BMC Neuroscience

BioMed Central

Poster presentation

Open Access

Snaking behavior of homoclinic solutions in a neural field model

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

Published: 13 July 2009

BMC Neuroscience 2009, **10**(Suppl 1):P297 doi:10.1186/1471-2202-10-S1-P297

This abstract is available from: http://www.biomedcentral.com/1471-2202/10/S1/P297

Introduction

In our work, we investigate stationary homoclinic solutions of a neural field model with Mexican hat connectivity. Homoclinic solutions, often called "bumps," represent local activity of neural tissue in a state of global quiescence and are related to short-term memory. The solutions have a snake-like shape in the bifurcation diagram. Therefore the evolution of multiple bump solutions are often called "snaking." The scaled model is reduced to parameters of the firing rate function that represents the averaged spike rate of neurons. It can be presented in either an integro-differential equation or an ordinary differential equation (ODE). We investigate the range of parameters in which single bump and multiple bump solutions exist.

Method

To cope with our model we choose an ansatz developed in [1]. It makes use of the integrability of the ODE and of physiologically reasonable boundary conditions. Further, the symmetry of the system is exploited. This approach allows us to reduce the free parameters of the solutions to one. The remaining free parameter is determined by continuation of the boundary conditions and checking the resulting solutions for symmetry. As to general firing rate functions, this method has proven to be advantageous in comparison to shooting methods. In addition to this we investigate the stability of the homoclinic solution by using an ansatz presented in [2]. It approximates the firing rate function to a step function and delivers $2N$ eigenvalues for N-bump solutions.

Conclusion

The neural field model with Mexican hat connectivity produces stable single and multiple bump solutions. The existence of these solutions depends on parameters shaping the firing rate function. It turned out that homoclinic solutions exist only for low firing thresholds. Regarding the fact that just one neuron type is involved, it is still arguable that our results foster insights to the physical basis of short-term memory.

References

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