TSA toolbox

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This Matlab toolbox allows the Time Specific Analysis of complex systems dynamics through the use of two different approaches [1] for the computation of Information Storage (IS). The former is based on the identification of an autoregressive (AR) model through the recursive least squares (RLS) algorithm as described in [2] under non-stationary assumption and is called time-varying IS (TV-IS). The latter is called local IS (L-IS) and can provide a time-specific representation of the information stored in a system assuming stationarity [3].

[1]- Antonacci, Yuri, et al. "A comparative study of Adaptive Time-Varying and Local Information Storage approaches with Application to physiological systems"(2023).

[2]- Antonacci, Yuri, et al. "Time-varying information measures: an adaptive estimation of information storage with application to brain-heart interactions." Frontiers in Network Physiology 3 (2023).

[3]- Barà, Chiara, et al. "Local and global measures of information storage for the assessment of heartbeat-evoked cortical responses." Biomedical Signal Processing and Control 86 (2023): 105315. [4]- Barnett, Lionel, and Anil K. Seth. "The MVGC multivariate Granger causality toolbox: a new approach to Granger-causal inference." Journal of neuroscience methods 223 (2014): 50-68. [5]- https://www.physionet.org/content/santa-fe/1.0.0/

[6]- https://figshare.com/articles/dataset/epicranialEEG_10rats_zip/5909122/1

To get started, we recommend that you run and work through the two demonstration scripts.

Demonstration scripts

Test_Simulation1,2,3 - These script computes Local and time-varying IS in a

simulative settings for three different scenarios as described in the main paper [1]. (Figure 1-2)

Test_Apnea - This script reproduces the results of Figure 3. Specifically, we analyzed Respiration amplitude [5] from a subject suffering from sleep apneas was used to investigate how local and time-varying approaches work in distinguishing state transitions in breathing dynamics.

Test_EpiEEG - In this script we analyzed Epicranial multichannel EEG from a rodent (IC070523) taken from the dataset [6], during a right whisker stimulation as described in the main paper. Specifically, we investigated how local and time-varying approaches work in distinguishing state transitions in somatosensory evoked potentials.

Functions

RLS_ID_AR1 - Identification procedure of an AR model (only for scalar processes) by using RLS algorithm.

RLS_ID_AR1_IC - Identification procedure of an AR model (only for scalar processes) by using RLS algorithm with fixed initial conditions for AR parameters and innovations variance.

tv_IS - Estimation of time-specific Information storage starting from the matrix of AR coefficients and the residuals variance.

var_nonstat - Generate random multi-trial non-stationary Gaussian VAR time series. This function is part of the toolbox MVGC [4].

surrshuf - Generates surrogate data from original time series through the permutation of temporal order of samples.

mos_idMVAR - estimates the optimal model order with several different criterion.

idMVAR - Given the optimal model order, estimates the AR coefficients and the innovation variance of the process.

localVAR - computes the covariances matrices necessary to compute local IS.

localInfoStorage - Computes Local Information Dynamics analytically for a stationary univariate process starting from the output of the localVAR function.

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