Mathematical modelling in neurosciences

J. Henry
INRIA Bordeaux-Sud-Ouest

The objective of this course is to show an example of the use of the mathematical modelling in Biology. It is here about modelling in neurosciences. The human central nervous system is far too complex to hope to make a precise and complete description by means of the usual mathematical tools. We shall however try to show how mathematical models which are idealized images quite simplified compared to the biological reality, allow to make precise and to analyze the biological knowledge.

The course will include a presentation for non-specialist of the necessary elements of neurosciences to understand the modelling. We shall present models used classically in this domain which allow a description at various scales.

The questions raised in computational neurosciences on these models concern generally their qualitative asymptotic behavior : does the sytem go towards an equilibrium state, a periodic orbit ? What is the stability of this behavior, what happens when we change parameters, outside inputs ? A part of the course will thus concern the theory of dynamical sytems and bifurcation. The used models are of differential or partial differential kind (conservation law).

Course overview

- Elements of biology
- Model of Hodgkin-Huxley (non linear differential equations)
- Notion of threshold of excitability
- Simplified models deriving from Hodgkin-Huxley
- Firing rate models
- Elements of dynamical system theory and bifurcation
- Synchronization, theorem of Malkin
- Population of neurons, PDE for laws of conservation