

Dynamics of activity fronts in a continuum mean field model of cortex

Schmidt, Helmut; Bojak, Ingo; Coombes, Stephen

DOI:

[10.1186/1471-2202-11-S1-P28](https://doi.org/10.1186/1471-2202-11-S1-P28)

License:

Creative Commons: Attribution (CC BY)

Document Version

Publisher's PDF, also known as Version of record

Citation for published version (Harvard):

Schmidt, H, Bojak, I & Coombes, S 2010, Dynamics of activity fronts in a continuum mean field model of cortex. in *BMC Neuroscience: Nineteenth Annual Computational Neuroscience Meeting: CNS*2010*. vol. 11 (suppl 1), P28, BMC Neuroscience, no. (Suppl 1), vol. 11, Nineteenth Annual Computational Neuroscience Meeting, 2010, San Antonio, TX, United States, 24/07/10. <https://doi.org/10.1186/1471-2202-11-S1-P28>

[Link to publication on Research at Birmingham portal](#)

General rights

Unless a licence is specified above, all rights (including copyright and moral rights) in this document are retained by the authors and/or the copyright holders. The express permission of the copyright holder must be obtained for any use of this material other than for purposes permitted by law.

- Users may freely distribute the URL that is used to identify this publication.
- Users may download and/or print one copy of the publication from the University of Birmingham research portal for the purpose of private study or non-commercial research.
- User may use extracts from the document in line with the concept of 'fair dealing' under the Copyright, Designs and Patents Act 1988 (?)
- Users may not further distribute the material nor use it for the purposes of commercial gain.

Where a licence is displayed above, please note the terms and conditions of the licence govern your use of this document.

When citing, please reference the published version.

Take down policy

While the University of Birmingham exercises care and attention in making items available there are rare occasions when an item has been uploaded in error or has been deemed to be commercially or otherwise sensitive.

If you believe that this is the case for this document, please contact UBIRA@lists.bham.ac.uk providing details and we will remove access to the work immediately and investigate.

POSTER PRESENTATION

Open Access

Dynamics of activity fronts in a continuum mean field model of cortex

Helmut Schmidt¹, Ingo Bojak^{2*}, Stephen Coombes¹

From Nineteenth Annual Computational Neuroscience Meeting: CNS*2010
San Antonio, TX, USA. 24-30 July 2010

The functional organization of cortex appears to be roughly columnar, with the laminar sub-structure of each column organizing its micro-circuitry. These columns tessellate the two-dimensional cortical sheet with high density, e.g., 2,000 cm² of human cortex contain 10⁵ to 10⁶ macrocolumns, comprising about 10⁵ neurons each. Continuum mean field models (cMFMs) describe the mean activity of such columns by approximating the cortical sheet as continuous excitable medium [1]. cMFMs can generate rich patterns of emergent spatiotemporal activity [2]. This has been used to understand phenomena from visual hallucinations to the generation of EEG signals. Pattern boundaries are here defined as the interface between low and high states of average neural activity.

cMFMs support travelling patterns as well as the formation of intricate structures, as in Fig. 1. Here we derive equations of motion for the pattern boundaries of a simple cMFM, showing that their normal velocities are driven by Biot-Savart-style interactions. The solutions of these exact, but dimensionally reduced, equations for activity fronts are in excellent numerical agreement with those of the full nonlinear integral equation defining the neural field. A linear stability analysis of the dynamics of the interfaces allows us to understand mechanisms of pattern formation arising from instabilities of spots, fronts, and stripes. We further test our results against partial differential equations equivalent to the original integral equation, c.f. [3], and perform numerical simulations on a large spatial grid that represents a sizable cortical sheet. In particular, we clarify how more realistic firing rates (computed with

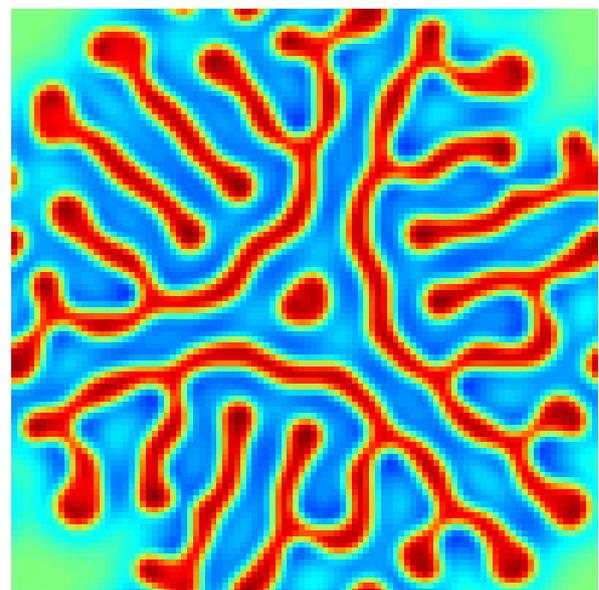


Figure 1 Pattern formation originating in an instable spot. cMFMs support travelling waves that underlie EEG signals; but also spots of localized high firing activity, which have been linked to models of working memory. These spots can become instable and pattern cortex with intricate structures, such as the labyrinthine one shown here. Red color indicates high activity, blue low. The original spot is still visible in the center.

sigmoidal functions instead of Heaviside steps) influence the dynamics of activity fronts.

Conclusions

Changes of brain activity are often of greater interest than the current state per se. On the cortical sheet, two-dimensional patterns can be defined by boundaries between high and low states of activity, and their dynamics can be specified by tracking the evolution of these interfaces. Using a simple cMFM, we show here

* Correspondence: i.bojak@donders.ru.nl

²Donders Institute for Brain, Cognition and Behaviour, Centre for Neuroscience, Radboud University Nijmegen (Medical Centre), P.O. Box 9101 // 126, 6500 HB Nijmegen, The Netherlands

that one can describe the motion of activity fronts with equations of reduced complexity, which nevertheless reproduce the observed dynamics faithfully. This improves our ability to study pattern formation and suggests more generally that modelling the interfaces of patterns, rather than the patterns themselves, may lead to novel, efficient descriptions of brain activity.

Author details

¹School of Mathematical Sciences, University of Nottingham, Nottingham NG7 2RD, UK. ²Donders Institute for Brain, Cognition and Behaviour, Centre for Neuroscience, Radboud University Nijmegen (Medical Centre), P.O. Box 9101 // 126, 6500 HB Nijmegen, The Netherlands.

Published: 20 July 2010

References

1. Coombes S: **Large-scale neural dynamics: Simple and complex.** *Neuroimage* 2010, doi:10.1016/j.neuroimage.2010.01.045.
2. Coombes S, Venkov NA, Shiau L, Bojak I, Liley DTJ, Laing CR: **Modeling electrocortical activity through improved local approximations of integral neural field equations.** *Phys Rev E Stat Nonlin Soft Matter Phys* 2007, **76**:051901.
3. Bojak I, Liley DTJ: **Axonal velocity distributions in neural field equations.** *PLoS Comput Biol* 6:e1000653.

doi:10.1186/1471-2202-11-S1-P28

Cite this article as: Schmidt et al.: Dynamics of activity fronts in a continuum mean field model of cortex. *BMC Neuroscience* 2010 11(Suppl 1):P28.

**Submit your next manuscript to BioMed Central
and take full advantage of:**

- Convenient online submission
- Thorough peer review
- No space constraints or color figure charges
- Immediate publication on acceptance
- Inclusion in PubMed, CAS, Scopus and Google Scholar
- Research which is freely available for redistribution

Submit your manuscript at
www.biomedcentral.com/submit

