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Directed Wavelet Covariance

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Abstract

A causal wavelet decomposition of the covariance structure for bivariate locally stationary processes, named directed wavelet covariance, is introduced and discussed. Theoretically, when compared to Fourier-based quantities, wavelet-based estimators are more appropriate to non-stationary processes and processes with local patterns, outliers and rapid regime changes. Results of directed coherence (DC), wavelet coherence (WTC) and directed wavelet covariance (DWC) with simulated data are also presented. All three quantities could identify the simulated covariances structures. Finally, an illustration of the proposed directed wavelet covariance in a task-based EEG experiment is given.

Keywords: Time series, Cross Spectrum, Directed Coherence, Wavelet Covariance.

1. Introduction

Inferences on potential causal relations between non-stationary time series is a key topic in Neuroscience. The identification of recurrent patterns and understanding the organization of brain networks are fundamental to propose effective treatments for diseases like Parkinson disease, epilepsy, schizophrenia and Alzheimer disease. Analytical tools such as directed coherence (DC, Saito and Harashima (1981)), partial directed coherence (PDC, Baccalá and Sameshima (2001)), cross wavelet transform (XWT) and wavelet coherence (WTC, Torrence and Compo (1998) and Grinsted et al. (2004)) have been used to study the source and direction of information. DC and PDC are more appropriate in cases of stationary signals. XWT and WTC are more flexible but require complex wavelet bases leading to a more difficult interpretation of the findings.

On the other hand, when analyzing brain activity, non-stationarity cases are common, such as abrupt pattern changes or local properties of the signals. These signals peculiarities might not

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