On Modeling Electrophysiological Activities

This course aims to discuss models in neuroscience and particularly models of electrophysiological activities. We will discuss the field of application of such models. We will introduce the concepts of dynamical systems. Then we will implement these models during lab sessions. Finally, we will discuss the results of simulations in relation to the data obtained experimentally.

Session 1:

- Systems and complex system in neurosciences
- Origines of electrophysiological signals and measurements
- Electrophysiology and relevant features for computational modeling:
    - Membrane potential
    - Raster plot
    - Local field potential

Session 2:

- Understanding the time evolution of the electrophysiological signals from a dynamical systems point of view.
- Introduction to dynamical systems for neurosciences:
    - Differential equations
    - Phase space representation
    - Stability and domain of attraction
- Unidimensional and bidimensional models
    - Dynamics of integrate-and-fire models
    - Repertoire of 2 D models
    - Reduction of Hodgkin-Huxley model

Session 3:

- 2D and Higher dimensions models:
    - Particular role of the reset
    - Possibility of chaos
- Models of synapses
- Limits of models:
    - Biophysical and mechanistic description
    - Phenomenology
- Introduction to the first lab session (with Brian2 simulator)

Session 4:

- First Lab Session:
    - Repertoire of electrophysiological patterns
    - Models of networks
    - Global measure on simulations

Session 5:

- Second lab session:
    - analysis of the results
    - relations to the data
- Conclusive discussion