



HAL
open science

Bumps and waves in a two-dimensional multilayer neural field model

Olivier Faugeras, François Grimbert

► **To cite this version:**

Olivier Faugeras, François Grimbert. Bumps and waves in a two-dimensional multilayer neural field model. BMC Neuroscience, 2007, 8 (Suppl 2), pp.P68. hal-00784466

HAL Id: hal-00784466

<https://inria.hal.science/hal-00784466>

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

Bumps and waves in a two-dimensional multilayer neural field model

Olivier Faugeras and François Grimbert*

Address: Odyssee Laboratory, INRIA/ENPC/ENS, INRIA Sophia Antipolis, France

Email: Olivier Faugeras - Olivier.Faugeras@sophia.inria.fr; François Grimbert* - Francois.Grimbert@sophia.inria.fr

* Corresponding author

from Sixteenth Annual Computational Neuroscience Meeting: CNS*2007
Toronto, Canada. 7–12 July 2007

Published: 6 July 2007

BMC Neuroscience 2007, 8(Suppl 2):P68 doi:10.1186/1471-2202-8-S2-P68

© 2007 Faugeras and Grimbert; licensee BioMed Central Ltd.

Background

Neural field models of firing rate activity have played a major role in developing an understanding of the dynamics of neural tissues [1]. They can be used to model extrinsic optical imaging signals and understand how different neuronal layers contribute to them. A two-dimensional, multi-population approach is therefore required. At a higher level of detail, biological data on horizontal cortical connectivity must be well taken into account. Finally, the spatial resolution of extrinsic optical imaging and biological connectivity studies involving patches of neurons [2,3] suggest a mesoscopic neural mass approach.

Methods

We model a cortical area as a two-dimensional neural field composed of one excitatory and one inhibitory layer of neural masses. It is governed by a four-dimensional integro-differential system that we write as the sum of two terms. The first term is linear and describes the synaptic integration made by the neural masses. The second term is the input feeding a neural mass at a given point of the field. It sums up the contributions of all neural masses in the field by a weighted integral of their instantaneous firing rates. This is done through kernels that include both quantitative ("In which proportion do different types of neurons connect to each other?") and spatial ("How are these connections distributed on the cortical surface?") information between each pair of neuronal types. Neural masses are described by two average variables: the average membrane potential (dendritic compartment) and the

average firing rate (axonal compartment), which is obtained from the potential by a Heaviside transformation.

Results

We have considered translation invariant, rotationally symmetric connectivity kernels and looked for rotationally symmetric bumps and pulses solutions [1,4]. For both problems, the analysis falls in two parts: find solutions and check their stability. In the case of stationary bump solutions, expressing connectivities in terms of Bessel functions leads to closed forms depending on the parameters of the model. But not all these solutions are actual bumps and we need sufficient conditions to characterize acceptable bump radii according to other parameters values. A first step is made by writing several local necessary conditions, *e.g.*, the solution must be equal to the threshold of its Heaviside voltage-to-rate transformation on the boundaries of the bump. The same problem arises for traveling pulses solutions. We then check the stability of bumps and pulses solutions to a family of perturbations with separated polar coordinates by reducing the analysis to an eigenvalue problem. Technical computations lead to implicit formulas for the eigenvalues. In the case of bumps it takes the simple form of a second order polynomial.

Conclusion

The model we have proposed extends previous related work [1,4] in two directions: we can deal with several pop-

ulations of neural masses and perform the model analysis in the framework of a 2D continuum as opposed to 1D. Our analysis raises several interesting biological questions related to connectivity functions that may be answered using optical imaging.

References

1. Coombes S: **Waves, bumps, and patterns in neural fields theories.** *Biol Cybern* 2005, **93**:91-108.
2. Thomson A, Bannister A: **Interlaminar Connections in the Neocortex.** *Cerebral Cortex* 2003, **13**:5-14.
3. Kisvrdy ZF, Toth E, Rausch M, Eysel U: **Orientation-specific relationship between populations of excitatory and inhibitory lateral connections in the visual cortex of the cat.** *Cerebral Cortex* 1997, **7**:605-618.
4. Pinto D, Ermentrout G: **Spatially structured activity in synaptically coupled neuronal networks: I. traveling fronts and pulses.** *SIAM J Appl Math* 2001, **62**:206-225.

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

