	73.91	80.00	100.00	100.00	10.00	72.22	40.00	-20.00	73.91
		SEIZURE 3	100.00	90.63	-1100.00	50.00	88.89	88.89	36.36	10.00	0.00	86.36	0.00	94.87	100.00	97.14	88.57	70.59	0.00	0.00	-1100.00	-300.00	75.00	88.24	88.57
RAME 1&	ALPHA	SEIZURE 1	0	0.01	0	0.01	0.03	0.06	0.03	0.04	0.03	0.06	0.04	0.01	0.02	0.01	0.01	0.01	0.1	0.04	0	0	0.02	0.01	0.01
		SEIZURE 2	0	0.01	0.01	0.03	0.01	0.08	0.01	0.02	0	0.1	0.06	0.02	0	0.01	0	0.01	0.01	0	0.01	0.01	0.01	0.01	0
		SEIZURE 3	0	0.01	0.01	0.04	0.01	0.02	0.05	0.01	0.01	0.05	0.03	0.02	0.01	0.03	0.01	0.05	0.03	0	0.01	0.01	0.01	0.01	0.01
	DELTA	SEIZURE 1	0.09	0.17	0.03	0.09	0.1	0.09	0.01	0.03	0.18	0.07	0.11	0.03	0.16	0.19	0.03	0.01	0.24	0.19	0.03	0.02	0.27	0.02	0.03
		SEIZURE 2	0.24	0.02	0.14	0.31	0.07	0.07	0.42	0.18	0.02	0.09	0.3	0.23	0.06	0.01	0.08	0.34	0.02	0.08	0.14	0.25	0.31	0.34	0.08
		SEIZURE 3	0.03	0.09	0.03	0.14	0.1	0.09	0.15	0.17	0.04	0.05	0.16	0.03	0.05	0.05	0	0.11	0.12	0.06	0.03	0.02	0.1	0.12	0
	PERCENT DIFFERENCE OF ALPHA AND DELTA	SEIZURE 1	100.00	94.12	100.00	88.89	70.00	33.33	-200.00	-33.33	83.33	14.29	63.64	66.67	87.50	94.74	66.67	0.00	58.33	78.95	100.00	100.00	92.59	50.00	66.67
		SEIZURE 2	100.00	50.00	92.86	90.32	85.71	-14.29	97.62	88.89	100.00	-11.11	80.00	91.30	100.00	0.00	100.00	97.06	50.00	100.00	92.86	96.00	96.77	97.06	100.00
		SEIZURE 3	100.00	88.89	66.67	71.43	90.00	77.78	66.67	94.12	75.00	0.00	81.25	33.33	80.00	40.00	#DIV/0!	54.55	75.00	100.00	66.67	50.00	90.00	91.67	#DIV/0!
RAME 2&:	ALPHA	SEIZURE 1	0.02	0.01	0.01	0.02	0.01	0.01	0	0.01	0	0.04	0.05	0.01	0.01	0.01	0.01	0	0.05	0.03	0.01	0.01	0	0.03	0.01
		SEIZURE 2	0	0	0	0.02	0	0.03	0.02	0.01	0.01	0.11	0.01	0.03	0.01	0	0.02	0.03	0.02	0.01	0	0	0	0	0.02
		SEIZURE 3	0	0	0.02	0.02	0	0.03	0	0	0	0	0.01	0	0	0.01	0	0.01	0.08	0.3	0.02	0	0.01	0	0
	DELTA	SEIZURE 1	0.05	0.21	0.26	0.09	0.08	0.09	0.16	0.16	0.04	0.03	0.03	0.02	0.04	0.28	0.13	0.11	0.04	0.19	0.26	0.06	0.2	0.06	0.13
		SEIZURE 2	0.35	0.12	0.23	0.26	0.24	0.16	0.39	0.3	0.13	0.06	0.49	0.09	0.24	0.19	0.18	0.13	0.07	0.02	0.23	0.5	0.21	0.54	0.18
		SEIZURE 3	0.06	0.09	0.21	0.13	0.13	0.1	0.09	0.28	0.09	0.09	0.06	0.03	0.01	0.12	0.03	0.03	0.13	0.22	0.21	0.2	0.11	0.1	0.03
	PERCENT DIFFERENCE OF ALPHA AND DELTA	SEIZURE 1	60.00	95.24	96.15	77.78	87.50	88.89	100.00	93.75	100.00	-33.33	-66.67	50.00	75.00	96.43	92.31	100.00	-25.00	84.21	96.15	83.33	100.00	50.00	92.31
		SEIZURE 2	100.00	100.00	100.00	92.31	100.00	81.25	94.87	96.67	92.31	-83.33	97.96	66.67	95.83	100.00	88.89	76.92	71.43	50.00	100.00	100.00	100.00	100.00	88.89
		SEIZURE 3	100.00	100.00	90.48	84.62	100.00	70.00	100.00	100.00	100.00	100.00	83.33	100.00	100.00	91.67	100.00	66.67	38.46	-36.36	90.48	100.00	90.91	100.00	100.00

RESULTS FROM PERCENTAGE INCREASE CALCULATION BASED ON PREVIOUS STEP

RESULTS

PATIENT CH02

SEIZURE FILE	START TIME	END TIME	SEIZURE LENGTH	ELECTRODE	FRAME 3 & 2	FRAME 2 & 1	FRAME 1 & ICTAL	PERCENTAGE INCREASE
CHB_16	130	212	82	F4 - C4	-33.33	14.29	75.00	144.44
CHB_16+	2972	3053	81	CZ - PZ	50.00	100.00	100.00	50.00
CHB_19	3369	3378	9	F3 - C3	70.00	77.78	88.89	21.25
					RELATIVE ALPHA	0.0516	RELATIVE DELTA	0.5793

PATIENT CH04

SEIZURE FILE	START TIME	END TIME	SEIZURE LENGTH	ELECTRODE	FRAME 3 & 2	FRAME 2 & 1	FRAME 1 & ICTAL	PERCENTAGE INCREASE
CHB_05	7804	7853	49	F3 - C3	28.57	55.56	90.91	68.57
CHB_08	6446	6557	111	P4 - O2	-300.00	58.82	100.00	400.00
CHB_28	1679	1781	102	FT10 - T8	-50.00	0.00	56.52	188.46
CHB_28	3782	3898	116	T7 - P7	84.21	90.00	93.62	10.05
					RELATIVE ALPHA	0.0475	RELATIVE DELTA	0.4218

PATIENT CH07

SEIZURE FILE	START TIME	END TIME	SEIZURE LENGTH	ELECTRODE	FRAME 3 & 2	FRAME 2 & 1	FRAME 1 & ICTAL	PERCENTAGE INCREASE
CHB_12	4920	5006	86	P3 - O1	-75.00	66.67	88.24	185.00
CHB_13	3285	3381	96	P7 - O1	-400.00	88.89	91.43	537.49
CHB_19	13688	13831	143	FZ - CZ	78.57	92.00	100.00	21.43
					RELATIVE ALPHA	0.065	RELATIVE DELTA	0.5616

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PATIENT CH09

SEIZURE FILE	START TIME	END TIME	SEIZURE LENGTH	ELECTRODE	FRAME 3 & 2	FRAME 2 & 1	FRAME 1 & ICTAL	PERCENTAGE INCREASE
CHB_06	12231	12295	64	FP1 - F7	-250.00	47.37	92.00	371.74
CHB_08	2951	3030	79	C4 - P4	-200.00	12.50	95.45	309.53
CHB_08	9196	9267	71	C4 - P4	50.00	53.33	76.09	34.29
CHB_19	5299	5361	62					
					RELATIVE ALPHA	0.1075	RELATIVE DELTA	0.3355

PATIENT CH11

SEIZURE FILE	START TIME	END TIME	SEIZURE LENGTH	ELECTRODE	FRAME 3 & 2	FRAME 2 & 1	FRAME 1 & ICTAL	PERCENTAGE INCREASE
CHB_82	298	320	22	P7 - O1	-100.00	60.00	81.82	222.22
CHB_92	2695	2727	32	P8 - O2				
CHB_99	1454	2206	752	F3 - C3	42.86	80.00	96.43	55.55
					RELATIVE ALPHA	0.0564	RELATIVE DELTA	0.5033

PATIENT CH17

SEIZURE FILE	START TIME	END TIME	SEIZURE LENGTH	ELECTRODE	FRAME 3 & 2	FRAME 2 & 1	FRAME 1 & ICTAL	PERCENTAGE INCREASE
CHB_03	2282	2372	90	F8 - T8	50.00	50.00	98.16	49.06
CHB_04	3025	3140	115	T7 - P7	0.00	76.92	93.33	100.00
CHB_63	3136	3224	88	FP2 - F4	-16.67	66.67	71.43	123.34
					RELATIVE ALPHA	0.043	RELATIVE DELTA	0.5938

PATIENT CH19

SEIZURE FILE	START TIME	END TIME	SEIZURE LENGTH	ELECTRODE	FRAME 3 & 2	FRAME 2 & 1	FRAME 1 & ICTAL	PERCENTAGE INCREASE
CHB_28	299	377	78	C4 - P4	-100.00	22.22	76.00	231.58
CHB_29	2964	3041	77	F3 - C3	0.00	76.92	100.00	100.00
CHB_30	3159	3240	81	FP1 - F3	-33.33	50.00	92.31	136.11
					RELATIVE ALPHA	0.0922	RELATIVE DELTA	0.3928

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PATIENT	ALPHA	DELTA	PERCENTAGE CHANGE
CH01	0.0139	0.7892	98.24%
CH02	0.0516	0.5793	91.09%
CH03	0.0336	0.544	93.82%
CH04	0.0475	0.4218	88.74%
CH05	0.0134	0.4459	96.99%
CH06	0.0305	0.657	95.36%
CH07	0.065	0.5616	88.43%
CH08	0.011	0.8283	98.67%
CH09	0.1075	0.3551	69.73%
CH10	0.0379	0.5776	93.44%
CH11	0.0564	0.5033	88.79%
CH14	0.0514	0.6376	91.94%
CH16	0.0653	0.5359	87.81%
CH17	0.043	0.5938	92.76%
CH18	0.046	0.6045	92.39%
CH19	0.0922	0.3928	76.53%
CH20	0.0463	0.8696	94.68%
CH21	0.035	0.6552	94.66%
CH22	0.04	0.5288	92.44%

Conclusion

- Identifies the power spectral density of alpha, beta, gamma, theta, and delta waves
- Numerically determines Alpha Slowing in electrodes suggestive of seizure focal point
- Provides time frame of each epoch as output
- Helps neurologists to efficiently pinpoint key moments of unusual brain activity by identifying time frames of a suspected epileptic activity

Future Enhancements

- Implementation of a CNN model to accurately pinpoint the onset of an epileptic seizure using the existing extracted features
- Further feature extraction using mean power of the brain waves
- Identification of new correlations between the brain waves in different frames of the preictal stage

Prediction of epileptic seizure using CNN model for Patient 23 - chb23_09.csv

Model: "sequential_1"

Layer (type)	Output Shape	Param #
conv1d_3 (Conv1D)	(None, 21, 32)	128
max_pooling1d_2 (MaxPooling1D)	(None, 10, 32)	0
conv1d_4 (Conv1D)	(None, 8, 64)	6,208
max_pooling1d_3 (MaxPooling1D)	(None, 4, 64)	0
conv1d_5 (Conv1D)	(None, 2, 64)	12,352
flatten_1 (Flatten)	(None, 128)	0
dense_2 (Dense)	(None, 64)	8,256
dense_3 (Dense)	(None, 1)	65

Prediction of epileptic seizure using CNN model for Patient 23 - chb23_09.csv

```
loss, accuracy = model.evaluate(X_test_array, y_test_array)
print(f'Test loss: {loss}')
print(f'Test accuracy: {accuracy}')
```

```
23082/23082 ━━━━━━━━━━━━━━━━━━━━ 37s 2ms/step - accuracy: 0.9871 - loss: 0.0407
Test loss: 0.04057246074080467
Test accuracy: 0.9871258735656738
```

```
print(accuracy)
```

```
0.9871258735656738
```


References

- A.T. Tzallas, M.G. Tsipouras and D.I. Fotiadis, "Epileptic Seizure Detection in EEGs Using Time–Frequency Analysis," in IEEE Transactions on Information Technology in Biomedicine, vol. 13, pp. 703-710, Sept. 2009, doi: 10.1109/TITB.2009.2017939.
- J Gotman, “Automatic recognition of epileptic seizures in the EEG, Electroencephalography and Clinical Neurophysiology”, Volume 54, Issue 5,1982, pp. 530-540,https://doi.org/10.1016/0013-4694(82)90038-4.

References

- L. Boubchir, B. Daachi and V. Pangracious, "A review of feature extraction for EEG epileptic seizure detection and classification," 2017 40th International Conference on Telecommunications and Signal Processing (TSP), Barcelona, Spain, 2017, pp. 456-460, doi: 10.1109/TSP.2017.8076027.

Appendix B: Vision, Mission, Programme Outcomes and Course Outcomes

DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING

RAJAGIRI SCHOOL OF ENGINEERING & TECHNOLOGY (AUTONOMOUS)

RAJAGIRI VALLEY, KAKKANAD, KOCHI, 682039

(Affiliated to APJ Abdul Kalam Technological University)

Vision, Mission, Programme Outcomes and Course Outcomes

Institute Vision

To evolve into a premier technological institution, moulding eminent professionals with creative minds, innovative ideas and sound practical skill, and to shape a future where technology works for the enrichment of mankind.

Institute Mission

To impart state-of-the-art knowledge to individuals in various technological disciplines and to inculcate in them a high degree of social consciousness and human values, thereby enabling them to face the challenges of life with courage and conviction.

Department Vision

To become a centre of excellence in Computer Science and Engineering, moulding professionals catering to the research and professional needs of national and international organizations.

Department Mission

To inspire and nurture students, with up-to-date knowledge in Computer Science and Engineering, ethics, team spirit, leadership abilities, innovation and creativity to come out with solutions meeting societal needs.

Programme Outcomes (PO)

Engineering Graduates will be able to:

1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

2. Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4. Conduct investigations of complex problems: Use research-based knowledge including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. Individual and Team work: Function effectively as an individual, and as a member or leader in teams, and in multidisciplinary settings.

10. Communication: Communicate effectively with the engineering community and with society at large. Be able to comprehend and write effective reports documentation. Make effective presentations, and give and receive clear instructions.

11. Project management and finance: Demonstrate knowledge and understanding of engineering and management principles and apply these to one's own work, as a member and leader in a team. Manage projects in multidisciplinary environments.

12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change.

Programme Specific Outcomes (PSO)

A graduate of the Computer Science and Engineering Program will demonstrate:

PSO1: Computer Science Specific Skills
The ability to identify, analyze and design solutions for complex engineering problems in multidisciplinary areas by understanding the core principles and concepts of computer science and thereby engage in national grand challenges.

PSO2: Programming and Software Development Skills
The ability to acquire programming efficiency by designing algorithms and applying standard practices in software project development to deliver quality software products meeting the demands of the industry.

PSO3: Professional Skills
The ability to apply the fundamentals of computer science in competitive research and to develop innovative products to meet the societal needs thereby evolving as an eminent researcher and entrepreneur.

Course Outcomes

After the completion of the course the student will be able to:

CO1:

Identify technically and economically feasible problems (Cognitive Knowledge Level: Apply)

CO2:
Identify and survey the relevant literature for getting exposed to related solutions and get familiarized with software development processes (Cognitive Knowledge Level: Apply)

CO3:
Perform requirement analysis, identify design methodologies and develop adaptable & reusable solutions of minimal complexity by using modern tools & advanced programming techniques (Cognitive Knowledge Level: Apply)

CO4:
Prepare technical report and deliver presentation (Cognitive Knowledge Level: Apply)

CO5:
Apply engineering and management principles to achieve the goal of the project (Cognitive Knowledge Level: Apply)

Appendix C: CO-PO-PSO Mapping

COURSE OUTCOMES:

After completion of this course the student will be able to

SL NO.	DESCRIPTION	Bloom's Taxonomy Level
CO1	Identify technically and economically feasible problems (Cognitive Knowledge Level: Apply)	Level 3: Apply
CO2	Identify and survey the relevant literature for getting exposed to related solutions and get familiarized with software development processes (Cognitive Knowledge Level: Apply)	Level 3: Apply
CO3	Perform requirement analysis, identify design methodologies and develop adaptable & reusable solutions of minimal complexity by using modern tools & advanced programming techniques (Cognitive Knowledge Level: Apply)	Level 3: Apply
CO4	Prepare technical report and deliver presentation (Cognitive Knowledge Level: Apply)	Level 3: Apply
CO5	Apply engineering and management principles to achieve the goal of the project (Cognitive Knowledge Level: Apply)	Level 3: Apply

CO-PO AND CO-PSO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	2	3	2	3	2	2		3	3	3	3
CO2	3	3	2		2	3		3	2	2		3	3	3	3
CO3	3	3	3	2	3	3		3	2	2	3	3			3
CO4	3	2	3	2	2	3		3	3	3	3	3			3
CO5	3	3	3	3	3	3	2	3	3	3	3	3	3	3	3

3/2/1: high/medium/low

JUSTIFICATION FOR CO-PO MAPPING:

MAPPING	LOW/ MEDIUM/ HIGH	JUSTIFICATION
101003/CS622T.1 - PO1	**HIGH**	Identify technically and economically feasible problems, by applying the knowledge of mathematics , science and engineering fundamentals to the solution of complex engineering problems.
101003/CS622T.1 - PO2	**HIGH**	Identify technically and economically feasible problems to formulate, review research literature, and analyze complex engineering problems to reach substantiated conclusions.
101003/CS622T.1 - PO3	**HIGH**	Identify technically and economically feasible problems to design solutions for complex engineering problems and system components or processes that meet the specified needs for the public health and safety, and the cultural, societal, and environmental considerations.
101003/CS622T.1 - PO4	**HIGH**	Identifying technically and economically feasible problems and use research-based knowledge to provide valid conclusions.
101003/CS622T.1 - PO5	**MEDIUM**	Identify technically and economically feasible problems to create, select, and apply appropriate techniques, resources, and modern engineering and IT tools with an understanding of the limitations.
101003/CS622T.1 - PO6	**HIGH**	Identify technically and economically feasible problems and apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
101003/CS622T.1 - PO7	**MEDIUM**	Identify technically and economically feasible problems to understand the impact of the professional engineering solutions in societal and environmental contexts.
101003/CS622T.1 - PO8	**HIGH**	Identify technically and economically feasible problems to apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
101003/CS622T.1 - PO9	**MEDIUM**	Identify technically and economically feasible problems to function effectively as an individual, and as a member or leader in teams, and in multidisciplinary settings.

101003/CS622T.1 - PO10	**MEDIUM**	Identify technically and economically feasible problems to communicate effectively with the engineering community and with society at large.
101003/CS622T.1 - PO12	**HIGH**	Identify technically and economically feasible problems to recognize the need for, and have the preparation and ability to engage in independent and lifelong learning in the context of technological change.
101003/CS622T.1 - PSO1	**HIGH**	Identify technically and economically feasible problems to identify, analyze and design solutions for complex engineering problems in multidisciplinary areas by understanding the core principles and concepts of computer science.
101003/CS622T.1 - PSO2	**HIGH**	Identify technically and economically feasible problems to acquire programming efficiency by designing algorithms and applying standard practices in software project development.
101003/CS622T.1 - PSO3	**HIGH**	Identify technically and economically feasible problems to apply the fundamentals of computer science in competitive research and to develop innovative products to meet societal needs.
101003/CS622T.2 - PO1	**HIGH**	Identify and survey the relevant literature to get exposed to related solutions and get familiarized with software development processes to apply the knowledge of mathematics, science, and engineering fundamentals to the solution of complex engineering problems.
101003/CS622T.2 - PO2	**HIGH**	Identify, formulate, review research literature, and analyze complex engineering problems to reach substantiated conclusions.
101003/CS622T.2 - PO3	**MEDIUM**	Design solutions for complex engineering problems and design system components or processes that meet the specified needs for the public health and safety, and the cultural, societal, and environmental considerations.
101003/CS622T.2 - PO5	**MEDIUM**	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools with an understanding of the limitations.
101003/CS622T.2 - PO6	**HIGH**	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

101003/CS622T.2 - PO8	**HIGH**	Apply ethical principles and commit to the professional ethics, responsibilities, and norms of the engineering practice.
101003/CS622T.2 - PO9	**MEDIUM**	Function effectively as an individual, and as a member or leader in teams, and in multidisciplinary settings.
101003/CS622T.2 - PO10	**MEDIUM**	Communicate effectively with the engineering community and with society at large. Be able to comprehend and write effective report documentation. Make effective presentations, and give and receive clear instructions.
101003/CS622T.2 - PO12	**HIGH**	Recognize the need for, and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change.
101003/CS622T.2 - PSO1	**HIGH**	The ability to identify, analyze, and design solutions for complex engineering problems in multidisciplinary areas by understanding the core principles and concepts of computer science.
101003/CS622T.2 - PSO2	**HIGH**	The ability to acquire programming efficiency by designing algorithms and applying standard practices in software project development to deliver quality software products meeting the demands of the industry.
101003/CS622T.2 - PSO3	**HIGH**	The ability to apply the fundamentals of computer science in competitive research and to develop innovative products to meet societal needs, thereby evolving as an eminent researcher and entrepreneur.
101003/CS622T.3 - PO1	**HIGH**	Perform requirement analysis and apply the knowledge of mathematics, science, and engineering fundamentals, to the solution of complex engineering problems.
101003/CS622T.3 - PO2	**HIGH**	Identify and design methodologies to identify, formulate, review research literature, and analyze complex engineering problems, reaching substantiated conclusions.
101003/CS622T.3 - PO3	**HIGH**	Perform requirement analysis, design solutions for complex engineering problems, and system components or processes that meet the specified needs for the public health and safety.
101003/CS622T.3 - PO4	**MEDIUM**	Perform requirement analysis, identify design methodologies, and develop adaptable & reusable solutions of minimal complexity and use research-based knowledge to provide valid conclusions.

101003/CS622T.3 - PO5	**HIGH**	Perform requirement analysis, design solutions of minimal complexity by using modern tools to create, select, and apply appropriate techniques, resources, and modern engineering and IT tools with an understanding of the limitations.
101003/CS622T.3 - PO6	**HIGH**	Perform requirement analysis, identify design methodologies and develop adaptable & reusable solutions of minimal complexity to assess societal, health, safety, legal, and cultural issues.
101003/CS622T.3 - PO8	**HIGH**	Application of ethical principles and commitment to professional ethics and responsibilities and norms of the engineering practice.
101003/CS622T.3 - PO9	**MEDIUM**	Identify design methodologies and develop adaptable & reusable solutions and function effectively as an individual, and as a member in teams.
101003/CS622T.3 - PO10	**MEDIUM**	Perform requirement analysis, identify design methodologies and develop adaptable & reusable solutions and communicate effectively.
101003/CS622T.3 - PO11	**HIGH**	Identify methodologies and develop adaptable & reusable solutions to demonstrate knowledge and understanding of engineering and management principles.
101003/CS622T.3 - PO12	**HIGH**	Recognize the need for, and have the preparation and ability to engage in independent and lifelong learning.
101003/CS622T.3 - PSO3	**HIGH**	Perform requirement analysis, design solutions of minimal complexity by using modern tools to apply the fundamentals of computer science in competitive research.
101003/CS622T.4 - PO1	**HIGH**	Prepare technical reports and deliver presentations on the application of knowledge of mathematics, science, engineering fundamentals, to the solution of complex engineering problems.
101003/CS622T.2 - PO2	**MEDIUM**	Prepare technical reports and deliver presentations on the identification, formulation, review of research literature, and analysis of complex engineering problems
101003/CS622T.4 - PO3	**HIGH**	Design solutions for complex engineering problems and design system components or processes
101003/CS622T.4 - PO4	**MEDIUM**	Prepare technical reports and deliver presentations on the use of research-based knowledge to provide valid conclusions.

101003/CS622T.4 - PO5	**MEDIUM**	Technical reports and presentations on the techniques, resources, and modern engineering and IT tools used.
101003/CS622T.4 - PO6	**HIGH**	Responsibilities relevant to the professional engineering practice to prepare technical reports and deliver presentations.
101003/CS622T.4 - PO8	**HIGH**	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
101003/CS622T.4 - PO9	**HIGH**	Function effectively as an individual, and as a member or leader in teams in the preparation of reports and presentations.
101003/CS622T.4 - PO10	**HIGH**	Be able to comprehend and write effective reports documentation. Make effective presentations, and give and receive clear instructions.
101003/CS622T.4 - PO11	**HIGH**	Manage projects in multidisciplinary environments.
101003/CS622T.4 - PO12	**HIGH**	Recognize the need for, and have the preparation and ability to engage in independent and lifelong learning
101003/CS622T.4 - PSO3	**HIGH**	The ability to apply the fundamentals of computer science in competitive research.
101003/CS622T.5 - PO1	**HIGH**	Apply engineering and management principles to achieve the goal of the project by applying the knowledge of mathematics, science, engineering fundamentals, to the solution of complex engineering problems.
101003/CS622T.5 - PO2	**HIGH**	Identify, formulate, review research literature, and analyze complex engineering problems to achieve the goal of the project.
101003/CS622T.5 - PO3	**HIGH**	Design solutions for complex engineering problems and design system components or processes that meet the specified needs of the project.
101003/CS622T.5 - PO4	**HIGH**	Use research-based knowledge including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
101003/CS622T.5 - PO5	**HIGH**	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools to achieve goals of the project.

101003/CS622T.5 - PO6	**HIGH**	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
101003/CS622T.5 - PO7	**MEDIUM**	Understand the impact of the professional engineering solutions, and demonstrate the knowledge of, and need for sustainability throughout the development of the project.
101003/CS622T.5 - PO8	**HIGH**	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice to achieve the goals of the project.
101003/CS622T.5 - PO9	**HIGH**	Function effectively as an individual, and as a member or leader in teams, and in multidisciplinary settings aiming for the completion of the project.
101003/CS622T.5 - PO10	**HIGH**	Communicate effectively with the engineering community and with society at large, Be able to comprehend and write effective reports and documentation for the project.
101003/CS622T.5 - PO11	**HIGH**	Manage all aspects of the project in multidisciplinary environments.
101003/CS622T.5 - PO12	**HIGH**	Recognize the need for, and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change.
101003/CS622T.5 - PSO1	**HIGH**	Identification, analysis and designing solutions for complex engineering problems in multidisciplinary areas by understanding the core principles and concepts of computer science towards the goals of the project.
101003/CS622T.5 - PSO2	**HIGH**	Acquire programming efficiency by designing algorithms and applying standard practices in software project development to deliver quality software products.
101003/CS622T.5 - PSO3	**HIGH**	Application of the fundamentals of computer science in competitive research and to develop innovative products to meet societal needs thereby evolving as an eminent researcher and entrepreneur.