



## COURSE DESCRIPTION CARD - SYLLABUS

Course name

Adaptive and robust control [N2AiR1-ISAiR>SAiO]

### Course

Field of study

Automatic Control and Robotics

Year/Semester

1/1

Area of study (specialization)

Intelligent Control and Robotic Systems

Profile of study

general academic

Level of study

second-cycle

Course offered in

Polish

Form of study

part-time

Requirements

compulsory

### Number of hours

Lecture

20

Laboratory classes

10

Other

0

Tutorials

0

Projects/seminars

0

### Number of credit points

4,00

### Coordinators

dr inż. Jacek Michalski

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### Lecturers

### Prerequisites

"Knows and understands in enhanced level the selected areas of mathematics. [K2\_W01 (P7S\_WG)] Has an advanced and enhanced knowledge of methods of analysis and design of control systems [K2\_W02 (P7S\_WG)] Has an organized and theoretically based detailed knowledge of the design and analysis of optimal systems. [K2\_W03 (P7S\_WG)] Has an organized and in-depth knowledge of modelling and identification of linear and non-linear systems. [K2\_W08 (P7S\_WG)]" The graduatee can construct an algorithm for solving a complex and unusual engineering task and a simple research problem, as well as implement, test and run it in a selected development environment for selected operating systems. [K2\_U07 (P7S\_UW)] The graduatee is ready to critically evaluate the received content. The graduate understands the need for and knows the possibilities of continuous learning - improving professional, personal and social competences, the graduate is able to inspire and organize the learning process of others. [K2\_K01 (P7S\_KK)]

### Course objective

The course aims at presenting to students basic methods and algorithms of adaptive control, as well as theory and methods of robust control. Discrete-time adaptive controllers and continuous-time robust controllers are mainly discussed.

## Course-related learning outcomes

### Knowledge

1. Has an organized and in-depth knowledge in the field of adaptive systems. [K2\_W10 (P7S\_WH)]
2. Has an organized and in-depth knowledge of modelling and identification of linear and non-linear systems. [K2\_W08 (P7S\_WG)]

### Skills

1. The graduatee is able to use knowledge - to determine models of complex and untypical systems and processes, as well as to use them for the analysis and design of automation and robotics systems. [K2\_U04 (P7S\_UW)]
2. The graduatee can construct an algorithm for solving a complex and unusual measurement and computing-control task as well as implement, test and run it in a selected development environment on a microprocessor platform.. [K2\_U08 (P7S\_UW)]

### Social competences

1. The graduatee is ready to critically evaluate the received content. The graduate understands the need for and knows the possibilities of continuous learning - improving professional, personal and social competences, the graduate is able to inspire and organize the learning process of others. [K2\_K01 (P7S\_KK)]
2. The graduate is ready to think and act in an entrepreneurial way. [K2\_K05 (P7S\_KO)]

## Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

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Lecture: exam.

Laboratory exercises: verification of practical abilities, writing tests.

## Programme content

Review of adaptive control methods for deterministic and stochastic systems. Closed-loop identification. Direct and indirect control methods. Gain-scheduling control. Idea of robustness, uncertainty, including uncertainty to block diagrams, design of a robust controller.

## Course topics

### LECTURES

1. Models of processes. Adaptive control methods. Applications of adaptive control.
2. Model reference adaptive control. MIT and Lyapunov methods.
3. Adaptive controllers for deterministic plants: pole-placement control, model reference control. Indirect adaptive control. Direct self-tuning controllers. Known disturbances.
4. Gain scheduling. Minimum-variance control. Generalization of self-tuning controllers. Predictive control. Auto-tuning of PIDs.
5. Robust control idea. Optimal loop shaping. Optimal disturbance rejection. Robust stability. Uncertainty. Uncertainty in block diagrams. Robust stability tests. Nominal performance. Robust performance. Small-gain theorem.  $H_\infty$  control problem. Design of robust controllers in Matlab.
6. Structure and operation for disturbance observer. Design of Active Disturbance Rejection Control (ADRC).

### LABORATORY EXERCISES

Computer simulation in MATLAB/SIMULINK of basic adaptive and robust control algorithms, using recursive estimation methods. Multimedia slideshows accompanied by a discussion of solutions in selected adaptive control systems. Presentation of an adaptive control system using a laboratory stand (hardware in the loop control). Design of an adaptive and optimal control system with a full report.

## Teaching methods

### a) lecture

- pdf slides (figures, photos), with additional information written on the blackboard,
- lectures accompanied by self-studying handouts via Moodle,
- theory presented with reference to current knowledge of students and to practical problems,
- new subjects preceded by recalling subjects connected or known from other lectures.

## b) laboratory exercises

- sample problems solved in teams,
- commented solutions of the solved problems by the tutor and discussing solutions,
- numerical experiments.

## Bibliography

### Basic

- [1] Horla D., Sterowanie adaptacyjne, Ćwiczenia laboratoryjne, 3rd ed, Wyd.Politechniki Poznańskiej, Poznań 2019
- [2] Astrom K. J., Wittenmark B., Adaptive control, Addison Wesley, 1998
- [3] Królikowski A., Sterowanie adaptacyjne z ograniczeniami sygnału sterującego, Poznań, Wyd. Politechniki Poznańskiej, 2004.

### Additional

- [1] Horla D., Adaptive Predictive Controller for a Servo Drive - Actuator/Sensor Failure Study Experiments, 14th International Conference on Informatics in Control, Automation and Robotics ICINCO, Madrid, Spain , 2017, pp. 551-558
- [2] M. M. Michałek, Wprowadzenie do identyfikacji systemów, Wydawnictwo Politechniki Poznańskiej, 2023
- [3] Horla D., Minimum Variance Adaptive Control of A Servo Drive with Unknown Structure and Parameters, Asian Journal of Control, 2013, vol. 15, no. 1, pp. 120-131
- [4] Horla D., Simulation vs. experimental results of pole-placement controller with full adaptation, 2013 International Conference on Systems, Control and Informatics, 2013, Venice, Italy, pp. 27-33
- [5] E. Lavretsky, K. A. Wise, Robust and adaptive control with aerospace applications, Springer, 2012

## Breakdown of average student's workload

	Hours	ECTS
Total workload	100	4,00
Classes requiring direct contact with the teacher	30	1,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	70	3,00