Statistical interference for stochastic biochemical processes

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Room: to be announced

Usability: Master of Mathematics (TUM), Master of Statistics (LMU), Master of Biostatistics (LMU)

Prerequisites: Bachelor in mathematics, bioinformatics, statistics or related fields.
Basic MATLAB programming skills.

The course "Parameter Estimation for Dynamic Biological Systems I (PE I)" is recommended.

Exercises: The exercises will cover fundamental principles, theoretical aspects as well as programming in MATLAB.

ECTS: 6 (2 SWS lecture and 2 SWS exercise)

Number of participants: < 30

Language: english

Topic: Mathematical models are nowadays essential for the quantitative assessment of technical, physical, chemical, and biological processes. While a broad class of models is used in the different field, almost all models share one common property: the need for accurate parameter values. Due to experimental constraints, many parameters cannot be measured directly, but have to be estimated from the available experimental data.

In this course, we will provide an overview about a variety of dynamic models used in mathematical and systems biology. In particular, we considered deterministic and stochastic chemical kinetics (MJ and CME) as well as structured populations (PDEs). These models can be used to describe, e.g., signal transduction, gene expression, cell fate decisions as well as proliferation processes, as we will illustrate throughout the course. For these models the respective parameter estimation problems will be formulated and methods will be presented to solve these problems rigorously. Furthermore, we will address the problem of model selection and introduce different methods to determine the most plausible models among the model alternatives.

The participants will gather hands-on experiences with parameter estimation and uncertainty analysis, including the implementation of own models and estimation procedures in MATLAB. The estimation methods are presented in the context of biological processes, but the approaches are applicable in many other fields.

Aims:

After the course, the participants can:

1. model deterministic and stochastic biological processes.
2. simulate deterministic and stochastic biological processes MATLAB.
3. solve parameter estimation problems and model selection problems.
4. analyze the uncertainty of parameter estimates.
5. critically evaluate parameter estimation and model selection procedures.

Parameter Estimation for Dynamic Biological Systems II (PE II)

Topic 3 **Stochastic chemical kinetics (MJP, CME) ……..…… 9 lectures**

1) Stochastic modeling using the Chemical Master Equation (3 lectures)
2) Bayesian parameter estimation and uncertainty analysis (2 lectures)
    a. Likelihood-based methods
    b. Likelihood-free methods
3) Parameter estimation using the moment equation (2 lectures)
    a. Introduction of the moment equation
    b. Likelihood function and estimation
4) Model selection (2 lectures)

Topic 2 **Structured population models (PDEs) …… 4 lectures**

5) Introduction of different modeling approaches (2 lectures)
    a. division-structured population models
    b. age-structured population models
    c. label-structured population models
6) Bayesian parameter estimation for proliferating cell population (1.5 lectures)
7) Model selection (0.5 lectures)

Summary and Outlook ……..…….. 1 lectures

PDE … partial differential equation

MJP … Markov jump processes

CME … Chemical Master Equation