COURSE DESCRIPTION CARD - SYLLABUS

Course name
System identification

Course

Field of study
Automatic Control and Robotics
Area of study (specialization)

Level of study
First-cycle studies
Form of study
full-time

Year/Semester
3/6
Profile of study
practical
Course offered in
Polish
Requirements
compulsory

Number of hours

Lecture
15
Tutorials
0

Laboratory classes
30
Projects/seminars
0

Other (e.g. online)
0

Number of credit points
4

Lecturers

Responsible for the course/lecturer:
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Prerequisites

A student should know fundamentals on statistics, signal processing, and systems theory (input-output description in the continuous and distrete time domains, linear approximation of dynamics). Moreover, he/she should have skills in Matlab programming, implementation and simulation of block schemes in the Simulink environment; should have skills to acquire knowledge from selected sources, skills in using basic information-communication tools, and should be ready to cooperate in a team.

Course objective

Extension of student's knowledge on designing and validation of experimental models, build based on measurement data taken from a plant; familiarization of student with selected identification techniques and methods, and shaping skills in implementation and practical utilization of identified models; shaping the skills for cooperation in a small team.

Course-related learning outcomes

Knowledge

1. Extended knowledge on objectives and rules of buidling models for static and dynamic systems and on technical and non-technical applications of models. Analytical vs. empirical modeling; properties of experimental models, and design rules for identification experiments. [K1_W17]
2. Knowledge on basic model structures of dynamical systems used for identification in the continuous and discrete time domains; extended and deepen knowledge on deterministic and stochastic identification methods of static and dynamic (linear and nonlinear) systems for the continuous and discrete time domains. [K1_W17]
3. Deepen knowledge on selected computational techniques and mathematical methods needed for solving specialized tasks of system identification. [K1_W1],[K1_W17]
4. Knowledge on methods used to get an initial (a priori) information on system properties for modeling purposes; validation of experimental models and their assessment in the context of flexibility and parsimony. [K1_W17],[K1_W11]

Skills

1. Planning and preparation of an identification experiment and an identification procedure using either synthetic or real data taken from a system/plant; selection of appropriate methods and tools for solving the tasks in system identification. [K1_U14],[K1_U24]
2 . Building, validation, and assessment of experimental models of SISO/MISO systems, and their utilization for technical purposes. [K1_U9],[K1_U11],[K1_U14]
3. Preparation and presentation of laboratory results in the area of system identification. [K1_U4],[K1_U5]

Social competences

1. Ability to cooperate in a team with a responsibility for a common task. [K1_K3]
2. Consciousness of neccessity to professionally approch to technical tasks. [K1_K5]

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

A) For lectures: Verification of the teaching results during an exam in the form of a final selection test written by students. The test includes 20-30 questions, every one with A,B,C,D answers, where two of them are correct and other two are false. A student earns maximally 1 point for a question if he/she selects two correct answers. One correct answer and one answer left empty results on 0.5 point. Other possibilities result in 0 points for a question. A positive mark from the test needs earning more than a

half of a maximal possible number of points. The result determines the mark OT which, together with a mark OL from laboratory classes, determine (after rounding) the final mark OK computed as follows: OK = OT*0.7 + OL*0.3. The result OK < 3.0 leads to a negative mark from the course.
B) For laboratory classes: Verification of the teaching results is performed by current checks of students' knowledge (preparation to classes and verification of previously learned topics), and also by assessment and 'defending' the final project results (assessment of: obtained results, quality of the written report, and answers to questions formulated by an instructor and related to the given project task).

Programme content

The course presentes the following topics:
- definition of a model, types and roles of models, identification as an alternative approach to modeling, pragmatic approach to empirical modeling, a general scheme of an identification procedure, modeling errors, properties of experimental models, the black-box and grey-box approaches to modeling,
- structures of static models, universal structures of input-output models in the continuous and discrete time domains, linearity of the models with respect to parameters,
- predicting a response of a plant: the optimal one-step-ahead predictor vs. simulation model,
- non-parametric identification methods (time response approach, corellation analysis, frequency analysis),
- properties and general identification schemes for models in the continuous and discrete time domains,
- equation error vs. output error; selected stochastic methods of batch identification: least squares of equation errors method (LS), instrumental variable method (IV); statistical properties of selected identification methods,
- selecter stochastic methods of recursive identification methods (RLS, RELS, RIV); construction of instrumental variables, selected implementation issues concerning recursive methods,
- adaptive recursive identification for systems with time-varying parameters (forgetting factor, covariance matrix resetting),
- designing an identification experiment (planning the experiment, initial processing of measurement data, selection of a sampling frequency, selection and shaping excitation signals, persistency excitation order),
- identification in a closed-loop control system,
- model quality assessment methods (flexibility and parsimony of models); model validation and final model selection,
- discussion on potential application areas of experimental models.

Laboratory classes are divided into two-part sessions. In the first part, all students perform the same set of simulation tasks, where they excersise selected signal processing and identification methods. This part includes the following topics:
- analysis of deterministic signals and stochastic processes in the time and frequency domains (stationary stochastic process and its mean and variance, white and colored noise, corelation function of signals, periodogram, power spectrum of a signal),
- non-parametric identification of SISO systems (approximation of dynamics upon time-responses, corelation analysis),
- parametric identification in a batch form (LS and IV methods),

- recursive parametric identification (RLS, RELS, RIV, adaptive identification – forgetting factor and covariance matrix resetting).

In the second part of laboratory classes, every student team (2-4 persons) chooses and performs one identification task using measurement data recorded from a real plant. This part is summarized by a report, written by the team of students, which describes the whole identification procedure.

Teaching methods

A) Lectures: Presentation of slides illustrated by additional examples provided and analyzed on a blackboard.

B) Laboratory classes: Fifteen 2-hour excercises in a laboratory room, performed by teams of 2-3 students, in a form of programing-computing and simulation tasks of model designing upon collected input-output data from a plant.

Bibliography

Basic

[1] System identification, T. Soderstrom, P. Stoica, Prentice Hall Int. 1989

[2] Identyfikacja obiektów sterowania. Metody dyskretne parametryczne, A. Królikowski, D. Horla, J. Ziętkiewicz, WPP, 2017

Additional

[3] Principles of system identification. Theory and practice, A. K. Tangirala, CRC Press, 2015

[4] Multivariable system identification for process control, Y. Zhu, Pergamon Elsevier Science, 2001

[5] Identification of continuous-time models from sampled data, H. Garnier, L. Wang, Springer, 2008

[6] Identyfikacja obiektów sterowania. Metody dyskretne, A. Królikowski, D. Horla, WPP, Poznań, 2005

[7] System identification. Theory for the user. Second Edition, L. Ljung, PTR Prentice Hall, 1999

[8] Identyfikacja obiektów sterowania. Ćwiczenia laboratoryjne, J. Ziętkiewicz, WPP, 2018

[9] Identyfikacja obiektów i sygnałów. Teoria i praktyka dla użytkownika Matlaba, A. Zimmer, A. Englot, WPK, 2005

[10] Cyfrowe przetwarzanie sygnałów. Od teorii do zastosowań, T. P. Zieliński, WKŁ, Warszawa, 2007

[11] Probabilistyka, A. Plucińska, E. Pluciński, WNT, Warszawa, 2000

Breakdown of average student's workload

	Hours	ECTS
Total workload	114	4
Classes requiring direct contact with the teacher	50	2
Student's own work (literature studies, preparation for laboratory classes, testing the programs after classes, preparation of a final report from a second part of classes, preparation to a credit for classes, preparation for exam) [1]	64	2

[1] delete or add other activities as appropriate