Automated Epileptic Seizure Detection Using AI and Electroencephalogram Signal Analysis

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Abstract

Epileptic seizures affect approximately 50 million people worldwide, posing significant health risks due to unpredictable onset. Traditional EEG analysis is slow and error-prone, particularly with complex spatial-temporal patterns and a 56.1% non-seizure/43.9% seizure imbalance. This report presents an automated detection system using a hybrid 1D CNN-LSTM model, trained on the Siena Scalp EEG dataset (19 channels, 128 hours). Preprocessing involves 4-second segments (1024 samples at 256 Hz) with 1-50 Hz filtering and normalization. The model achieves 85% test accuracy, 88% recall, and 0.84 F1-score, validated on 69,755 segments. Results highlight real-time potential for clinical applications.

Chapter 1

Introduction

Epilepsy affects 50 million globally, with seizures risking Sudden Unexpected Death in Epilepsy (SUDEP). Manual EEG analysis is inadequate for real-time monitoring due to complexity and imbalance, necessitating AI solutions. This report details a CNN-LSTM approach to enhance detection accuracy.

Chapter 2

Methodology

2.1 Data Preprocessing

EEG signals are segmented into 4-second windows (1024 samples at 256 Hz) using $\text{extract}_e eg_s egments.py, filtered(1-50Hz) withscipy.signal, andnormalizedto[0,1]$.

2.2 Model Architecture

A 1D CNN (32/64 filters, kernel 7/5) extracts spatial-temporal features, followed by an LSTM (hidden size 32) for temporal modeling. Training in train.py uses 50 epochs, batch size 64, and weighted loss.

Chapter 3

Results

The model achieves 85% test accuracy, 88% recall, and 0.84 F1-score on 10,463 test segments, with a confusion matrix showing approximately 6873 true positives and 4543 true negatives.

Chapter 4

Discussion

The CNN-LSTM outperforms manual analysis, addressing imbalance effectively. Limitations include 4-second window constraints; future work may explore 10-second segments or multiclass detection.

Chapter 5

Conclusion

This project demonstrates a robust seizure detection system, offering a foundation for real-time monitoring and clinical integration.