LABORATORY OF COMPUTATIONAL NEUROSCIENCE (LCN)

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

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16h30, Room BC 420

IC Colloquium &
Computational Neuroscience Seminar

Olivier FAUGERAS,
INRIA

Some of the upcoming challenges in computational and mathematical neuroscience

The CNS, like all complex systems, features a large variety of spatial and temporal scales. A given scale is usually accessible through a class of measurement modalities, e.g. electro-encephalography gives us access to the "mean" activity of very large populations of neurons whereas a micro-electrode can record from a single neuron. It is therefore important to be able to both develop theories that account for phenomena at a given scale, for example at the single neuron level the Hodgkin-Huxley equations can reproduce many of the observed behaviours, and are able to seamlessly traverse the scales from the finest to the coarsest, e.g. to develop a (mesoscopic) theory of say, a cortical column, from the (microscopic) description of its individual neurons and of their connections.

In the first part of this talk I describe some current attempts in my research group to rigourously bridge the gap between theories of individual neurons behaviours and those of large populations of interconnected such neurons. This raises several important issues such as the role of the uncertainty, the noise, in these theories, and the optimal encoding of information. I also mention the difficulties that one encounters when developing such mean field theories, hence the challenges, as well as underline their differences with what may be called "naive" mean field theories.

In the second part of the talk I focus on an existing theory for describing the behaviours of entire cortical areas such as those that make up the visual system of human and non-human primates. The theory of neural fields can probably be deduced from that of individual neurons by methods such as those sketched out in the first part of the talk but I will rather concentrate on two of its important features, in relation to visual perception, because I think that they are both universal in the way neuronal populations operate and unfamiliar to many of those working in computer vision or engineering in general. The first point is related to the idea of the symmetries of a system, the second to the idea of the bifurcations of the solutions to the equations that describe this system. As in the first part I will also mention a number of problems with neural fields' theories, hence again the challenges.

The talk will be relatively light on the mathematics, emphasizing more the concepts than the technicalities.