Neurons relay messages by abrupt changes in the voltage over their cell membrane. These spikes transmit information and perform computation in the brain. Neurons are connected to each other by synapses, where the spike of one neuron is relayed through chemical messenger molecules in chemical synapses or as ion leakage through gap-junctions in electrical synapses to the next neuron. One of the most used identifier for neuronal activity is to record spikes from the neurons, since they are easily detectable by electrodes. When recorded over time, these spikes form spike trains, where successive spikes from the neurons are assigned to single spike train. A set of spike trains is called raster plot.

In order to discriminate between neuronal responses to different stimuli some kind of measure of neuronal responses needs to be carried out. The most used quantifier of responses is the similarity of their spike trains to repeated stimuli. In a typical setup different stimuli are presented repeatedly and a pairwise dissimilarity analysis with spike train distances is carried out in order to evaluate whether neuronal responses to the same stimulus exhibit higher degrees of synchrony than responses to different stimuli. Two most used time scale parametric methods for spike train similarity are Victor-Purpura [1] and Van Rossum distances [2]. These methods have however a drawback of being sensitive only to one timescale, which is given by the user as a parameter. This means that the result obtained depends on the user input and they do not perform well if the spike trains contain more than one time scale. These drawbacks have been eliminated in time scale independent ISI- [3] and SPIKE-distances[4] and SPIKE-synchronization [5] measure by Kreuz et al., since these methods always adapt to the local firing rate.

The PhD will be done for COSMOS [6] European Joint Doctorate program European Union's Horizon 2020 research and innovation programme under Marie-Sklodowska-Curie grant. The project is jointly supervised by Prof. Thomas Kreuz at the University of Florence and Profs. Andreas Daffertshofer and Bob van Dijk at Vrije Universiteit Amsterdam. In this project we will apply three recently developed measures of spike train synchrony to simulated and real data. These measures comprise the ISI-distance, the SPIKE-distance, and SPIKE-synchronization. One of the main objectives is to develop and apply an algorithm which identifies within a larger neuronal population the one subpopulation which discriminates the presented stimuli best.

Project description in COSMOS page

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[1] J. D. Victor, K. P. Purpura, Nature and precision of temporal coding in visual cortex: A metric-space analysis, J Neurophysiol 76 (1996) 1310.
[2] M. C. W. van Rossum, A novel spike distance, Neural Computation 13 (2001) 751.
[3] T. Kreuz, J. S. Haas, A. Morelli, H. D. I. Abarbanel, A. Politi, Measuring spike train synchrony, J Neurosci Methods 165 (2007) 151.
[4] T. Kreuz, D. Chicharro, M. Greschner, R. G. Andrzejak, Timeresolved and time-scale adaptive measures of spike train synchrony, J Neurosci Methods 195 (2011) 92.
[5] T. Kreuz, M. Mulansky, N. Bozanic, Spiky: A graphical user interface for monitoring spike train synchrony, J Neurophysiol 113 (2015) 3432.
[6] http://www.uni-potsdam.de/cosmos-itn/?page_id=198