

# tv-OIR toolbox

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Several data-driven approaches based on information theory have been proposed to analyze high-order interactions (HOIs) involving three or more components in a network system. However, most of these methods are limited to the time domain and assume stationarity in the underlying dynamics, making them inherently unable to capture frequency-specific behaviors or track transient functional links in physiological networks.

This toolbox introduces a novel method that enables time-varying and time-frequency analysis of HOIs by leveraging the Entropy Rate (ER) measure to disentangle interactions in physiological networks. The framework is built on a time-resolved representation of vector autoregressive models, combined with its spectral decomposition at each time step, allowing for the assessment of synergistic and redundant interactions among groups of processes.

The toolbox contains a simulation showing how the time-frequency analysis is able to highlight transient synergistic behaviors emerging in specific frequency bands which cannot be detected by time-domain stationary analyses. The application on brain evoked potentials in rats elicits the presence of redundant information timed with whisker stimulation and mostly occurring in the contralateral hemisphere

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. [1] 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.

[1] - Y. Antonacci, *et al.* "A Method for the Time-Frequency Analysis of High-Order Interactions in Non-Stationary Physiological Networks". Submitted to *IEEE Transactions on Biomedical Engineering*.

## Demonstration scripts

TestTheoreticalExample - Computes the theoretical profiles of the HOIs according with Figure 2 of the main paper

Test\_Simulation\_Experiment - Performs time-variant identification of VAR model using recursive least squares (RLS) analysis, as described in Section II [1], and estimates HOIs of orders 3 and 4 for the simulated TV-VAR process.

### **Functions**

- mos\_id\_tv\_VAR\_RLS - model order selection according with the MSPE criterion.
- tvID\_VAR\_RLS - Identification of the TV-VAR model using RLS with a forgetting factor
- tv\_fdVAR - time-frequency representation of a TV-VAR model. This function returns the frequency domain analysis of a TV-VAR model at each time-step.
- tv\_lrp\_oir - this function returns the time-resolved OIR for any given combination of block processes
- tv\_oir - this function returns the time-frequency OIR

### **Contacts**

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