GHENT UNIVERSITY

Course Specifications

Valid as from the academic year 2018-2019

Modelling and Simulation of Dynamical Systems (E005722)

Course size (nominal values; actual values may depend on programme)

Credits	6.0	Study time	180 h	Contact hrs	60.0 h

Course offerings and teaching methods in academic year 2020-2021

A (semester 2)	English	seminar	15.0 h
		lecture	30.0 h
		project	15.0 h

Lecturers in academic year 2020-2021

Crevecoeur, Guillaume	TW08	lecturer-in-charge

Offered in the following programmes in 2020-2021	crdts	offering
Bridging Programme Master of Science in Electromechanical Engineering (main subject Control Engineering and Automation)	6	A
Bridging Programme Master of Science in Industrial Engineering and Operations Research	6	A
Bridging Programme Master of Science in Industrial Engineering and Operations Research	6	A
Master of Science in Electromechanical Engineering (main subject Control Engineering and Automation)	6	A
Master of Science in Electromechanical Engineering (main subject Electrical Power Engineering)	6	A
Master of Science in Electromechanical Engineering (main subject Maritime Engineering)	6	A
Master of Science in Electromechanical Engineering (main subject Mechanical Construction)	6	A
Master of Science in Electromechanical Engineering (main subject Mechanical Energy Engineering)	6	A
Master of Science in Industrial Engineering and Operations Research	6	A
Master of Science in Chemical Engineering	6	A
Master of Science in Industrial Engineering and Operations Research	6	A
Master of Science in Chemical Engineering	6	A

Teaching languages

English

Keywords

dynamic models, simulation, bond graphs, optimization, optimal control, estimators, networks

Position of the course

This course uses the basic concepts from the courses on "Signals and Systems" and on "modelling and control of dynamical systems" by teaching structured, general tools for modelling large and complicated dynamical systems. Euler-Lagrange, electric circuit theory and bond graphs are used for continuous dynmical systems. Automata models and hybrid systems models allow expansion of the analysis to systems with discrete events. The emphasis in this course is the decomposing of systems in components, and describing the interaction between components.
These general methods are used for developing simulation tools allowing the performance analysis for large systems, model based feedback control design, and state estimation. Topics treated for this purpose are: numerical integration methods, incl. differential-algebraic and stiff systems, and Monte Carlo simulation models for

discrete event systems; hierarchical control, including process control and supervisory control.
The modelling tools are applied to the optimisation of the behaviour of dynamical systems (using dynamic programming and other optimisation tools), and to model based state estimation (including particle filtering). Some optimisation algorithms are introduced and applied. The course treats as case studies various applications from e. g. robotics, autonomous vehicles, MEMS, road traffic systems.

Contents

1 Goals and tools for simulation of dynamical systems: examples, why modelling?
2 Mathematical modelling techniques: general methods for electrical circuit analysis, Euler-Lagrange methods for mechanical systems, fluid dynamics and thermodynamics, numerical integration of linear system models.
3 Modelling of electromechanical systems using bond graphs: power transfer between components, from bond graphs to state equations, signal transformation in generalised bond graphs.
4 Optimal Control and Optimisation: gradient-based optimisation algorithms, system optimisation, non-linear optimal control, model-based optimal control.
5 Data-driven models: regression, classification, neural networks.
6 Hybrid systems: synchronous and asynchronous models, specification and supervision, examples of modelling for real time systems.

Initial competences

Mathematical analysis (differential equations; linear algebra; Taylor series and convergence), physics (mechanics; electromagnetism; power and energy), electrical circuit theory, basics of probability and statistics.

Final competences

1 Insight in how to model a complicated system: simplest possible accurate system model.
2 Use of compositionality, abstraction, hierarchy to develop mathematical models of systems, to be able to implement for simulation, to reduce and to validate.
3 Use of Euler-Lagrange methods, classical electrical network analyses, and bond graphs of electromechanical systems.
4 To be able to implement mathematical models of continuous systems for simulation purposes using numerical integration routines.
5 Use the laws of preservation for the validation of models and simulation programs; efficient use of simulation tools such as Simulink.
6 Develop system models for systems having asynchronous events using automata and Petri nets.
7 Use of dynamic system models of production processes for the design and validation of supervisors.
8 Design model based control for discrete time system models for hybrid systems.
9 Use of computer platforms for the implementation of simulation programs.

Conditions for credit contract

Access to this course unit via a credit contract is determined after successful competences assessment

Conditions for exam contract

This course unit cannot be taken via an exam contract

Teaching methods

Lecture, project, seminar

Learning materials and price

Lecture notes in English

References

- Karnopp, Marcolis and Rosenberg: System Dynamics: Modelling and simulation of mechatronic systems, Wiley, 2000
- P.P. Varaiya: Notes on Optimization, Van Nostrand Reinhold 1972
- A. van der Schaft en H. Schumacher: An introduction to Hybrid Dynamical Systems, Springer, 2000
- T. Braunl: Embedded Robotics, Springer, 2003

Course content-related study coaching

Evaluation methods

end-of-term evaluation and continuous assessment

Examination methods in case of periodic evaluation during the first examination period

Oral examination

Examination methods in case of periodic evaluation during the second examination period

Oral examination

Examination methods in case of permanent evaluation

Report

Possibilities of retake in case of permanent evaluation

examination during the second examination period is possible in modified form

Extra information on the examination methods

During examination period: oral closed-book exam, written preparation. During semester: graded project reports.

Calculation of the examination mark

Students must successfully complete the project during the semester, and pass the oral, closed book exam; score consists of 30% for oral presentation and written report on project work during the semester, and for 70% for oral exam.