POSITION AVAILABLE AT Inria

Postdoctoral position in computational neuroscience at INRIA, France

From real retinas to a virtual retina

Context : Our understanding on how the retina works has progressively known a paradigm change : whereas retina was up to recently viewed as a relatively simple organ (acting roughly like a camera), it is now admitted by the scientific community that « eyes are smarter than scientists believed » [Gollisch-Meister, 2010]. The retina is able to perform such clever tasks as detecting differential motion or anticipating motion. These wonderful properties are largely due to the sophisticated retina structure in terms of cells differentiation as well as connectivity. This results in a complex dynamical system where the response to visual inputs is encoded *in a collective way* by neurons dynamics. The « output » of the retina, a sequence of action potentials or spike train emitted by ganglion cells, is transmitted to the visual cortex via the optic nerve (constituted by the axons of the ganglion cells). In this way, the retina is able to « encode » a visual scene in the form of spike trains. How to decipher this collective code is an open problem.

The Multi-Electrode Array (MEA) technique allows scientists to register spike trains in order to analyze their statistical properties and to extract potential generic laws giving keys to decipher the code on the one hand; on the other hand, techniques such as two-photons imaging or calcium imaging provide more and more detailed information about the retina circuitry and dynamics. This opens up several scientific challenges : on the theoretical side, building new mathematical models allowing to relate the retina circuitry and dynamics to spike trains statistics as a response to a visual scene ; on the applied side, creating software that mimics retina functioning with potential applications in the domain of fundamental research (simulating virtual retinas instead of performing experiments on animals) and therapy (e.g. analyzing the effect of drugs on retina functions, in silico).

Project : The project we propose is at the corner between these two aspects. The goal is to develop a new hybrid retina simulator, emulating the outer retina. On the theoretical side, the project will use statistical methods developed in our team to perform spike train analysis [1,2] from experiments done by our partners (Evelyne Sernagor from NewCastle University and Luca Berdondini from IIT Genova), in order to construct a virtual layer of Amacrine and Ganglion cells emulating realistic spike statistics, instead of replicating the detailed laminar connectivity of the retina. For this, generic neural network models studied in our team will be used. These models neglect the detailed biological description of neurons, but take into account anatomical constraints such as connectivity and reproduce collective statistics of RGCs types in response to specific stimuli. On the applied side, this layer will be integrated to the Virtual Retina software developed in our team [3]. This postdoc is part of the RenVision European project. It is funded by the European Union FP7 FET (Future Emerging technology) proactive program: Neuro-Bio-Inspired Systems Call 9 Objective 9.11. This highly interdisciplinary project aims at understanding and modeling the biological processing of visual information in the retina and exploiting this new knowledge to build retina-inspired artificial visual processing systems.

RENVISION website: https://www.renvision-fp7.eu

Profile : The work is highly interdisciplinary, and applicants must have strong mathematical and computational skills. Preferred educational background is a PhD in Computational Neuroscience. Previous experience with neural population coding and C++ programming skills is required. Applicants should email a CV, brief research statement, relevant publications, and contact details for two academic references to: bruno.cessac@inria.fr and pierre.kornprobst@inria.fr.

Bruno Cessac website: http://www-sop.inria.fr/members/Bruno.Cessac
Pierre Kornprobst website: http://www-sop.inria.fr/members/Pierre.Kornprobst

Laboratory: The INRIA team Neuromathcomp is working in the fields of mathematical and computational neuroscience, and biological vision modeling with applications to artificial vision. We are involved in several European research projects. The group is located in Sophia-Antipolis between Nice and Cannes on the French Riviera.

INRIA is the only French public research body fully dedicated to computational sciences. Combining computer sciences with mathematics, INRIA's 3,500 researchers strive to invent the digital technologies of the future. Educated at leading international universities, they creatively integrate basic research with applied research and dedicate themselves to solving real problems, collaborating with the main players in public and private research in France and abroad and transferring the fruits of their work to innovative companies. The researchers at INRIA published over 4,450 articles in 2012. They are behind over 250 active patents and 112 start-ups. The 180 project teams are distributed in eight research centers located throughout France.

Neuromathcomp website: http://www-sop.inria.fr/neuromathcomp
INRIA website: http://www.inria.fr

Starting date: January 2014, on the basis of a competitive application. The position is open now until filled.

Contract duration: 2 years (1 year probation)

Net salary: 2140 euros/month

Related references:

[1] B. Cessac and A. Palacios, Spike train statistics from empirical facts to theory: the case of the retina, In Mathematical Problems in Computational Biology and Biomedicine, F. Cazals and P. Kornprobst, Springer (2013)
[2] J.C. Vasquez, A. Palacios, O. Marre, M.J. Berry II, B. Cessac, Gibbs distribution analysis of temporal correlation structure on multicell spike trains from retina ganglion cells, J. Physiol. Paris, 106(3-4), pp. 120-127 (2012)
[3] A. Wohrer and P. Kornprobst. Virtual Retina: A biological retina model and simulator, with contrast gain control, Journal of Computational Neuroscience, 26(2), pp. 219-249 (2009)