ISS0031 Modeling and Identification: Program

Subject code	ISS0031
Subject title	Modeling and Identification
Subject title (in Estonian)	Modelleerimine ja identifitseerimine
Subject webpage	http://a-lab.ee/edu/courses/iss0031-2017
Instructor	Aleksei Tepljakov
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Rewarded ECTS	5.0
Stationary study (weekly hours)	Lectures/exercises: 2/2
Teaching semester	Autumn

Description

The aim of the course is to give an overview of modeling and identification methods for sovling static and dynamic problems such as optimal resource planning and industrial control. The major topics covered in the first part of the course include:

- Static and dynamic models and applications.
- Optimization. Linear programming. Convexity. Least squares. Newton's Method. Simplex method. Nelder-Mead method (applications).
- Linear models. Time domain and frequency domain analysis.
- Identification. Model types. Validation. Residual analysis.

In the second part of the course, the following contemporary modeling topics will be discussed:

- Fractional-order modeling and control.
- Artificial Neural Network based identification.
- Global optimization methods. Genetic algorithms.
- Fuzzy logic based modeling.

These topics will be delivered during several invited lectures and will be accompanied by corresponding practical works. Most of the practical assignments of the course will be solved in MATLAB/Simulink environment. The first practice will be given on the 3rd week of the semester.

Learning Outcomes

By the end of the course the student

- Knows and understands the basics of mathematical programming;
- Knows and is able to formulate basic and advanced modeling, optimization, and identification problems;
- Knows and is able to apply global optimization algorightms;
- Can describe systems using mathematical models;
- Knows how to derive mathematical models;
- Knows advanced modeling and control theory:
  - Fractional-order modeling and control;
  - Symbolic Regression;
  - Artificial Neural Networks based modeling;
  - Genetic Algorithm based model structure identification;
  - Fuzzy Logic based modeling.
- Is able to use the MATLAB/Simulink environment to analyze and solve different mathematical programming, identification, and control problems.

Course Project

In general, the project may be one of the following:

- Solution of a research problem relevant to the student's area of interest within the scope of the course;
- Independent study of a topic not covered in the course (e.g., reading a scientific article or book chapter).

The student must compile a report about the project. The report must consist of

- An introduction and a clear problem statement;
- Overview of tools used to fulfill the project goals;
- Proposed solution for the problem;

- Examples or practical results;
- Result analysis and conclusions;
- Properly formatted list of references to credible sources.

The prospective length of the report is 15-20 pages. Submission deadline is the 15^{th} week of the semester. In addition, the student must

- Give short, 3-5 minute talks:
  - The first, describing his project idea, must be presented on the 3th week of the semester;
  - The second, presented on the 6th week, must provide an update illustrating the progress;
- Finally, the student must give a 10-12 minute talk about the finished project at the end of the course.

On both occasions, the instructor and other students may give feedback about the project.

The following list contains some project ideas proposed by the instructor. Other topics are also possible.

- *Modeling for Virtual Reality Applications.* Reference: http://www.recreation.ee/
- *Control System Toolbox for Python.* Reference: https://pypi.python.org/pypi/control/0.7.0
- *Modeling and Implementation of Fractance Networks for Control Applications.* Reference: A. S. Elwakil, Fractional-Order Circuits and Systems: An Emerging Interdisciplinary Research Area. Circuits and Systems Magazine, 10(4):40–50, 2010.
- *Modeling a Laboratory Object.* Reference: http://www.a-lab.ee/equipment
- *NelinSys Toolbox for MATLAB.* Reference: http://goo.gl/kJcy7V
- *FOMCON Toolbox Port to Octave or Scilab.* Reference: http://fomcon.net/

Practical Works

Practical works are carried out in the laboratory using personal computers and MATLAB/Simulink software. Reports are expected for five practical works. These will award 2 course points each if submitted within 2 weeks of carrying out the practical work. For the reports to be accepted, the following must hold.

- Reports are about 2-3 pages long and contain a brief summary of the problem, solution methods, as well as an assessment of results;
- Graphs, if present, must be illustrative—screenshots of the working software environment are not required;

- The reports must contain answers to questions posed by the instructor for each particular practical work.

Formatting of the report is up to the student, but clearly typeset LaTeX-style reports are welcome. Only PDF format is accepted and must be submitted electronically to the instructor.

Policies

The learning outcomes of the course are evaluated in the following way:

- Two tests, each giving 20% of the grade.
- Five practice reports, each giving 2% of the grade.
- An individual project report and presentation thereof giving 50% of the grade.
- Bonuses: reports for practical works where a report is not required by default; other bonuses also possible.

All of these components are summed up at the end of the semester and form the exam grade.

The following policies are in effect:

- There is only one attempt to do each of the tests during the semester. It is however possible to improve the result (if desired) during finals. Among the attempts, the one with the best grade will be counted as final.
- The practice reports will cover the topics from the second part of the course. The report for each practice must be submitted within two weeks of the date of carrying out the practical work in the laboratory. If a report is not received within the allocated time interval, the grade points for the practical work are not awarded. If the report is submitted, but not accepted, the student may introduce changes to the report and resubmit it within 1 week of the acceptance date to obtain the course points for the practical work. Reports are accepted electronically in PDF format.
- Topics for the individual project may be selected from a list offered by the instructor, or proposed by the student. In the latter case, the topic of the project must be within the scope of the course. At the end of the course, a report for the project must be prepared and submitted for evaluation. The prospective length of the report is 15-20 pages. Submission deadline is the 15^{th} week of the semester. The report is accepted electronically in PDF format.

The project may also be a work-in-progress. In such a case, the results obtained by the end of the course must clearly demonstrate the advances in the developed topic. For project presentation policies, see the information above in the corresponding section.

Prospective Course Schedule

In Table 1 a summary of the prospective organization of the course is provided. Small changes are possible due to changes in the availability of invited lecturers.

Table 1: Prospective course schedule. Some changes are possible due to changes in the availability of invited lecturers

Class	Type	Content
1	L	Introduction. Overview of course topics. Course policies and evaluation. Course project.
2	L	Modeling: Model types. Applications. Linear programming. Graphical method.
3	L+P	First project talks. Optimization. Newton's Method. Least Squares. Problems with bounds and constraints.
4	L+P	Simplex method. Nelder-Mead method. Penalty functions.
5	L+P	Linear models and analysis. Frequency domain analysis.
6	T	Second student talk regarding chosen course project. Test #1.
7	L+P	Modeling for Power Systems (invited lecture)
8	L+P⋆	Identification. Time domain identification of dynamic models. Validation. Residual analysis. Modeling of physical systems. Control design.
9	L+P⋆	Fractional-order modeling and control
10	L+P⋆	Artificial Neural Network based modeling (invited lecture)
11	L+P⋆	Global optimization. Genetic algorithms. Symbolic regression.
12	L+P⋆	Fuzzy logic based modeling (invited lecture)
13	L+P	Nonlinear systems. Second-order systems. Phase plane analysis.
14	T	Test #2
15	E	Course project report submission deadline. Student project talks.
16	E	Student project talks (continued).

Legend
L — lecture
P — practice, ⋆ — report expected
T — test
E — exam

Literature

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