



Self-Organization and Brain Function

Project URL: <http://brainhack.org/self-organization-and-brain-function>

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1 Introduction

Self-organization is a fundamental property of complex systems, describing the order spontaneously arising by the local interactions of the system components not mediated by top-down inputs. Though, self-organizing systems typically possess a large number of components and exhibit complex dynamics, their evolution is deterministic and governed by a small number of order parameters. This property was used to model the self-organization of the ocular dominance columns of the striate cortex in patterns of neighboring stripes [1], which respond preferentially to inputs from the left or the right eye. In this model the self-organization across ocular dominance and orientation preference layers was coupled, were both layers were modeled with the Swift-Hohenberg equation [2]. We reduce the model complexity by including only the cortical dominance layer and investigate the parameter dependency of the self-organization with a Matlab implementation.

2 Approach

The Swift-Hohenberg equation [2] was used to model the self-organization of the ocular dominance columns. There are two order parameters in this equation, the first one determines the spatial wavelength λ of the stripes and the second one the branchiness ϵ of the pattern. Δ is the Laplace operator.

$$\partial_t \psi(x, y, t) = [\epsilon - (\Delta + \frac{4\pi^2}{\lambda^2})^2] \cdot \psi - \psi^3 \quad (1)$$

The algorithm used to generate the results has been modified from an [open source script](#). The Swift-Hohenberg equation was solved by applying periodic

boundary conditions after a Fourier transform to k space, which simplifies the computation of the solution.

3 Results

Figures (a), (b) and (c) show the temporal evolution of the solution to the Swift-Hohenberg equation for random initial conditions (a), constant ϵ and time increasing from (a) to (c). In (c), (d) and (e) three solutions with different ϵ are shown. The branchiness increases with ϵ from (c) to (e). The wavelength λ was set to the same value in all figures and the pattern in (d) is similar to the ocular dominance layers found in the visual cortex.

4 Conclusions

A simple model suffices to study basic properties of ocular dominance self-organization. Possibly, a combination of models for self-organization in neighboring cortical layers would allow to investigate even higher organizational principles of the cortex [1], e.g. the coordination between ocular dominance layers, orientation layers, and cytochrome oxidase.

Availability of Supporting Data

More information about this project can be found at:

<http://brainhack.org/self-organization-and-brain-function>.

Further data and files supporting this project are hosted in the *GigaScience* repository

https://github.com/Brainhack-Proceedings-2015/Pfan_HBM_SOBF.

Competing interests

None

Author's contributions

JPP, RCM, LCTH, and DD performed the project and wrote the report.

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References

1. Reichl, L., Heide, D., Löwel, S., Crowley, J.C., Kaschube, M., Wolf, F.: Coordinated optimization of visual cortical maps (i) symmetry-based analysis. *PLoS Comput Biol* **8**(11), 1002466 (2012).
doi:[10.1371/journal.pcbi.1002466](https://doi.org/10.1371/journal.pcbi.1002466)
2. Hohenberg, P.C., Swift, J.B.: Effects of additive noise at the onset of rayleigh-bénard convection. *Phys. Rev. A* **46**, 4773–4785 (1992).
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