Numerical continuation of solutions of periodically forced neural field models

L3 internship Project

Neural fields are continuous assemblies of mesoscopic models arising when modelling macroscopic parts of the brain such as the primary visual area V1. They are modelled by nonlinear integro-differential equations [1]. The study of the stationary solutions of these equations allowed to reproduce neural hallucinations [2, 4]. These are spontaneously generated behaviours reproducing drug-induced hallucinations. We are interested in similar percepts but induced by a controlled stimulus. A good example is the flicker-induced geometric phosphenes [3], easily observed with specific glasses, and modelled with a periodic forcing of neural field equations. The goal of this internship is to numerically compute (and follow with respect to some parameter) the time periodic solutions of these equations when the forcing is oscillatory in time and has a specific spatial structure. Based on [4], we expect nonlocal behaviours and potentially new predicted percepts. The rich mathematical structure (symmetries, bifurcations) will surely provide a nice interplay between theory and numerical results.

The intern is asked to develop a program (that can be called from Python) for the computation of periodic orbits of integro-differential equations. The program may be based on the Trilinos library [5] or PETSc [6] and will be used either on the cluster or on GPUs. This is a challenging problem because of the large dimensionality of the system.

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References

[1] Bressloff PC. Spatiotemporal dynamics of continuum neural fields. J Phys A: Math Theor. 2012 Jan 27;45(3):033001.

[2] Bressloff PC, Cowan JD, Golubitsky M, Thomas PJ, Wiener MC. What geometric visual hallucinations tell us about the visual cortex. Neural Computation. 2002;14(3):473–91.

[3] Rule M, Stoffregen M, Ermentrout B. A Model for the Origin and Properties of Flicker-Induced Geometric Phosphenes. PLoS Comput Biol. 2011;7(9):e1002158.

[4] Veltz R, Chossat P, and Faugeras O. On the effects on cortical spontaneous activity of the symmetries of the network of pinwheels in visual area V1. INRIA Sophia Antipolis, 2014, *https://hal.inria.fr/hal-01079055*

[5] http://trilinos.sandia.gov/

[6] http://www.mcs.anl.gov/research/projects/petsc/index.html