EVALUATION OF DIRECT CAUSALITY MEASURES AND LAG ESTIMATIONS IN MULTIVARIATE TIME SERIES

Jolan Heyse[1,*], Pieter van Mierlo[1]

[1]Ghent University, Medical Image and Signal Processing, Belgium

1. INTRODUCTION

The detection and characterization of causal effects among simultaneously observed systems provides knowledge about the underlying network and is a topic of interests in many scientific areas such as EEG analysis for identification of the seizure onset zone in epilepsy.

In this work we examine the behavior of several causality measures on a set of multivariate simulation models with distinct generative processes and connectivity characteristics. This way we can assess how well these measures perform in- and outside their “comfort zone”.

Furthermore, the lag between communicating nodes forms an essential part of physiologic systems and can have a significant impact on the network dynamics. These lags are often forgotten, and we lack proper tools to estimate them. We propose 3 new methods for lag estimation.

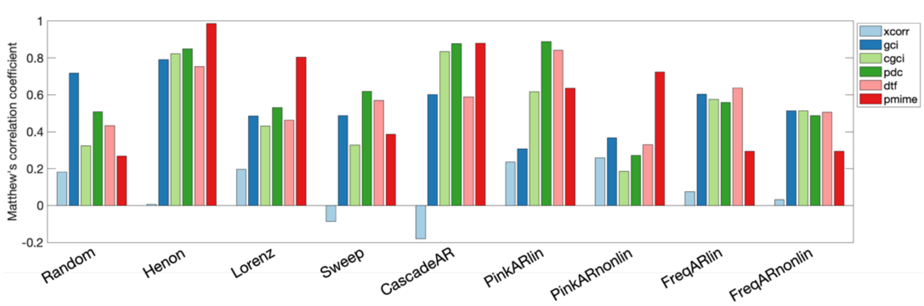
2. MATERIALS AND METHODS

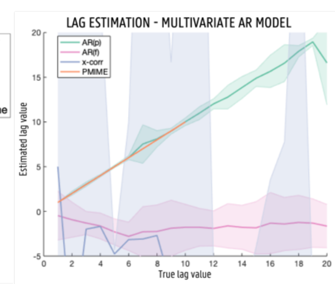
We compare the performance of six well-known methods for detecting directed causal interactions: cross-correlation, (conditional) Granger causality index (CGCI), partial directed coherence (PDC), directed transfer function (DTF) and partial mutual information on mixed embedding (PMIME).

All considered coupling measures are computed on 100 realizations of stochastic and chaotic coupled and uncoupled systems, with general or frequency-specific (non-)linear interaction terms.

Three new lag estimation methods are proposed based on AR models in time- and frequency domain, and the PMIME measure.

3. RESULTS AND CONCLUSION





PDC and DTF give the best results for linear AR models. In cases where non-linear interaction terms are present, their sensitivity and precision drop, as was expected. PMIME is able to reliably detect non-linear interactions and also works best for chaotic models.

Lag estimation with the AR model in time domain shows to reliably estimate the delays in linear multivariate systems for different embedding dimensions. PMIME-based lag estimation works well for both linear and non-linear systems.

Jolan Heyse phone: +329 332 43 26 e-mail: jolan.heyse@ugent.be