Poster D-2

A time series analysis tool for the analysis of neuronal activity in Parkinson disease

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Short Abstract: We present a computational tool that integrates classic and novel graphical statistical methods to make a qualitative and quantitative analysis of neural activity signal recordings from in vivo rats with induced Parkinson disease, allowing systematically assessing neuronal behavior and detecting synchrony between firing patterns of neurons affected by Parkinson disease.

Long Abstract:
Although the physiological behaviour of a neuron is well understood, it remains unknown the different activities and patterns of interaction among them. There are about 1011 neurons in the human brain, where each neuron can have up to 1000 synaptic connections. In order to understand Parkinson disease, the electrophysiological changes of neurons in the SNpr (Substantia Nigra Pars Reticulata), which is the area of the brain affected by the disease, were characterized in rat experimental models induced to get Parkinson by 6-OHDA toxin. This assessment showed a high percentage (~40%) of the neurons were firing in bursts, where in animal control neurons (with spontaneous discharges) the bursting is detected only in up to 5% of the cells [Mur/97]. A later work showed a periodic activity on the bursting frequency, discharging approximately once per second. Furthermore, the electrophysiological recording analysis on pairs of neurons demonstrated that these periodic discharges occur in a synchronize way in the neurons affected by the Parkinson disease [Tse/01]. Motivated by a problem raised from scientists at the Neurophysiology Laboratory about the difficulty to systematically assess neuronal behavior and to detect synchrony between firing patterns of different neurons affected by Parkinson disease, we present computational tool that makes a qualitative and quantitative assessment of the neural activity signals (extracellular single neural unit recordings). The software integrates classic and novel graphical statistical methods corresponding to the non-linear time series analysis to enhance our vision of the data set, to reveal underlying activity patterns in the firing structure of the neurons and to detect synchrony on pairs of neurons by reconstructing the corresponding attractor to the neuron dynamics in a restricted phase space. The analyzed signals were recorded simultaneously in vivo from the SNpr on rat models with induced Parkinson disease. The program is java implemented and includes the following graphical methods and techniques: autocorrelation diagrams, crossed correlation diagrams, inter-spikes intervals (ISI) histograms, generation of spike raster-grams and real time dynamic graphs to compare inter-spikes intervals. In addition, and innovating, we present the variability diagrams, which are a graphical method to represent the existing (higher order)

local correlation among the successive values of a time series. Because most of the biological experimental data have a high dimensionality, the variability diagrams here presented proved to be a useful method, not used before, to understand the underlying dynamics of these no lineal systems. The application of these methods on Parkinson neuronal time series let us detected a kind of inhibitory synchrony among neurons, a negative correlation pattern where one neuron is inhibited while the other exited, that the research done by the time in this area was unaware. The resulting software is able to detect the existence of determinism (underlying patterns) and synchronism in the neuronal dynamics. It helps the scientists researching in the area to make a fast diagnostic in relation to the analysed recordings. The tool has been generalized to process other signals obtained from different dynamic systems such as the non linear biological systems.