Master 2 Internship

«Reading the motion of an object in spatio-temporal retinal correlations»

Project: When an object moves across our visual field, it generates a transient spiking activity in the retina, conveyed to the thalamus and to the visual cortex [1,2]. The trajectory of this object involves long-range correlations in space and in time. Local information about this motion is encoded in the spike trains produced by specific retinal cells - the retinal ganglion cells - in a coordinated manner. Yet, lateral connectivity in the retina - especially via amacrine cells connecting ganglion cells or electric synapses - plays a central role in motion processing (see e.g. [3]). What is the role of this lateral connectivity in motion processing ? Clearly, one may expect that the motion of objects in the visual field induces spatial and temporal correlations in spiking activity, as an echo, a trace, of the object trajectory. This raises the question of which information can be extracted from spatio-temporal correlations in a network of connected neurons, like the retina, submitted to a transient stimulus. What is the effect of the stimulus on these correlations ?

The goal of this internship is to use the mathematical formalism developed in [4] to reply to these questions in a conductance-based Integrate and Fire neuron model [5]. In addition, numerical simulations of this situation will be performed using the software Pranas developed at Inria [6].

The internship will be done in collaboration between B. Cessac (Biovision, INRIA, Sophia-Antipolis), R. Cofré and M. J. Escobar (CIMFAV and AC3E/UTFSM, Valparaiso, Chili). The duration is 6 months. The internship will be done at INRIA. This master 2 internship could be followed by a PhD, in which retinal experiments and experimental data analysis are expected to be done with the Centro Interdisciplinario de Neurociencia Valparaiso.

Profile. The project is interdisciplinary, so the candidate is expected to have a strong background in mathematics or physics and programming skills. He/she must also have a great interest in the field of visual neuroscience, both in fundamental aspects of visual processing and clinical research.

Contacts:
INRIA bruno.cessac@inria.fr
Web page http://www-sop.inria.fr/members/Bruno.Cessac/

Teams
Biovision. The goal of the Biovision team is to investigate new solutions to help vision impaired people. Visual impairment affects some 285 million people in the world, mostly in developed countries: 85% have low vision, i.e., have remaining sight, and 15% are totally blind. It is predicted that the prevalence of visual disabilities will increase markedly during the next 20 years, owing largely to the aging. In this context, Biovision aims at developing fundamental research as well as technology transfer along two axes (i) development of high tech vision aid systems for low vision patients (ii) precise modeling of the visual system for normal and dystrophic conditions, targeting applications for low vision and blind patients. These axes are developed in strong synergy, involving a large network of national and international collaborators with neuroscientists, physicians, and modelers.

CIMFAV and AC3E (Valparaiso). The CIMFAV (Centre for Research and Modeling of Random Phenomena - Valparaíso) is a unit of the Faculty of Engineering of the University of Valparaíso (UV) created in the year 2012 and dedicated to applied mathematics. Its goal is to investigate the modeling, the analysis and the numerical simulation of random phenomena with applications in: Biostatistics, Biomechanics, Pharmacological dynamics, Neurosciences… The Advanced Center of Electrical and Electronic Engineering, AC3E, is part of the Universidad Técnica Federico Santa María (UTFSM). It is composed of a multi and interdisciplinary research group and contribute to the technological development and competitiveness of the Chilean economy by achieving excellence in research, fostering knowledge exchange, educating advanced human capital, and generating technology transfer in areas of societal impact through the field of electrical and electronic engineering.

References

[1] M. J. Berry II, I. H. Brivanlou, T. A. Jordan, and M. Meister, *Anticipation of Moving Stimuli by the Retina*, Nature, 398: 334-338, 1999.

[2] O. Marre, V. Botella-Soler, K. D. Simmons, T. Mora, G. Tkacik, M.J. Berry 2nd. *High accuracy decoding of dynamical motion from a large retinal population*, PLoS. Comput. Biol., 11, e1004304 (2015).

[3] T. Gollisch and M. Meister, *Eye smarter than scientists believed: neural computations in circuits of the retina*, Neuron, 65(2):150--164, January 2010.

[4] B. Cessac and R. Cofre, *Linear response for spiking neuronal networks with unbounded memory*, https://arxiv.org/abs/1704.05344

[5] Rodrigo Cofré and Bruno Cessac Dynamics and spike trains statistics in conductance-based Integrate-and-Fire neural networks with chemical and electric synapses, Chaos, Solitons & Fractals, Volume 50, May 2013, Pages 13-31. http://lanl.arxiv.org/abs/1212.3577

[6] B. Cessac, P. Kornprobst, S. Kraria, H. Nasser, D. Pamplona, G. Portelli, T. Viéville PRANAS: a new platform for retinal analysis and simulation, Frontiers in Neuroinformatics, Vol 11, page 49, (2017) http://journal.frontiersin.org/article/10.3389/fninf.2017.00049