

# Spike Sorting using Eigenfilter and Self-Organized Maps

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## 1 Introduction

In the framework of computational neuroscience, spike sorting methods seeks to identify discriminative components in the measures obtained by electrodes in brain tissues. The neuron's electrical information is essential to model the neural-stimulus coding and decoding. Despite the invasiveness of electrode measures, this is the only technique with enough temporal/spatial resolution to observe the electrical and local behavior of neurons. Most of the neural codes models are based on the time of neurons action potential, however the classification of its different shapes is relevant for noise identification in electrophysiological data and other applications. For instance, with neural decoding it is possible to read complex motor cortex signals in order to control external devices or to reproduce a cat's vision using a brain machine interface [2].

## 2 A brief discussion of methods and results

Based theoretically on the Lewicki review [3], we solved an unsupervised classification problem in a generated dataset of neuron's waveforms. It means that is expected fit the data in a class scheme. In order to generate the dataset Gaussian noise was added,  $\mathcal{N}(t_i, \mu = 0.02, \sigma = 0.02)$ , to seven neuron's action potential templates. These were obtained from Hodgkin-Huxley equation with different parameters and pulse duration as input. The data generation process is depicted in the figure 1.

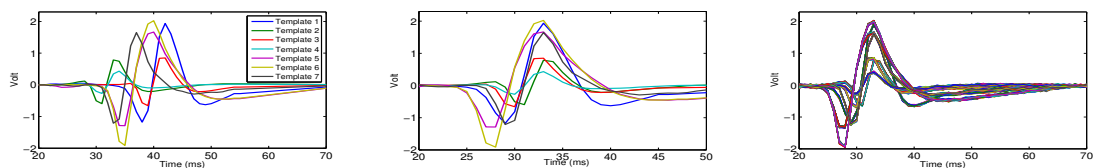


Figure 1: Left to right, respectively, the seven neuron's action potential templates, the templates centered and the fifty noisy instances generated for each class.

In the classification method of spike sorting was used the reconstruction coefficients of principal component analysis [3]. To acquire these, was applied the eigenfilter neural

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network was applied in the waveform dataset in order to obtain their principal components. This technique uses Generalized Hebbian Algorithm (GHA) to learn the eigenvalues and capture the mean waveform that composes each instance in the dataset [1]. The eigenfilter is a single layer feedforward neural network in which each neuron unit in the output layer is linear. The network has  $m$  entries e  $l$  outputs, with  $m$  being the dimensionality of input space and  $l$  the number of principal components to be extracted. Given the time  $n$ , the network adapts to the weights until it reaches the convergence of each principal components  $y_j(n)$ . The principal components are defined as a linear combination of weights with the waveform input,  $y_j(n) = \sum_{i=1}^m w_{ji}(n)x_i(n)$  for  $j = 1, \dots, l$  and the weights  $w_{j,i}$ , from input  $x_i$  to output  $y_j$ , are adapted by the GHA defined as follows,

$$\Delta w_{ji}(n) = \eta [y_j(n)x_i(n) - y_j(n) \sum_{k=1}^j w_{ki}(n)y_k(n)]$$

where  $\Delta w_{ji}(n)$  is the synaptic weight's modification applied to the weight  $w_{ji}(n)$  at time  $n$ , and  $\eta$  is the learning rate. In real spike sorting problems the classes are unknown. Here we are in absence of common issues such as spike overlapping in neuron waveform and electrode drift. The problem then is reduced to recognize properly each cluster as depicted in figure 2. In order to do this, was applied in the coefficients the self-organized map neural network [1], defined by a neuron's grid in which each unit competes with each other to describe the data. Our findings suggest that the grid can be used as class scheme to describe the clusters formation since the number of units in the grid overcome the number of clusters. Furthermore, an equal number of cluster and neurons on the grid do not guarantee a perfect match. Thus, the bigger the size of the grid, the lower the chance of missing the clusters, with a drawback of increasing the computing time.

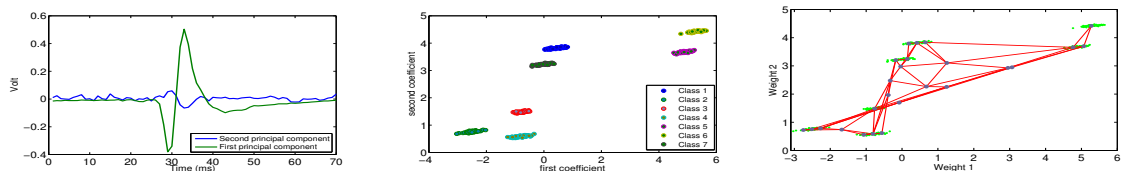


Figure 2: Left to right, respectively, the first two principal component obtained by the eigenfilter, the clusters obtained by the reconstruction coefficients and the self-organized maps (4x4) adapted to the seven clusters.

## References

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- [3] M.S. Lewicki, A review of methods for spike sorting: the detection and classification of neural action potentials, *Network: Computer Neural Systems*, 9, R53–R78, 1998