Analyzing Temporal Dynamics of Seizures to Model their Progression Using EEG data

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The real problem

TEMPORAL DYNAMICS

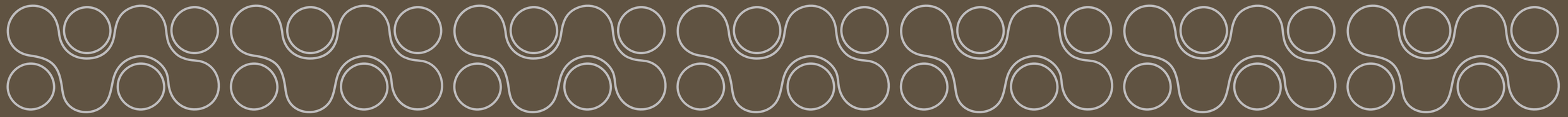
Studying how EEG signal features evolve before and during seizures allows for the development of systems that don’t just detect seizures but predict them.

BLACKBOX VS TRUST

Many high-performing AI models (like deep learning) lack interpretability, making them difficult for clinicians to trust or adopt.

EARLY SEIZURE DETECTION

Epileptic seizures can strike unpredictably, posing severe health and safety risks. Current reactive systems often fail to provide early warnings. Our research addresses this real-world medical challenge by analyzing how seizures evolve over time

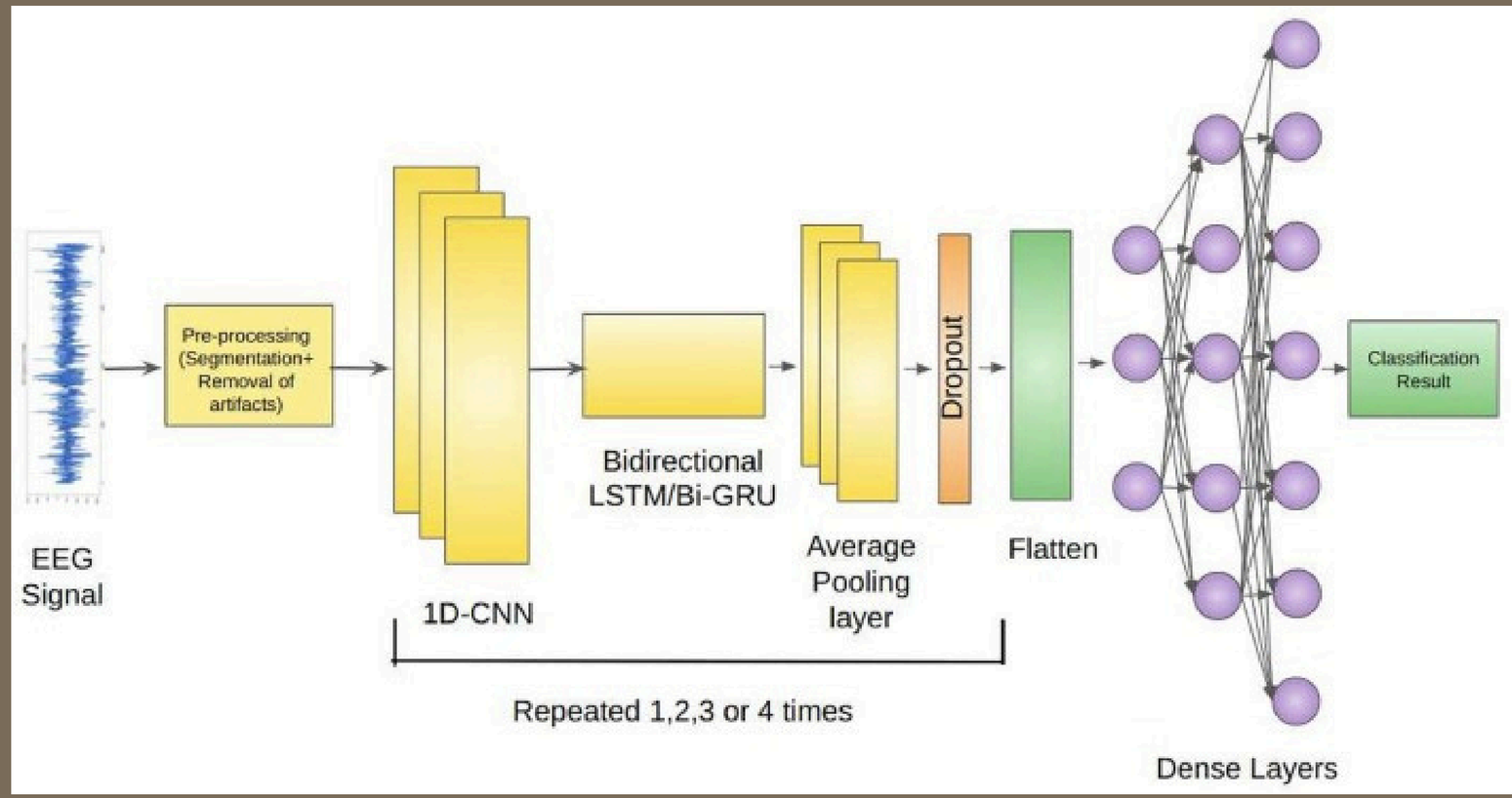


LITERATURE REVIEW

Paper 1: Novel deep learning framework for detection of epileptic seizures using EEG signals

1. Deep learning-based approach for detecting epileptic seizures
2. combines 1D convolutional layers, Bidirectional LSTM, and average pooling to extract temporal features from EEG data
3. The Bidirectional LSTMs help extract features from the temporal data

- Binary accuracy - 99-100%
- Temporal analysis accuracy - 95.81%–98%

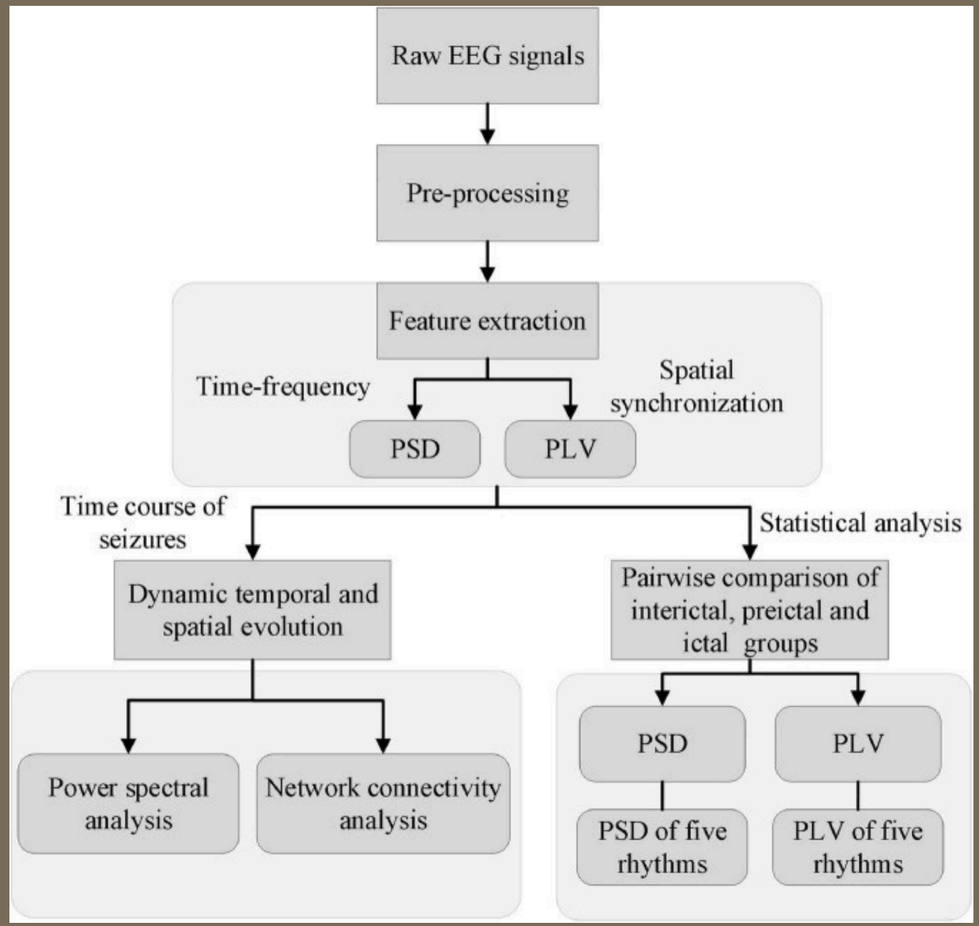


https://pmc.ncbi.nlm.nih.gov/articles/PMC11000706/

LITERATURE REVIEW

Paper 2: Temporal and spatial dynamic propagation of electroencephalogram by combining power spectral and synchronization in childhood absence epilepsy

1. Uses power spectral density (PSD) and phase locking value (PLV) to assess time-frequency-spatial characteristics.
2. study focuses on understanding the spatial and temporal propagation of epileptic signals to analyze how seizures spread in the brain.



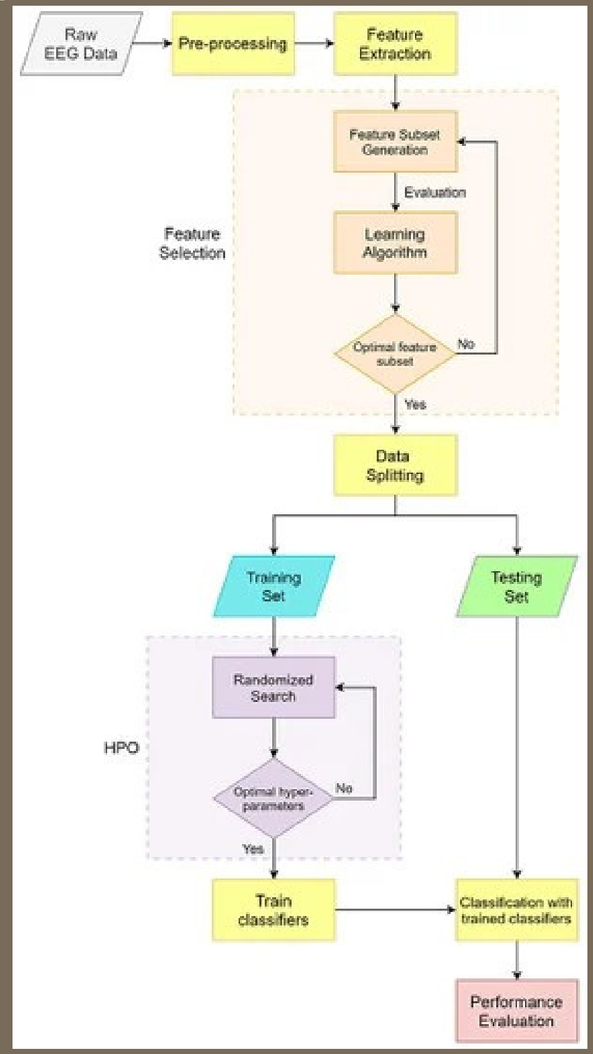
https://pmc.ncbi.nlm.nih.gov/articles/PMC9433125/

LITERATURE REVIEW

Paper 3: Application of Machine Learning in Epileptic Seizure Detection

1. Detect epileptic seizures using EEG data.
2. Uses statistical measures like mean, standard deviation, skewness, and kurtosis

- Accuracy - 98.5%



https://www.mdpi.com/1957998

D A T A S E T

Clinical purpose

Collected to study seizure dynamics and assess surgical candidacy

Nature

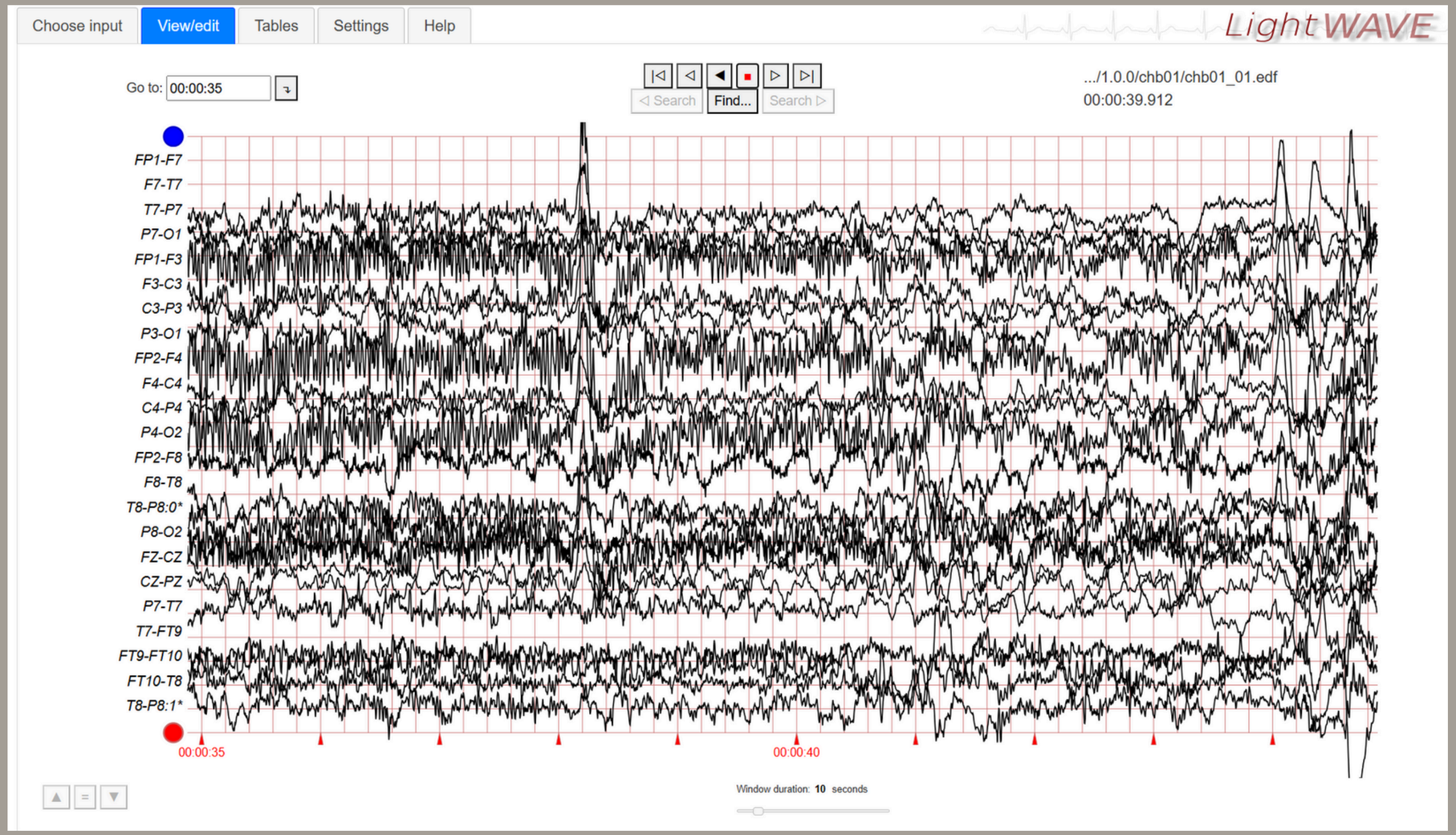
The CHB-MIT Scalp EEG Database is a widely-used publicly available dataset containing EEG recordings from pediatric patients with intractable epilepsy.

- Contains 198 annotated seizures across 686 recordings (over 950 hours)
- Standardized 256 Hz sampling rate with 16-bit resolution

File Type

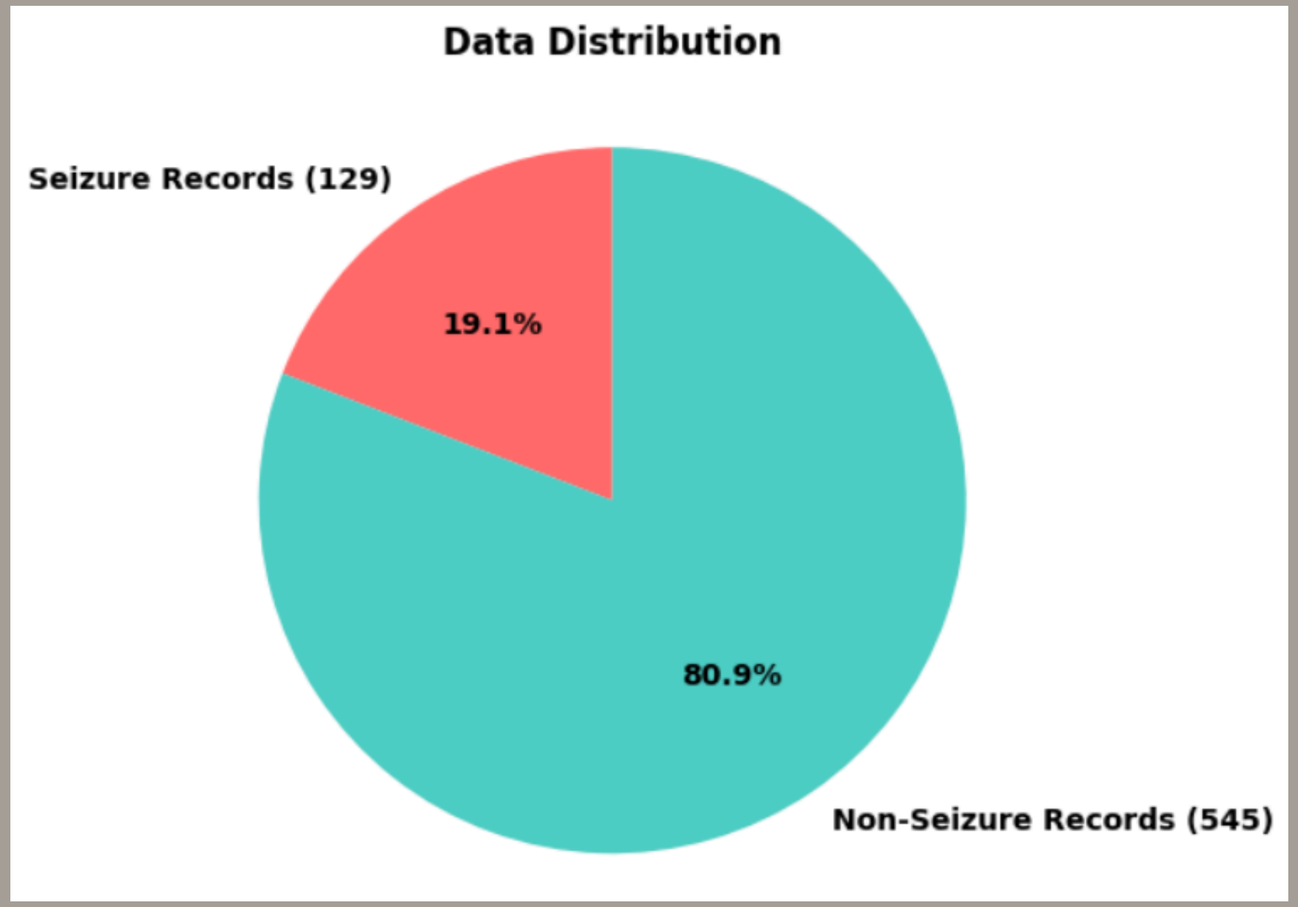
The European Data Format (EDF) is a simple and flexible format for exchange and storage of multichannel biological and physical signals.

DATASET



A time stamp of EEG data in .edf file format

DATASET



seizure v/s non seizure recordings

PREPROCESSING

Step 1: Rename channel names

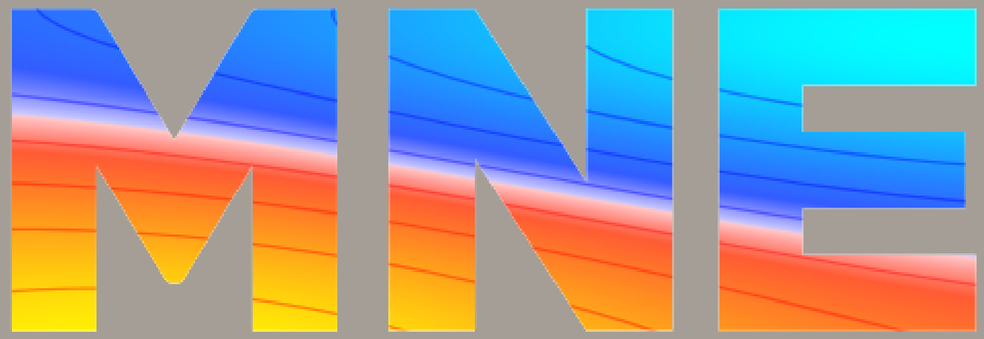
```
# Apply new names
rename_dict = {old: new for old, new in zip(raw.info['ch_names'], unique_channel_names)}
raw.rename_channels(rename_dict)
```

Step 2: Extract EEG Data and Time

```
# Extract the EEG data and timestamps
data, times = raw.get_data(return_times=True)
channel_names = raw.info['ch_names']
```

Step 3: Add time and outcome column to DF

```
# Construct DataFrame
df = pd.DataFrame(data.T, columns=channel_names)
df['Time (s)'] = times
df['Outcome'] = 0.0  # Default label column
```



MEG + EEG ANALYSIS & VISUALIZATION

Open-source Python package for exploring, visualizing, and analyzing human neurophysiological data: MEG, EEG, sEEG, ECoG, NIRS, and more.

ML Methodology

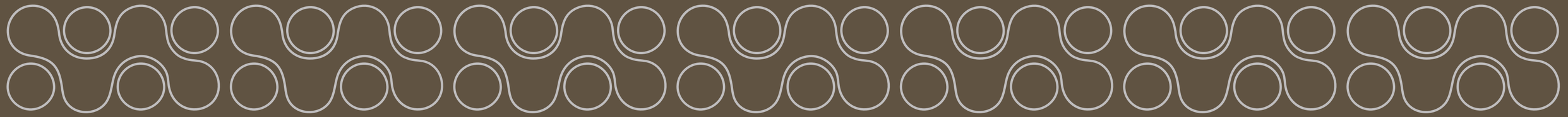
1. Random Forest Classifier
   - Robust to noise due to uses ensemble learning
   - Explainibility
   - Handles non-linear relationships well

2. SMOTE (Synthetic Minority Oversampling Technique)
   - Imbalanced data - many more preictal vs ictal
   - helps prevent bias

Challenges Faced and Solutions

1. Data imbalance
   - Used SMOTE to synthetically balance the training data
   - Evaluated performance using AUC-ROC which is better suited for imbalanced data than accuracy

2. Temporal Dependencies
   - Implemented a lookahead window (300 seconds) for labeling
   - Used overlapping sliding windows with stride (50% overlap)



Performance Metrics

PRECISION

- Class 0 - 93
- Class 1 - 0.91

F1 SCORE

- Class 0 - 0.92
- Class 1 - 0.92

RECALL

- Class 0 - 0.93
- Class 1 - 0.91

Accuracy = 92%

```
=== Evaluation ===
              precision    recall  f1-score   support

           0       0.92      0.91      0.92       120
           1       0.91      0.93      0.92       120

    accuracy                           0.92       240
   macro avg       0.92      0.92      0.92       240
weighted avg       0.92      0.92      0.92       240

AUC-ROC: 0.92
Confusion Matrix:
[[109  11]
 [  9 111]]
True Positives: 111
False Positives: 11
True Negatives: 109
False Negatives: 9
```

Can the solution be deployed at Plaksha to solve the problem you have chosen? If so, how? What may be some challenges for the deployed solution when it will scale up?

Get in Touch

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