Modelling and Simulation

Programme course

6 credits

Modellbygge och simulering

TSRT62

Valid from: 2017 Spring semester

Determined by
Board of Studies for Electrical Engineering, Physics and Mathematics

Date determined
2017-01-25

Replaced by
TSRT92

Main field of study
Electrical Engineering

Course level
Second cycle

Advancement level
A1X

Course offered for
- Computer Science and Engineering, M Sc in Engineering
- Industrial Engineering and Management - International, M Sc in Engineering
- Industrial Engineering and Management, M Sc in Engineering
- Information Technology, M Sc in Engineering
- Applied Physics and Electrical Engineering - International, M Sc in Engineering
- Applied Physics and Electrical Engineering, M Sc in Engineering
- Chemical Biology
- Mechanical Engineering, M Sc in Engineering
- Engineering Biology, M Sc in Engineering
- Computer Science and Software Engineering, M Sc in Engineering

Entry requirements
Note: Admission requirements for non-programme students usually also include admission requirements for the programme and threshold requirements for progression within the programme, or corresponding.

Prerequisites
Statistics, Automatic Control, Basic knowledge of electrical circuits and mechanics.

Intended learning outcomes

The course should give knowledge about methods and principles for constructing mathematical models of dynamic systems (systems described by differential/difference equations), and about how properties of the models can be studied through simulation. Furthermore, the significance of dynamic properties and the limitation of static models will be studied. Students will be expected to be able to do the following after completing this course:

- Define, describe and apply basic concepts related to models, identification and simulation.
- Simplify a given model by using static relations, replacing variables by constants, using idealized assumptions and aggregation of states.
- Use scaling and dimension-free variables in order to simplify analysis of systems.
- Model (one-dimensional) mechanical, electrical, flow and thermal systems from balance and equilibrium equations. Furthermore, construct models including combinations of different domains, in DAE form and (when possible) state-space form.
- Construct bond graphs for appropriate systems from the class mentioned above. Simplify and analyze bond graphs with respect to causality. From a given bond graph, compute a corresponding state-space model.
- Compute the index for a given DAE and describe the different standard forms for linear DAE:s.
- Model and simulate (one-dimensional) mechanical and electrical systems in Simulink and Modelica, and write simple Modelica objects in code.
- Use system identification to construct a model of a real system, through appropriate choices of experiment design, post-processing of data, model structure, and careful validation.
- Compute asymptotic bias and variance properties for a given linear system identification problem.
- Describe nonlinear graybox models, local models, local linear models and nonlinear regression models (in particular neural networks), and estimate models of these types for very simple cases.
- Determine whether a given simulation method is implicit or explicit and how many steps it contains. Compute the local error and stability region for simple simulation methods.
- Produce a well-written, informative lab report.

Course content

Models and modeling: Different types of models. Continuous and discrete time models. Differential and difference equations. State-space descriptions. Principles for model building, starting from physical relations. Balance and state equations. Simplification of models. Analogies between different physical domains. Bond graphs. Differential algebraic models. Object-oriented modeling. Models with disturbances. Black-box models.

Identification: Transient-response, frequency, correlation, and spectral analysis. Parameter estimation for linear and nonlinear dynamic models. System identification as a model building tool. Model validation.

Simulation: Methods for state-space and differential algebraic models. Numerical properties and stability. The simulation languages Simulink and Modelica.

Teaching and working methods

The course consists of lectures, lessons and laboratory work.

Examination

LAB1	Laboratory Work	1.5 credits	U, G
DAT1	Computer Examination	4.5 credits	U, 3, 4, 5

Grades

Four-grade scale, LiU, U, 3, 4, 5

Department

Institutionen för systemteknik

Director of Studies or equivalent

Johan Löfberg

Examiner

Claudio Altafini

Course website and other links

http://www.control.isy.liu.se/student/tsrt62/

Education components

Preliminary scheduled hours: 58 h
Recommended self-study hours: 102 h

Course literature

Additional literature

Books

Ljung, L., Glad. T, (2004) *Modellbygge och simulering* andra upplagan

Compendia

Common rules

Regulations (apply to LiU in its entirety)

The university is a government agency whose operations are regulated by legislation and ordinances, which include the Higher Education Act and the Higher Education Ordinance. In addition to legislation and ordinances, operations are subject to several policy documents. The Linköping University rule book collects currently valid decisions of a regulatory nature taken by the university board, the vice-chancellor and faculty/department boards.

LiU's rule book for education at first-cycle and second-cycle levels is available at http://styrdokument.liu.se/Regelsamling/Innehall/Utbildning_pa_grund-_och_avancerad_niva.