Modeling and control of dynamical systems in bioengineering

Lecturers
Philippe BOGAERTS (Coordinator) and Didier GONZE

Course mnemonic
BING-H4000

ECTS credits
5 credits

Language(s) of instruction
English

Course period
Second term

Campus
Solbosch

Course content

Part 1 (Ph. Bogaerts, 18h): Introduction to parameter estimation, Mathematical model structures (taxinomy and properties), Parameter estimation (least squares, maximum likelihood), Mathematical modeling of biological networks, Case studies.

Part 1 (D. Gonze, 18h): Discrete and continuous models (ODE) in population dynamics: logistic equation, Ricker's and Nicholson-Bailey's discrete models, Gompertz model, Allee effect, Lotka-Volterra's models, chemostat, SIR models. Overview of some recent scientific articles.

Part 2 (Ph. Bogaerts, 24h): (Bio)chemical process control (Control of a CSTR : basic principles, Control of a batch exothermic reactor, Control of time delay and minimum phase processes, Feedforward control, Control of MIMO systems).

Objectives (and/or specific learning outcomes)

At the end of the course, the student will be able to

- choose, develop and analyze a dynamical model for describing a system in biology and/or in bioengineering;
- build a mathematical model of a process on the basis of experimental data;
- design control structures for processes of chemical and biotechnological industries.

Pre-requisits and co-requisits

Required knowledge and skills

Generally: basics of linear algebra; function analysis; statistics and probability theory; linear system dynamics.

More specifically: vectors and matrices (product, inverse, trace, transpose, etc.); function minimization; Taylor series development; integration of first order ordinary differential equations; mathematical expectation, probability density function, mean, variance, stochastic processes, white noise, Gaussian distribution, uniform distribution; state equations and transfer functions for linear time-invariant dynamical systems.

Teaching method and learning activities

Part 1: 3 ECTS of ex cathedra courses.

Part 2: 1 ECTS of ex cathedra courses and 1 ECTS of seminars (simulations on computer).

Course notes

Podcast, Syllabus and Université virtuelle

Other information

Place(s) of teaching

Solbosch

Contact(s)

Philippe Bogaerts : École polytechnique de Bruxelles, 3BIO-BioControl (Biosystems Modeling and Control); email: philippe.bogaerts@ulb.be

Didier Gonze : Faculté des Sciences, Unit of Theoretical Chronobiology; email: didier.gonze@ulb.be

Evaluation method(s)

Oral examination and written examination

Evaluation method(s) (additional information)

1st exam: written exam with Prof. D. Gonze

- subject: Part 1 taught by Prof. Gonze

2nd exam: oral exam (without preparation) with Prof. Ph. Bogaerts

- subject of question 1: Part 1 taught by Prof. Bogaerts
- subject of question 2: Part 2

Determination of the mark (including the weighting of partial marks)

- Written exam with Prof. Gonze: 30% (mark 1)
- Oral exam with Prof. Bogaerts (Part 1): 30% (mark 2)
- Oral exam with Prof. Bogaerts (Part 2): 40% (mark 3)

Final mark = 0,3 * mark 1 + 0,3 * mark 2 + 0,4 * mark 3

If one of these partial marks is greater than or equal to 10/20, it is then definitively acquired (from one session to another and/or from one academic year to another) and the corresponding exam may not be taken anymore.

An attendance note (NDP) may be obtained for 1, 2 or the 3 above-mentioned partial marks, hence leading to an attendance note (NDP) for the whole course. However, it remains possible to definitively acquire a mark greater than or equal to 10/20 for the partial mark(s) whose corresponding exams have been successfully presented.

If, upon deliberation, the course is not validated, then all the exams associated to a mark lower than 10/20 must be redone (from one session to another and from one academic year to another).

Main language(s) of evaluation

English

Programmes

Programmes proposing this course at the Brussels School of Engineering

MA-IRBC | Master in Chemistry and Bio-industries Bioengineering | finalité Professional/unit 1 and MA-IRBE | Master in Environmental Bioengineering | finalité Professional/unit 1

Programmes proposing this course at the faculty of Sciences

MA-BINF | Master in Bio-informatics and Modelling | finalité Research/unit 2, MA-IRBC | Master in Chemistry and Bio-industries Bioengineering | finalité Professional/unit 1 and MA-IRBE | Master in Environmental Bioengineering | finalité Professional/unit 1