



## APPLICATION FORM OF NEW CREATION OR PRODUCT (INTELLECTUAL PROPERTY RIGHTS)

**TITLE:** VISSOR: A SOFTWARE PACKAGE FOR SPIKE SORTING OF NEURAL DATA.

**Acronym:** VISSOR (*Viability of Integrated Spike Sorting of Real Recordings*)

**AUTHORS:** Carmen Rocío Caro Martín, Raudel Sánchez Campusano, José María Delgado García, and Agnès Gruart i Massó.

**INSTITUTIONS:** Pablo de Olavide University. Division of Neurosciences. Ctra. Utrera, km. 1. 41013-Seville. Spain.

**FIELD:** *Software / Research tool / Data Mining / Pattern Recognition / Spike Sorting Neurophysiology / Neuroscience.*

### **SHORT DESCRIPTION (max. 300 words):**

**Subject:** Software package for spike sorting analysis of neural time series data. Available functions include data importing/exporting, preprocessing, spike classification, and visualization. The tools for the spike sorting based on shape, phase and distribution features and  $K$ -means clustering with validity and error indices are unique functions provided by this toolbox. All functions have been integrated into a simple and user-friendly graphical user interface environment designed for easy accessibility.

### ***Problem solving and advantages with respect to the state of the art:***

- VISSOR is a robust and non-redundant spike-sorting algorithms based on the exhaustive extraction of features with a clear physiological description of the spike-event. This physiological information is highly appreciated in the qualitative/quantitative characterization of the neuronal activity, including the neural modulating properties, and has practical uses in neurophysiology beyond the mere computation of the number of spikes, classes, or neurons.
- In contrast to other methods also based on feature extraction, the method/algorithm of VISSOR are based on shape, phase and distribution features of each spike-event. Removing the multi-collinearity among the extracted features, the resulting features vector (in a 24D space,  $R^{24}$ ) do not hold redundant information and therefore delete the need to reduce the dimensionality. Furthermore, these independent features can be quickly and easily calculated and represent no imminent threat to the computational cost and complexity of the algorithm.
- For objectively evaluating the spike-sorting capabilities of VISSOR, two integrative measures (cohesion-dispersion,  $CD$ -index; and clustering error,  $CE$ -index) were also implemented to verify both the cohesion-dispersion among spike-events and the misclassification of clustering.

### ***Essential technical characteristics:***

- Recognizes and supports files in text (.txt) and wave (.wav) formats.
- Introduces an adaptive amplitude threshold during the spike detection.

- Assigns a 24D-vector of shape, phase and distribution features for each spike-event.
- Use an unsupervised *K*-means clustering with validity and error indices.

***Technology that uses:***

The core functionality of the *VISSOR* software was implemented on MATLAB (version 7.12.0, R2011a, The MathWorks, Natick, MA, USA) platform.

***Note:*** attach if necessary additional documentation, figures, tables, etc. that help explain the object of the result / invention.

Enclosed please find the Supplementary Information: *VISSOR* Block Diagram (Figure S1) and *VISSOR* Extracted Features (Figure S2, and Tables S1 and S2) sections.

***Development status:*** *VISSOR* version 1.0 / R2017a - Available to the user from the website: <http://www.divisiondeneurociencias.es/>

***Applicability (max. 200 words): present and future applicability.***

In particular, this algorithm can be used for off-line analysis of neural data. The general application is the pattern recognition in real electrophysiological data (intracellular, extracellular or multi-electrode-array recordings), including the spike sorting analysis. *VISSOR* could be considered an efficient alternative toolbox of spike sorting to determine the actual spike identities and the modulating properties of the involved neurons, beyond the mere spike classification. *VISSOR* toolbox is suitable for both single-microelectrode recordings and for simultaneous recordings of multi-array electrodes. Moreover, we are positive influenced of the possibility of extending the *VISSOR* method/algorithm to off-line analysis of high-density arrays recordings. Optimizing the spike detection/identification step and keeping the relevant spike information during the feature extraction is possible to explore key physiological properties, such as the oscillation patterns of a particular neural event or the neuronal correlates of a specific cognitive process. Future versions of *VISSOR* will be toward the direction of investigating the on-line and multi-array electrodes performances of the proposed *VISSOR* method/algorithm for both research and clinical applications.

**NOVELTY:**

***Alternatives:*** List other alternative solutions to your research / invention result that already exist in the market today.

*Other spike-sorting toolboxes (current alternative packages):*

- CED Spike2 - spike sorting tool: Multi-unit spike discrimination using PCA clustering.
- Wave\_clus: Unsupervised spike sorting with wavelets and superparamagnetic clustering.

***Advantages:*** Indicate the main technical advantages of your research / invention result with respect to the solutions cited above / business benefits that could derive from the advantages.

- CED Spike2 vs. *VISSOR*: CED Spike2 uses principal component analysis (PCA) clustering, reducing dimensionality with the consequent loss of relevant information about the spike-events. *VISSOR* does not reduce dimensionality; instead, it removing the multi-collinearity between the extracted waveform features.
- Wave\_clus vs. *VISSOR*: There are no technical advantages between these toolboxes. Both use different feature extraction methods and different classification algorithms.

Too often, misapplication of the feature extraction method leads to extreme reduction of dimensionality and therefore the resulting feature matrices are “abstract” mathematical entities (based on coefficients, factors, or components) that do not reflect the main functional properties of the neural events under study. The uniqueness of the *VISSOR* package is that instead of the reduction of dimensionality adopted in most alternative toolboxes, it carries out spike sorting analyses based on a 24D-vector of independent features (shape, phase and distribution measures) for each spike, removing the multi-collinearity among features to simplify the classification process. Furthermore, the classification technique involves the *K*-means clustering with validity and error indices to verify both the cohesion-dispersion among spike-events and the misclassification of clustering, respectively. Besides, the proposed *VISSOR* method/algorithm ensured that both the resulting number of clusters and the value of the error index (*CE*-index) do not depend on the number of features used in the spike-sorting algorithm.

### **DIFFUSION:**

*Has the result or object of the invention been previously disclosed? If YES, indicate means of dissemination, date and content (e.g., theses, publications, congresses, conferences, etc.).*

No yet.

*Has not been published yet, but has the article been sent to a journal or congress?*

Not yet, but *VISSOR* toolbox will be published in the doctoral thesis of one of us (C.R. Caro-Martín).

*Has it been communicated to third parties under a confidentiality agreement? Attach if affirmative.*

No yet.

*Interest in dissemination and publication.*

Yes.

### **EXPLOITATION:**

*Product with possible commercial/market high potential success Is it an improvement of a product already known or is it totally new?*

High potential market. *VISSOR* is an alternative product whose functionality (method and algorithm) includes distinctive features (see above paragraphs) with respect to other current products (e.g., CED Spike2 - spike sorting tool and Wave\_clus toolbox).

*The potential market would be exclusively national / international (Europe / U.S.A. / Japan / others).*

National and International.

*Do you know of any company or entity that might be interested in this result / invention? If YES, indicate which one (s).*

No yet.

*Have you already contacted any company for possible transfer and exploitation?*

No yet.

*Reference prices or market.*

Reference price is under consideration.