Executive Summary: Automated Epileptic Seizure Detection Using AI and EEG Signal Analysis

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1 Overview

Epilepsy affects approximately 50 million people globally, with seizures posing risks such as Sudden Unexpected Death in Epilepsy (SUDEP). Traditional electroencephalogram (EEG) analysis, reliant on manual interpretation, is slow, subjective, and inadequate for real-time monitoring, especially given the complex spatial-temporal patterns and a 56.1% non-seizure/43.9% seizure imbalance in EEG data. This project, undertaken as part of the BS Computer Science degree (2021-2025) at Islamia College Peshawar, develops an automated seizure detection system using a hybrid 1D Convolutional Neural Network (CNN) and Long Short-Term Memory (LSTM) model to address these challenges.

2 Objectives

The primary objective is to create a robust, automated system for detecting epileptic seizures from EEG signals, achieving high accuracy and recall to support clinical diagnostics. Secondary goals include mitigating class imbalance, enabling real-time feasibility, and laying the groundwork for future multiclass classification and wearable device integration.

3 Methodology

The Siena Scalp EEG dataset (19 channels, 128 hours) is preprocessed by segmenting signals into 4-second windows (1024 samples at 256 Hz) with 50% overlap, applying a 1-50 Hz

bandpass filter, and normalizing amplitudes to [0, 1] using extract$_{e}eg_{s}egments.py.The1DCNN(32/64fi$
$temporalfeatures, whiletheLSTM(hiddensize32)modelstemporaldependencies.Trainingintrain.pyen$

4 Results

The model achieves 85% test accuracy, 88% recall, and 0.84 F1-score on 10,463 test segments (15% of 69,755 total), with a confusion matrix indicating approximately 6873 true positives and 4543 true negatives. Validation accuracy reaches 83%, with stable loss/accuracy curves after 50 epochs.

5 Discussion

The CNN-LSTM system outperforms manual analysis by effectively capturing complex patterns and handling imbalance. The 4-second window limits temporal context; extending to 10 seconds could enhance performance. Real-time potential is promising, though hardware optimization is needed for wearables.

6 Recommendations

Implement the model in clinical settings for trial, explore 10-second segments, and develop multiclass detection for seizure types. Collaborate with neurologists to validate findings and secure funding for wearable prototypes.