PO.11.SPIKE-order: A new method to sort spike trains from leader to follower

Measures of spike train synchrony (or inversely spike train distances) are estimators of the (dis)similarity between two or more spike trains. The terminology comes from neuroscience where spike train refers to a sequence of stereotypical neuronal action potentials (spikes). However, these measures can also be applied to many other sequences of discrete events.

Over the last years a wide variety of such measures have been introduced. Three recent proposals (ISI-distance, SPIKE-distance, SPIKE synchronization [**1,2,4**]) share the desirable property of being time-resolved and parameter-free (time-scale independent). However, their bivariate versions are symmetric and in consequence their multivariate versions are invariant to changes in the order of spike trains. None of these measures is designed to provide information about directionality.

Here we introduce a method (termed SPIKE order) that allows to sort multiple spike trains from leader to follower. This is meant purely in the sense of temporal sequence. The question asked is: Which are the spike trains that tend to fire first, and which are the ones that tend to fire last? Leader-follower dynamics are encountered frequently not only in neuroscience, but also in fields as wide-ranging as climatology, social communication, and human-robot interaction.

The algorithm uses the adaptive coincidence detection first proposed for the bivariate measure event synchronization [**3**] and then also employed in SPIKE synchronization to identify pairs of coincident spikes. For these pairs the consistency of the leader-follower relationship is quantified resulting in the final SPIKE order value.

Analyzing a spike train set with SPIKE order yields three kinds of results: How close is the original and how close is the optimal sorting to a synfire chain (consistent repetition of the same sequence of spikes), and which is the optimal sorting. The new method is distinguished by conceptual simplicity, flexibility, low computational cost, and universality (parameter-free and time-scale adaptive).

[1] Kreuz T, Mulansky M, Bozanic N. J Neurophysiol 113, 3432 (2015)
[2] Mulansky M, Bozanic N, Sburlea A, Kreuz T. IEEE Proceedings EBCCSP 1-8 (2015)
[3] Quian Quiroga R, Kreuz T, and Grassberger P. Phys Rev E 66, 041904 (2002)
[4] Source codes: http://www.fi.isc.cnr.it/users/thomas.kreuz/sourcecode.html; https://github.com/ma

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