Accepted Manuscript

Multi-scale permutation transfer entropy analysis of EEG

Wenpo Yao, Jun Wang

PII: S0378-4371(17)30491-0
DOI: http://dx.doi.org/10.1016/j.physa.2017.04.181
Reference: PHYSA 18283

To appear in: *Physica A*

Received date: 7 December 2016

Please cite this article as: W. Yao, J. Wang, Multi-scale permutation transfer entropy analysis of EEG, *Physica A* (2017), http://dx.doi.org/10.1016/j.physa.2017.04.181

Multi-scale permutation transfer entropy analysis of EEG

Wenpo Yao[a], Jun Wang[b*]

a, School of Telecommunications & Information Engineering，Nanjing Univ. of Posts & Telecomm, Nanjing 210003

b, School of Geo & Bio Information，Nanjing Univ. of Posts & Telecomm, Nanjing 210023

Abstract: From both the global and local perspectives, we symbolize two kinds of EEG and analyze their dynamic and asymmetrical information using the multi-scale transfer entropy. Multi-scale process of scale factor from 1 to 199 and step size of 2 is firstly applied to EEG of the healthy people and epileptic patients, then the permutation with embedding dimensions of 3 and global approach are used to symbolize the sequences. The forward and reverse symbol sequences are taken as the input of transfer entropy. Scale factor intervals of permutation and global way are (37, 57) and (65, 85) where the two kinds of EEG have satisfied entropy distinctions. When scale factor is 67, transfer entropy of the healthy and epileptic subjects of permutation have biggest difference which is 0.1137 and 0.1028 respectively. And the corresponding values of the global symbolization is 0.0641 and 0.0601 which lies in the scale factor of 165. Research results show that permutation which take the contribution of local information has better distinction and is more effectively applied to our multi-scale transfer entropy analysis of EEG.

Keywords: Symbolization, Permutation, Transfer entropy, Multi-scale, Epilepsy

1. Introduction

EEG, a typical multi-component system, is a kind of important bioelectric signal and has non-linear characteristic which is influenced by many factors[1]. Among the current researches of nonlinear analysis of EEG, entropy approach, a kind of symbolic time-series analysis, has obtained well-known achievements[2,3].

Symbolization is the base of symbolic time-series analysis[4], which involves transformation of raw time series into a series of discretized symbols[5,6]. And the degree of discretization, in many cases, can be quite severe. The commonly used global symbolization[7] extract global parameters of the time series and then symbolize each element by its relationship with the parameters. This kinds of global methods have their disadvantages in the extraction of detailed information and of the unsatisfied real-time performances. Some entropy analysis algorithms, therefore, carry out symbolization by extracting local information, such as permutation entropy[8,9]. Permutation entropy realizes the symbolization by reordering the elements in the reconstructed vectors as ascending or descending orders, having the features of simplicity and speediness. In this paper, the influences of symbolization methods on non-linear dynamic analysis of EEG is researched. We applied multi-scale method to signal preprocessing and symbolize the EEG of the epileptic patients and health subjects by permutation and the global way. And transfer entropy[10,11] is taken contribution in this research to analyze dynamical information and detect asymmetry in the interaction of EEG.

2. Methods

2.1. Symbolization

Symbolization is a compromise of obtaining dynamical information and having a sufficient good statistics, although it causes some loss of detailed information, the coarse dynamic behaviors are preserved, which simplify the signal analysis.

Comparing different kinds of symbolizations, a four-symbol method[7] is commonly used which transforms time series into symbols referring to three given levels. And the three levels are donated by the mean of sequence μ and a special parameter a . In applications, the symbolization is applied separately to the positive and

* Corresponding author. E-mail: wangj@njupt.edu.cn