TYPE - SHOWCASE • JULY 18 • SATURDAY

S Showcase

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11:00pm – 11:30pm S

Information theory and directed network inference (using JIDT and IDTxl)

Speakers: joseph.lizier@sydney.edu.au, Leonardo Novelli

Leonardo Novelli, Joseph T. Lizier

S1: Information theoretic measures including transfer entropy are widely used to analyse neuroimaging time series and to infer directed connectivity [1]. The JIDT [2] and IDTxl [3] software toolkits provide efficient measures and algorithms for these applications:

- JIDT (https://github.com/jlizier/jidt) provides a fundamental computation engine for efficient estimation of information theoretic measures for a variety of applications. It can be easily used in Matlab, Python, and Java, and provides a GUI interface for push-button analysis and code template generation.
- IDTxl (https://github.com/pwollstadt/IDTxl) is a specific Python toolkit for directed network inference in neuroscience. It employs multivariate transfer entropy and hierarchical statistical tests to control false positives and has been validated at realistic scales for neural data sets [4]. The inference can be run in parallel using GPUs or a high-performance computing cluster.

This tutorial session will help you get started with software analyses via brief overviews of the toolkits and demonstrations.

Tutorial Website

References

1. Wibral, M., Vicente, R., & Lizier, J. T. (2014). Directed Information Measures in Neuroscience. Springer, Berlin. https://doi.org/10.1007/978-3-642-54474-3
2. Lizier, J. T. (2014). JIDT: An Information-Theoretic Toolkit for Studying the Dynamics of Complex Systems. *Frontiers in Robotics and AI*, *1*, 11. https://doi.org/10.3389/frobt.2014.00011
3. Wollstadt, P., Lizier, J. T., Vicente, R., Finn, C., Martinez-Zarzuela, M., Mediano, P., Novelli, L., and Wibral, M. (2019). IDTxl: The Information Dynamics Toolkit xl: a Python package for the efficient analysis of multivariate information dynamics in networks. Journal of Open Source Software, 4(34), 1081. https://doi.org/10.21105/joss.01081
4. Novelli, L., Wollstadt, P., Mediano, P., Wibral, M., & Lizier, J. T. (2019). Large-scale directed network inference with multivariate transfer entropy and hierarchical statistical testing. Network Neuroscience, 3(3), 827–847. https://doi.org/10.1162/netn_a_00092

Link to software tools:

- JIDT: https://github.com/jlizier/jidt
- IDTxl: https://github.com/pwollstadt/IDTxl

11:30pm – 12:00am S **Introduction to the Brain Dynamics Toolbox**

Speakers: Stewart Heitmann

Stewart Heitmann

S2: The Brain Dynamics Toolbox (https://bdtoolbox.org) is an open-source toolbox for simulating dynamical systems in neuroscience using Matlab. It specifically solves initial-value problems in user-defined systems of Ordinary Differential Equations (ODEs), Delay Differential Equations (DDEs), Stochastic Differential Equations (SDEs) and Partial Differential Equations (PDEs). New models can typically be written in less than 100 lines of code and then applied at all stages of the research lifecycle. Rapid prototyping is done via the graphical interface where the dynamics can be explored interactively without the need for graphical programming. Interactive parameter surveys can then be semi-automated using the Matlab command window. Large-scale simulations can be fully-automated in user-defined scripts.

Once a model is written, the toolbox's hub-and-spoke architecture allows unlimited combinations of plotting tools (display panels) and solver algorithms to be applied to that model with no additional programming effort. The toolbox currently supports a dozen solvers and display panels. It also ships with approximately 30 example models that can be used for teaching or as starting points for building new models. Online training courses are available from the bdtoolbox.org website. Extensive documentation is provided in the Handbook for the Brain Dynamics Toolbox.

This software showcase aims to introduce the toolbox to a wider audience through a series of real-time demonstrations. The audience will learn how to get started with the toolbox, how to run existing models and how to semi-automate the controls to generate a bifurcation diagram.

Background reading and software tools

1. https://bdtoolbox.org•
2. Heitmann S, Breakspear M (2017-2019) Handbook for the Brain Dynamics Toolbox. QIMR Berghofer Medical Research Institute. 1st Edition: Version 2017c, ISBN 978-1-5497-2070-3. 2nd Edition: Version 2018a, ISBN 978-1-9805-7250-3. 3rd Edition: Version 2018b, ISBN 978-1-7287-8188-4. 4th Edition: Version 2019a, ISBN 978-1-0861-1705-9.
3. Heitmann S, Aburn M, Breakspear M (2017) The Brain Dynamics Toolbox for Matlab. Neurocomputing. Vol 315. p82-88. doi:10.1016/j.neucom.2018.06.026.

JULY 19 • SUNDAY

12:00am – 12:30am S **Advances in the PANDORA Matlab Toolbox for intracellular electrophysiology data**

Speakers: Cengiz Gunay

Cengiz Gunay

S3: PANDORA is an open-source toolbox for Matlab (Mathworks, Natick, MA) has been proposed for analysis and visualization of single-unit intracellular electrophysiology data (RRID: SCR_001831, Günay et al. 2009 *Neuroinformatics*, 7(2):93-111. doi: 10.1007/s12021-009-9048-z). Even though there are more modern and popular environments, such as the Python and Anaconda ecosystem, Matlab still offers an advantage in its simplicity, especially towards those less computationally inclined, for instance for collaboration with experimentalists. PANDORA was originally intended for managing and analyzing brute-force neuronal parameter search databases (Günay et al. 2008 *J Neurosci.* 28(30): 7476-7491; Günay et al. 2010 *J Neurosci.* 30: 1686–98). However, it has been proven useful for other types of simulation or experimental data analysis (Doloc-Mihu et al. 2011 *Journal of biological physics*, *37*(3), 263–283. doi:10.1007/s10867-011-9215-y; Lin et al. 2012 *J Neurosci* 32(21): 7267–77; Wolfram et al. 2014 *J Neurosci*, 34(7): 2538–2543; doi: 10.1523/JNEUROSCI.4511-13.2014; Günay et al. 2015 *PLoS Comp Bio.* doi: 10.1371/journal.pcbi.1004189; Wenning et al. 2018 *eLife* 2018;7:e31123 doi: 10.7554/eLife.31123; Günay et al. 2019 *eNeuro*, *6*(4), ENEURO.0417-18.2019. doi:10.1523/ENEURO.0417-18.2019). PANDORA's original motivation was to offer object-oriented analysis specific to neuronal data inside the Matlab environment, in particular with a database table-like object, similar to R and the Python PANDAS toolbox's "dataframe" object, and a new syntax for a powerful database querying system. The typical workflow would constitute of generating parameter sets for simulations, and then in the resulting output data, finding spikes and additional characteristics to construct databases, and finally analyze and visualize these database contents. PANDORA provides objects for loading datasets, controlling simulations, importing/exporting data, and visualization. Since it's inception, it has grown with added functionality. In this showcase, we review the toolbox's standard features and show how to customize them for a given project, and then introduce some of the new and experimental features, such as ion channel fitting, evolutionary/genetic algorithms. Furthermore, we will give a developers' perspective for those who may be interested in adding modules to this toolbox.