UNSUPERVISED SPIKE SORTING OF EXTRACELLULAR ELECTROPHYSIOLOGICAL RECORDING IN SUBTHALAMIC NUCLEUS OF PARKINSONIAN PATIENTS

Olga K. Chibirova[1], Tetyana I. Aksenova[1,2], Alim-Louis Benabid[1,3], Stephan Chabardes[1], Steeve Larouche[4], Jean Rouat[4], Alessandro E. P. Villa[1,3]

(1) Laboratory of Preclinical Neuroscience, INSERM U318,
CHUG Michallon Pavillon B, BP 217, F-38043 Grenoble Cedex 9, France
{Olga.Chibirova, Tatyana.Aksyonova, Alim-Louis.Benabid, Alessandro.Villa}@ujf-grenoble.fr
SChabardes@chu-grenoble.fr

(2) Institute of Applied System Analysis, Ukrainian Academy of Sciences,
Prospekt Peremogy, 37, Kyiv 03056, Ukraine

(3) Laboratoire de Neurobiophysique, Université Joseph Fourier Grenoble 1, UFR Médecine
CHUG Michallon Pavillon B, BP 217, F-38043 Grenoble Cedex 9, France

(4) Dépt de génie électrique et de génie informatique, IMSI, Université de Sherbrooke
2500 boul. de l'université, Sherbrooke, Québec, Canada J1K 2R1
slarouche@hermes.usherb.ca, Jean.Rouat@ieee.org

ABSTRACT

In our previous study [1,2] we present an approach for automatic classification Unsupervised Spikes Sorting (USS) of extracellularly recorded action potentials of neurons. The spike waveforms are described by the nonlinear oscillating model as an ordinary differential equation with perturbation, thus characterizing the signal distortions in both amplitude and phase. We have developed an unsupervised iteration-learning algorithm that estimates the number of classes and their centers according to the distance between spike trajectories in phase space. This algorithm scans the learning set in order to evaluate spikes trajectories with maximal probability density in their neighborhood. Following the learning step of the algorithm, the procedure of minimal distance is used to perform spike recognition.

In the present study we provide additional testing of the algorithm with artificial data set to estimate the accuracy of spike sorting. We present results of its application for the characterization of single unit activity recorded extracellularly in the Subthalamic Nucleus (STN) of Parkinsonian patients.

The simulated data set was generated with three spikes that were summarized with an original signal from STN. We have made several computational experiments to compare the percentage of errors with different level of noise and with the denoising technique Time and Spatial Adaptation (TSA) based on wavelet transform [3]. With the level of noise that it is typical for the real data recorded in the surgery room we found near 7% of missing spikes but no misclassification. An increase of denoising increases the percentage of errors because of the distortions in the original signal introduced by the denoising procedures. These results demonstrate that we can expect to have well isolated single units by an unsupervised procedure.

Multi-channel recordings of STN activity were collected from 5 Parkinsonian patients during the brain surgery aimed to locate the optimal sites for Deep Brain Stimulation. Stable neuronal activity was observed in 38 recording sites. The patterns of neuronal activity were characterized on the basis of the autocorrelograms and crosscorrelograms. Several examples of these patterns will be illustrated in the presentation.

Keywords: Extracellular spike sorting, deep brain stimulation, multi-channel recordings, subthalamic nucleus.

References

[1] Aksenova T.I., Chibirova O.K., Benabid A.-L., Villa A.E.P. (2002) Nonlinear Oscillation Models for Spike Separation, *Lecture Notes in Computer Science* **2526**: 61-70.

[2] Aksenova, T. I.; Chibirova O.K., Dryga, O.A., Tetko, I. V.; Benabid A.-L.; Villa, A. E. P. (2003) An unsupervised automatic method for sorting neuronal spike waveforms in awake and freely moving animals, *Methods* **30**: 178-187.

[3] Bahoura M., J. Rouat, (2003) Wavelet speech enhancement based on time space adaptation, IEEE Transactions on Speech and Audio Processing. Submitted.