National Institute of Technology Karnataka

Design And Development Task In Signal Processing

Mid Sem Report

Epileptic Seizure Detection using Machine Learning Algorithms

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1 Introduction

EEG (electroencephalographic) signal is time varying and exhibits a dynamic nature can be considered chaotic. Hence non-linear dynamics and deterministic chaos theory may present quantitative descriptors to study EEG dynamics. For accurate result we have extracted the following features: Largest lyapunov exponent, Hurst exponent, correlation dimension, embedding dimension and approximate entropy.

2 Chaotic systems

Chaotic systems are non-linear and deterministic. A chaotic signal is characterized by their highly sensitive behavior to their initial conditions. Chaotic motion is highly deterministic when their parameters and initial conditions are specified. Various studies indicate that the brain is a nonlinear dynamic system and EEG signals are its output due to which they are being analyzed by non-linear dynamics.

3 Features

3.1 Hurst Exponent

The Hurst exponent is referred to as the "index of dependence" or "index of long-range dependence". It quantifies the relative tendency of a time series either to regress strongly to the mean or to cluster in a direction. Hurst exponents for epileptic EEG and interictal EEG are both less than 0·5. This indicates that both epileptic and interictal EEGs show long-range anticorrelation. The value of Hurst exponent of epileptic EEG signals is lower than that of interictal EEG signals, showing that the degree of anticorrelation of epileptic EEG signals is larger than that of interictal EEG.

If we consider a time series, but increase the number of observations of it, the rescaled range will generally also increase. The increase of the rescaled range can be characterized by making a plot of the logarithm of R/s vs. the logarithm of n. The slope of this line gives the Hurst exponent, H. Here R is the range and s is standard deviation.

3.2 Approximate Entropy

Approximate entropy (ApEn) is a technique used to quantify the amount of regularity and the unpredictability of fluctuations over time-series data. The presence of repetitive patterns of fluctuation in a time series renders it more predictable than a time series in which such patterns are absent. ApEn reflects the likelihood that similar patterns of observations will not be followed by additional similar observations. A low value of the entropy indicates that the time series is deterministic; and a high value indicates randomness.

3.3 Embedding Dimension

The minimal embedding dimension gives the upper number of nonlinear dynamic system (NDS) freedom degrees and the minimal number of differential equations required for mathematical modeling of NDS. Therefore, the change of the structure of brain NDS during seizure can be shown by the change of embedding dimension of EEG signals if the human brain is considered as a nonlinear dynamic system.
The embedding dimension values of epileptic EEG signals vary intensively during seizure, whereas the embedding dimension values of normal EEG signals keep stable. The embedding dimension of EEG signals becomes much larger during seizure than that of normal EEG signals, the average value of embedding dimension of epileptic EEG signals is over 2 times larger than that of normal EEG signals

3.4 Correlation Dimension

Results from [4] show that the mean values of CD are 2.64 for epileptic EEG and 4.55 for interictal EEG. The values of CD of epileptic EEG are generally lower than those of interictal EEG, indicating less complexity of EEG signals during seizures.

References

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