

Time-VaryingIS

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This Matlab toolbox allows for the identification of an autoregressive (AR) model through the recursive least squares (RLS) algorithm, providing a time-specific estimation of the innovation variance and AR model parameters when the stationarity assumption cannot be fulfilled [1]. Subsequently, by employing a recursive solution of the Yule-Walker equations, an estimation of the process variance [2] and, by assuming Gaussianity, it becomes possible to derive information-theoretic measures from the autoregressive analysis of the analyzed process [3]. In this work, we focus on the analysis of Information Storage (IS), which represents the information content of a complex system.

[1]-E. Moller et al., Instantaneous multivariate eeg coherence analysis by means of adaptive high-dimensional autoregressive models. *Journal of neuroscience methods* 105 (2001) 143–158

[2]- Y. Antonacci et al., Time-varying Information measures: an adaptive estimation of information storage with application to brain-heart interactions

[3]- L. Barnett et al., Granger causality and transfer entropy are equivalent for Gaussian variables. *Physical review letters* 103 (2009) 238701.

The code is provided free of charge. It is neither exhaustively tested nor particularly well documented. The authors accept no liability for its use. Use, modification and redistribution of the code is allowed in any way users see fit. Authors ask only that authorship is acknowledged and ref. [2] is cited upon utilization of the code in integral or partial form. To get started, we recommend that you run and work through the two demonstration scripts.

Demonstration scripts

`Test_Simulation` - Performs time-varying identification of a first-order AR model with RLS and computes time-specific information storage as described in the Section III [2]. The coupling strength between the past state of Y and its present state has set to vary over time as a periodic square waveform.

`Test_Application` - Performs time-varying identification of a AR model with RLS

and computes time-specific information storage of brain signals as described in the Section IV [2]. Note that the analysis was reduced to one single subject and one EEG channel due to the high computational time required for the entire procedure. Upon reasonable request the dataset can be shared.

Functions

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

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].

Dataset description Phys_Signals.mat - includes two physiological signals used to compute brain-heart interactions. i) ECG signal of one healthy subject during rest condition; ii) EEG signal recorder over Fp1 according to the 10-20 international system in the same condition.

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