World Academy of Science, Engineering and Technology
International Journal of Mathematical and Computational Sciences
Vol:12, No:03, 2018

Analysis of Epileptic Electroencephalogram Using Detrended Fluctuation and Recurrence Plots

Authors : Mrinalini Ranjan, Sudheesh Chethil

Abstract : Epilepsy is a common neurological disorder characterised by the recurrence of seizures. Electroencephalogram (EEG) signals are complex biomedical signals which exhibit nonlinear and nonstationary behavior. We use two methods 1) Detrended Fluctuation Analysis (DFA) and 2) Recurrence Plots (RP) to capture this complex behavior of EEG signals. DFA considers fluctuation from local linear trends. Scale invariance of these signals is well captured in the multifractal characterisation using detrended fluctuation analysis (DFA). Analysis of long-range correlations is vital for understanding the dynamics of EEG signals. Correlation properties in the EEG signal are quantified by the calculation of a scaling exponent. We report the existence of two scaling behaviours in the epileptic EEG signals which quantify short and long-range correlations. To illustrate this, we perform DFA on extant ictal (seizure) and interictal (seizure free) datasets of different patients in different channels. We compute the short term and long scaling exponents and report a decrease in short range scaling exponent during seizure as compared to pre-seizure and a subsequent increase during post-seizure period, while the long-term scaling exponent shows an increase during seizure activity. Our calculation of long-term scaling exponent yields a value between 0.5 and 1, thus pointing to power law behaviour of long-range temporal correlations (LRTC). We perform this analysis for multiple channels and report similar behaviour. We find an increase in the long-term scaling exponent during seizure in all channels, which we attribute to an increase in persistent LRTC during seizure. The magnitude of the scaling exponent and its distribution in different channels can help in better identification of areas in brain most affected during seizure activity. The nature of epileptic seizures varies from patient-to-patient. To illustrate this, we report an increase in long-term scaling exponent for some patients which is also complemented by the recurrence plots (RP). RP is a graph that shows the time index of recurrence of a dynamical state. We perform Recurrence Quantitative analysis (RQA) and calculate RQA parameters like diagonal length, entropy, recurrence, determinism, etc. for ictal and interictal datasets. We find that the RQA parameters increase during seizure activity, indicating a transition. We observe that RQA parameters are higher during seizure period as compared to post seizure values, whereas for some patients post seizure values exceeded those during seizure. We attribute this to varying nature of seizure in different patients indicating a different route or mechanism during the transition. Our results can help in better understanding of the characterisation of epileptic EEG signals from a nonlinear analysis.

Keywords : detrended fluctuation, epilepsy, long range correlations, recurrence plots
Conference Title : ICCMN 2018 : International Conference on Computational and Mathematical Neuroscience
Conference Location : Paris, France
Conference Dates : March 15-16, 2018