Stochastic neuronal models

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Noise in neuronal coding

Biological neurons are subject to internal variability and operate in fluctuating environments. These factors, broadly referred to as "noise", can strongly alter the way information is encoded and transmitted by neurons. Motivated by experimental observations, these lectures will present the analysis of the impact of noise on neuronal coding from the point of view of stochastic dynamical systems.

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Stochastic neuronal models

The problem of understanding how the brain transmits information is one of the most stimulating tasks to which stochastic processes theory applies. Neurons encode information in the spike trains and the mathematical counterpart of spike trains are counting processes. Single neuron activity can be represented via specific counting processes. After introducing some basic features of biological neurons and networks we illustrate some stochastic models (Leaky integrate and fire models) that mimic the interspikes intervals of single neurons as first passage times of diffusion processes.Then, we show how these models can be used to get some insight on neuronal signal detection ability and information transmission.

Neuronal networks exhibit spatio-temporal patterns. We introduce jump diffusion models to describe small neuronal networks activity and we show how these models can catch features related with inhibition role or synchronization abilities.