COURSE DESCRIPTION CARD - SYLLABUS

Course name
Advanced identification methods for control systems [S2AiR2-ISA>PO1-ZMISA]

Course

Field of study
Automatic Control and Robotics

Year/Semester
1/2

Area of study (specialization)
Intelligent Control Systems

Profile of study
general academic

Level of study
second-cycle

Course offered in
Polish

Form of study
full-time

Requirements
elective

Number of hours

Lecture
30

Laboratory classes
30

Other
0

Tutorials
0

Projects/seminars
0

Number of credit points

4,00

Coordinators

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Lecturers

Prerequisites

Every student attending the subject is expected to have the knowledge and skill in automatic control basics and signal processing. Every student should also have basic knowledge of nonparametric and parametric identification of simple linear systems, both deterministic and stochastic.

Course objective

To extend student knowledge about system identification with issues concerning multivariable and nonlinear systems. To provide students with the knowledge of control algorithms relying on the models obtianed through system identification and dealing with the identifiability problems in such control systems.

Course-related learning outcomes

Knowledge:
[K2_W5]
[K2_W10, K2_W3]

Skills:
[K2_U10]

[K2_U21]
[K2_U27, K2_U12]

Social competences:
[K2_K4]

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Knowledge acquired during the lectures is assessed by means of a final test consisting of 20–40 closed-ended questions and open-ended questions requiring short answers.
Skills acquired during the laboratory classes are assessed through written quizzes and tests, evaluation of knowledge and skills demonstrated during laboratory exercises, and assessment of course projects prepared by students.

Programme content

Identifiability problems of systems described using transfer functions or state-space equations. System identification methods for multiple-input/multiple-output (MIMO) systems: relying on decomposition to MISO or SIMO subsystems and relying on state-space representation - subspace methods. Problem of minimum realization and Hankel matrix decomposition. Identification algorithms for nonlinear systems. Control methods utilising system identifocation and identifiability problems in such systems.

Course topics

LECTURES:
1. Advanced topics in mathematical modelling of dynamic systems. Analysis of model properties (identifiability, excitation conditions, uncertainty and validation). Generalized identification framework with emphasis on estimation theory aspects.
2. Identification of SISO and MIMO linear systems, including state-space and subspace methods, using deterministic and stochastic estimation approaches.
3. Modelling and identification of nonlinear systems – nonlinearities in dynamic systems, nonlinear model structures (e.g., polynomial and variable-structure models).
4. Fundamentals of nonlinear system analysis, elements of Lie algebra in nonlinear system representation, local linearization and feedback linearization as tools for structural analysis of nonlinear models.
5. Application of machine learning techniques to nonlinear system identification – artificial neural networks, fuzzy systems, and hybrid models.
6. Design of basic control systems based on models obtained via system identification, including adaptive (e.g., MRAC), robust (e.g., ADRC), and selected nonlinear control methods (e.g., FBL).
7. Overview of practical applications of experimentally identified models in analysis and control system design.

LABORATORY EXERCISES:
Simulation exercises focused primarily on advanced system identification methods using the MATLAB/Simulink environment. Basic control design procedures. Analysis and investigation of nonlinear system properties. Solving selected analytical problems. Practical demonstration of the acquired methods at an operational station. Implementation of an identification task based on recorded data from a real system, including preparation of a report.

Teaching methods

1. Lectures: interactive presentation supplemented by examples calculated on the blackboard. Students are encouraged to active participation in the classes.
2. Laboratory classes: practice excercises performed by students on computers, according to the instruction given by a teacher. Students are encouraged to independent thinking, analysis and solving problems arising in advanced system identification.

Bibliography

Basic:
[1] R. Isermann, M. Munchhof, Identification of dynamic systems: an introduction with applications,

Springer, 2011
[2] O. Nelles, Nonlinear system identification: From Classical Approaches to Neural Networks and Fuzzy Models, Springer, 2001
[3] Królikowski A., Horla D., Ziętkiewicz J., Identyfikacja obiektów sterowania, Wydawnictwo Politechniki Poznańskiej, 2017

Additional:
[1] J. Schoukens, L. Ljung, Nonlinear System Identification: A User-Oriented Road Map, IEEE Control Systems Magazine, 2019
[2] Astrom K. J., Wittenmark B., Adaptive control, Addison Wesley, 1998
[3] A. Isidori, Nonlinear Control Systems, Springer-Verlag London, 1995
[4] G. Herbst, R. Madonski, Active disturbance rejection control: From principles to practice. Springer, 2025
[5] M. M. Michałek, Wprowadzenie do identyfikacji systemów, Wydawnictwo Politechniki Poznańskiej, 2023
[6] Wachel P., Identyfikacja i agregacyjne modelowanie nieliniowych systemów dynamicznych, EXIT, 2017
[7] Juang J. N., Applied system identification, Englewood Cliffs: Prentice Hall, 1994

The literature has a comprehensive character; during the course, specific chapters relevant to the discussed topics are indicated.

Breakdown of average student's workload

	Hours	ECTS
Total workload	100	4,00
Classes requiring direct contact with the teacher	60	2,50
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	40	1,50