Novel Interpretation for EEG Data and Prediction of Epileptic Seizure

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Epilepsy is the second most common serious neurological disease after stroke, which affects approximately 50 million people worldwide. One of the devastating aspects of the disease is the inability to predict the time of seizure onset, requiring the constant use of medications with heavy side effects.

Attempts to predict seizures have started in the early 70s, but more seriously since early 90s. Research suggested that EEG signals became less chaotic and more coherent with a phase transition to a preictal stage about 5-7 min before seizure. Measures for phase synchronization, correlation density and dynamic similarity were suggested for detecting the preictal stage and predicting the onset of a seizure (Mormann et al. 2003).

Recently, complex network theory (Albert and Barabasi, 2002) has started playing an important role in EEG data analysis and epileptic seizure prediction in particular. Using this theory, a graph representation of brain activity is formed, and theoretical tools are applied for interpretation of network activity and early detection of seizure. The graph representation includes nodes which naturally represent the time series patterns of each electrode or an activity of a specific brain region. The edges in the graph indicate (Granger) causal relation (Dahlhaus & Eichler, 2003), or sometimes, synchronization (coherence) between the two nodes attached to an edge. Using such representation, it is possible to find causal relations between brain regions and determine functional dependency.

In this paper, we introduce a general method that relies on graph theory and level set theory, to form a graph representation of the dynamic EEG evolution. The complex network emphasizes a different aspect of the dynamics and enables an easy interpretation of EEG signals with respect to the likelihood of a nearing epileptic seizure. This method is general for analyzing different dynamical systems with respect to a certain condition.

Reference

1. R. Albert and A. Barabási. 2002 Statistical mechanics of complex networks. Rev. Mod. Phys. 74, 47 – 97.
2. R. Dahlhaus, & M. Eichler, 2003 Causality and graphical models in time series analysis. In Highly structured stochastic systems (ed. P. Green, N. Hjort & S. Richardson), pp. 115–137. Oxford Press.
3. Fl. Mormann et al. 2003 Automated detection of a preseizure state based on a decrease in synchronization in intracranial electroencephalogram recordings from epilepsy patients. Phys. Rev. E 67.

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