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Measuring spike train reliability

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Measuring the degree of synchrony between two or more neuronal spike trains is an important tool in order to address issues such as neuronal coding, information transmission and model validation. Another prominent application is to measure the reliability of the response of individual neurons upon repeated presentations of the same stimulus. A number of both multivariate and bivariate measures have been proposed to address this issue. Multivariate approaches include the reliability measures by Hunter and Milton [1] and by Tiesinga [2], while bivariate approaches comprise the Victor-Purpura [3] and the van Rossum [4] distance, as well as the similarity measure proposed by Schreiber et al. [5], and, the most recent proposal, the ISI-distance [6], a method based on relative instantaneous firing rates. These approaches can be applied to multivariate data in a pairwise fashion, e.g., reliability can be defined as the average over all pairwise similarities.

Here, we extend the bivariate ISI-distance to a truly multivariate measure [7]. This extension inherits the distinct properties of the ISI-distance, in particular, it is parameter free and time scale adaptive. In an application to *in vitro* recordings of cortical cells from rats we show that the multivariate ISI-distance serves as an excellent means to track relative firing patterns in the spike trains. The instantaneous degree of synchrony can be visualized easily, thus rendering this method a good choice for moving window applications on non-stationary neuronal dynamics. In particular, when estimating reliability this property allows the analyst to correlate intervals of high or low synchrony to the respective local stimulus features, which is desirable in many applications. Furthermore, we use a simulated network of Hindemarsh-Rose neurons with predefined clustering [8] as a controlled setting to evaluate the performance of the multivariate ISI-distance in distinguishing different sets consisting of a variable number of spike trains from different clusters. In a comparison with other multivariate approaches, as well as generalizations of several bivariate methods, the method presented here proves to be a very reliable indicator of set balance.

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