A Biologically-inspired, Biomarker-driven, Rapid Early Warning System for Epileptic Onset Prediction and Seizure Detection Using Machine Learning

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Epilepsy is a chronic brain disorder impacting over 65 million people globally. Each year, >100000 patients die from Sudden Unexpected Death in Epilepsy (SUDEP), many from fatal falls. A reliable seizure forecasting, and early warning system can help patients stay safe. This work presents real-time algorithmic methods for automated seizure detection by performing rapid feature extraction using CHB-MIT's scalp electroencephalogram (EEG) epilepsy database. A new time-frequency domain Discrete Wavelet Transform analysis enables near 100% seizure detection accuracy. Predicting seizures before they occur is a challenging research problem! By analyzing over 200 hours of chronic epileptic physiological data, three unique biomarker pre-seizure patterns were identified and utilized to develop a novel machine learning epilepsy prediction framework. In 16 of 23 patients, EEG data analysis shows distinct bursts of high-frequency oscillations (60-100 Hz range) preceding a seizure. A second biomarker was identified by examining fluctuations in electrocardiogram (ECG) data, called heart rate variability. Stress can precipitate seizures. By periodically monitoring variations in Cortisol, the stress hormone in the human body - elevated cortisol levels can be correlated to seizure onsets. The predictive feature vectors extracted from all three biomarkers are used to train supervised machine learning (ML) classifiers. The final trained ML model can successfully predict seizures 1-22 minutes prior to clinical onset with 91% classification accuracy. All three proposed biomarkers allow for non-invasive patient monitoring. A low-cost (<US$10) open-source electronics platform shows promise for a wearable "epilepsy alert device" to improve emergency response times and help save lives worldwide.

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