COURSE DESCRIPTION CARD - SYLLABUS

Course name
Adaptive control [S2AiR2-SSiR>SA]

Course

Field of study
Automatic Control and Robotics

Year/Semester
1/1

Area of study (specialization)
Control and Robotic Systems

Profile of study
general academic

Level of study
second-cycle

Course offered in
Polish

Form of study
full-time

Requirements
compulsory

Number of hours

Lecture
30

Laboratory classes
30

Other (e.g. online)
0

Tutorials
0

Projects/seminars
0

Number of credit points

4,00

Coordinators

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Lecturers

Prerequisites

A student entering the subject should have basic knowledge of identification of dynamic processes (type and structure of models, parametric estimation by the method of least squares) and of control and systems theory (description of systems in state space, input-output description for continuous and discrete time domain, stability analysis by Lyapunov method, linear approximation of system models). In addition, he should have the ability to solve basic problems in the design of automatic control systems for linear systems, the ability to implement programs in Matlab and C language, the ability to create and test block diagrams in the Simulink environment, the ability to obtain information from indicated sources, and should be ready to cooperate as part of a team.

Course objective

The objectives of the course are: discussion of selected techniques of recursive identification of dynamic systems and formation of skills of their implementation and practical use; introduction and explanation of selected techniques and algorithms of adaptive control used in automation and robotics systems; formation of skills of practical implementation of basic control systems adaptive control systems and shaping the ability to work in a small team.

Course-related learning outcomes

Knowledge
1. The properties and uses of selected computational techniques necessary to solve specialised tasks in the identification of dynamical systems. [K2_W1]
2. Knowledge of selected types and structures of dynamical systems models for recursive identification in continuous and discrete time domain. K2_W5]
3. Theoretical and applied knowledge of selected adaptive control techniques and algorithms for linear and non-linear dynamic systems; knowledge of the applicability conditions of adaptive control methods. [K2_W9]
4. Basic knowledge of supervisory and protection circuits in adaptive systems; knowledge of examples of commercial systems using adaptive techniques. [K2_W9]
Skills
1 Determine empirical dynamic models of single-input single-output (SISO/MISO) systems and be able to use them to design control systems. [K2_U10]
2. Select appropriate methods and tools to solve specific recursive identification and adaptive control tasks. [K2_U22]
3. Implement selected types of adaptive control algorithms and run them in a simulation environment and also in a rapid prototyping environment using real physical objects. [K2_U9][K2_U15].
4. Prepare and present the results of laboratory work. [K2_U8]
Social competences
1. Ability to cooperate in a team with a responsibility for a common task. [K2_K3]
2. Consciousness of neccessity to professionally approch to technical tasks. [K2_K4]

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Learning outcomes presented above are verified as follows:
A) In the scope of lectures the verification of the assumed learning outcomes is realized by the assessment of the student's knowledge demonstrated during the completion of the lecture content in the form of a choice test; the test contains 30 questions - each with four answers A, B, C, D, of which two are correct and two are false; the selection by the student of both correct answers gives 1 point for a given question; the selection of one correct answer and leaving the other answer unanswered gives 0.5 point for a given question. question; selecting one correct answer and one false answer results in no point for the given question (the other choices, or lack thereof, also result in no point for the given question). Obtaining a positive grade on the credit test requires a minimum of 15.5 points.
B) In terms of laboratory classes, verification of the established learning outcomes is realized by evaluation and 'defense' by the student team of the final report on the implementation of the rapid prototyping task prototyping task; the quality of the results obtained, the content and quality of the final report are checked and evaluated of the final report, as well as answers to factual questions related to the completed task and/ or with the scope of the material covered in the laboratory program.

Programme content

The course covers the following topics:
- design and analysis of selected adaptive control algorithms,
- implementation issues concerning adaptive control systems,
- simulation and experimental verification of selected adaptive control laws,
- discussing selected applications of adaptive controllers.

Course topics

The lecture program covers the following topics:
- model definition, identification as an alternative approach to model development,
- selected types and structures of dynamic input-output models in the continuous and discrete time domain; linearity of model structures due to parameters,
- general identification schemes for continuous and discrete time dynamic models,
- selected stochastic recursive identification methods, statistical properties of selected identification methods, implementation issues of recursive methods,
- adaptive recursive identification of systems with variable parameters (forgetting factor forgetting, resetting the covariance matrix),
- identification problem in a control system with feedback,

- Adaptation and adaptive control, objectives of adaptive control, features of ideal and real adaptive control system, general scheme of adaptive control, comments on the practical applicability of adaptive systems, decision-making scheme of application of the system adaptive control,
- application of identification in adaptive control and controller tuning issues,
- selected methods of adaptive control: control with model identification (MIAC), control with multiple switched models (MMAC), control with reference model (MRAC, SAC), control with parameter/gain serialization (P/GS), control with active/adaptive disturbance rejection (ADRC),
- issues of practical implementation of adaptive control systems (supervision and protection),
- examples of commercial adaptive control systems.

Laboratory classes are conducted in the form of fifteen 2-hour exercises, held in the laboratory. The exercises are carried out by teams of 2 students. The program of the laboratory is divided into two parts. In the first part, all teams implement the same set of 4 exercises simulation exercises in the following topics:
- recursive parametric identification methods, adaptive recursive identification (coefficient of forgetting and resetting the covariance matrix),
- design and simulation testing of the MIAC type control system,
- design and simulation testing of the MRAC type control system,
- design and simulation testing of the ADRC-type control system.

In the second part, each student team selects and carries out one of a set of given tasks of a programming and computational nature combined with the performance of experiments on physical objects physical objects (PMxR, ZB2, HILSys, TRAS, 3DCrane, PME1R) in a rapid prototyping system (Code Composer Studio, VisSim, Matlab-Simulink + Real Time Workshop). Task topics include issues of implementation and testing of selected adaptive control systems using real dynamic objects.

Teaching methods

A) Lectures: multimedia presentation (slides) further illustrated by examples given and analysed on the blackboard.
B) Laboratory exercises: performance of programming, calculation, simulation and rapid prototyping tasks of control systems in topics given by the lecturer - practical exercises.

Bibliography

Basic
[1] Robust and adaptive control with aerospace applications, E. Lavretsky, K. A. Wise, Springer, London, 2012
[2] Adaptive control. Algorithms, analysis and applications. Second Edition, I. D. Landau, R. Lozano, M. M'Saad, A. Karimi, Spronger, London, 2011
[3] Adaptive control. Second Edition, K. J. Astrom, B. Wittenmark, Addison Wesley, 1995
Additional
[4] Wprowadzenie do identyfikacji systemów, M. M. Michałek, WPP, Poznań, 2023
[5] Adaptive control tutorial, P. Ioannou, B. Fidan, SIAM, Philadelphia 2006
[6] Direct adaptive control algorithms. Theory and applications. Second Edition, H. Kaufman, I. Barkana, K. Sobel, Springer, New York, 1998
[7] Advanced PID control, K. J. Astrom, T. Hagglund, ISA, 2006
[8] Cyfrowe przetwarzanie sygnałów. Od teorii do zastosowań, T. P. Zieliński, WKŁ, Warszawa, 2007

Breakdown of average student's workload

	Hours	ECTS
Total workload	114	4,00
Classes requiring direct contact with the teacher	62	2,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	52	2,00