



**HAL**  
open science

## Parametric estimation of spike train statistics

Bruno Cessac, Thierry Viéville

► **To cite this version:**

Bruno Cessac, Thierry Viéville. Parametric estimation of spike train statistics. BMC Neuroscience, 2009, 10 (Suppl 1), pp.P165. hal-00784454

**HAL Id: hal-00784454**

**<https://inria.hal.science/hal-00784454>**

Submitted on 4 Feb 2013

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Poster presentation

Open Access

## Parametric estimation of spike train statistics

Bruno Cessac\*<sup>1,2</sup> and Thierry Viéville<sup>3</sup>

Address: <sup>1</sup>LJAD, U. Of Nice-Sophia, France, <sup>2</sup>NEUROMATHCOMP, INRIA Sophia-Antipolis Méditerranée, France and <sup>3</sup>CORTEX, INRIA-LORIA, France

Email: Bruno Cessac\* - Thierry.Vieville@sophia.inria.fr

\* Corresponding author

from Eighteenth Annual Computational Neuroscience Meeting: CNS\*2009  
Berlin, Germany. 18–23 July 2009

Published: 13 July 2009

BMC Neuroscience 2009, **10**(Suppl 1):P165 doi:10.1186/1471-2202-10-S1-P165

This abstract is available from: <http://www.biomedcentral.com/1471-2202/10/S1/P165>

© 2009 Cessac and Viéville; licensee BioMed Central Ltd.

### Introduction

We consider the evolution of a network of neurons, focusing on the asymptotic behavior of spikes dynamics instead of membrane potential dynamics. The spike response is not sought as a deterministic response in this context, but as a conditional probability: "Reading the code" consists in inferring this probability [1]. Since one has experimentally only access to finite time raster plots and since the convergence of the empirical statistics to their average can be quite slow, we use a parametric statistical model using a thermodynamic formalism. The natural candidate for spike train statistics is a Gibbs measure [2]. Our work generalizes this seminal and profound work of Bialek and collaborators. This model allows us to predict the conditional probability of rank  $R$  Markovian spike patterns and is strongly linked with the thermodynamic formalism [3]. It generalizes most spike patterns statistical models (e.g. Poisson, correlated Poisson, etc.).

### Methods

A minimal instantiation of the formalism is reviewed, following [3,4], while a general algorithmic estimation method is proposed, minimizing the relative entropy, yielding fast convergent implementations. It is also made explicit how several spike observables (entropy, rate, synchronizations, correlations) are given in closed-form from the parametric estimation. This paradigm not only allows us to estimate the spike statistics, given a design choice, but also to compare different models, thus answering comparative questions about the neural code such as are

correlations or time synchrony or a given set of spike patterns significant with respect to rate coding?

### Results

A numerical validation of the method is proposed, in order to analyze the statistics of small groups (up to 8/12) of neurons, while the state of the art considers pairs only. The parametric statistical potential of Markov processes up to rank 16/20 is calculable, thus considering up to  $2^{20}$  states for the process. The method has been carefully calibrated with respect to standard processes such as Bernoulli processes. The implementation considers several well-established numerical methods, in order to be applicable to a large set of possible data. It is available as an open-source module in the <http://enas.gforge.inria.fr> middle-ware set. EnaS is a set of classes allowing to simulate and analyze so called "event neural assemblies." It is designed mainly as existing simulator plug-in (e.g. MVASpike or other simulators via the NeuralEnsemble meta-simulation platform) or as an add-on for computations with neural unit assembly on standard platforms. It is usable in C/C++, Java and Python.

### Acknowledgements

Partially supported by the ANR MAPS & the MACCAC ARC projects.

### References

1. Rieke F, Warland D, de Ruyter van Steveninck R, Bialek W: *Spikes, Exploring the Neural Code* MIT Press; 1996.
2. Schneidman E, Berry MJ, Segev R, Bialek W: **Weak pairwise correlations imply strong correlated network states in a neural population.** *Nature* 2006, **440**:1007-1012.

3. Chazottes JR, Floriani E, Lima R: **Relative entropy and identification of Gibbs measures in dynamical systems.** *J Statist Phys* 1998, **90**:697-725.
4. Cessac B, Rostro-Gonzalez H, Vasquez JC, Viéville T: **How Gibbs distribution may naturally arise from synaptic adaptation mechanisms.** *Stat Phys* in press.

Publish with **BioMed Central** and every scientist can read your work free of charge

*"BioMed Central will be the most significant development for disseminating the results of biomedical research in our lifetime."*

Sir Paul Nurse, Cancer Research UK

Your research papers will be:

- available free of charge to the entire biomedical community
- peer reviewed and published immediately upon acceptance
- cited in PubMed and archived on PubMed Central
- yours — you keep the copyright

Submit your manuscript here:  
[http://www.biomedcentral.com/info/publishing\\_adv.asp](http://www.biomedcentral.com/info/publishing_adv.asp)

