DYNAMICAL MODELING, ANALYSIS, MONITORING AND CONTROL OF BIOLOGICAL SYSTEMS

Denis Dochain
ICTEAM, UCL, Belgium

Course description

Aim: The objective of this course is to give an introduction and cover recent aspects of dynamical modeling, monitoring and control of biochemical processes. The course will cover the following topics.

Dynamical modeling of biochemical processes: the notion of reaction networks and mass balance modeling will be introduced and used to build a general dynamical model for bioprocesses, both stirred tank reactors (described by ODE's (ordinary differential equations)) and incompletely mixed reactors, such as tubular reactors as well as population balance models (described by PDE's (partial differential equations)). Mathematical concepts of the general dynamical model, including model reduction and stability, as well as microbial ecology concepts like the competitive exclusion principle, will be addressed. The link with metabolic engineering will also be explicated. The course will also cover the identification of bioprocess models (including the structural and practical model identifiability and the design of optimal experiments for parameter estimation).

Monitoring: this part of the course will be dedicated to the design applications of state observers (Luenberger observers, Kalman filters, asymptotic observers, robust observers, …) and parameter estimation algorithms (in particular to estimate reaction rates and yield coefficients).

Control: the course will emphasize adaptive linearizing control (including adaptive extremum seeking). The choice of these control approaches will be motivated in the context of bioprocess applications.

Several practical applications will be used to illustrate the techniques and principles covered in this course. Examples will cover application fields from the food industry and the pharmaceutical industry to the environment and the (waste) water treatment.