COURSE DESCRIPTION CARD - SYLLABUS

Course name

Optimal control systems

Course

Field of study	Year/Semester
Automatic Control and Robotics	3/5
Area of study (specialization)	Profile of study
	practical
Level of study	Course offered in
First-cycle studies	polish
Form of study	Requirements
full-time	compulsory

Number of hours

Lecture	Laboratory classes	Other (e.g. online)
15	30	
Tutorials	Projects/seminars	

Number of credit points

3

Lecturers

Responsible for the course/lecturer:

Sławomir Stępień Ph.D., D.Sc, Eng.

Associate Professor

email: Slawomir.Stepien@put.poznan.pl

tel. 61 665 23 64

Faculty of Control, Robotics and Electrical Engineering

Piotrowo 3a, 60-965 Poznan

Responsible for the course/lecturer:

Prerequisites

The student, starting this subject should have basic knowledge of mathematics including algebra, calculus of variation and the knowledge necessary to describe dynamic systems and analyze its stability. Ability to model automation systems and manipulators. Programming using high-level languages C++, Java, and scripting Python, Matlab, etc. The student starting this subject should be able to apply knowledge to the control problems that are being solved. Ability to work in a team. Exchange of acquired knowledge and experience.

Course objective

1.Knowledge related to dynamic optimization methods without and with constraints

2.Ability to develop strategy for controlling optimal linear-quadratic regulator LQR

3.Ability to develop strategy for time-optimal control and with minimal energy

4.Ability to develop a suboptimal control strategy SDRE

5.Shaping students' teamwork skills by implementing project elements and combining them together

Course-related learning outcomes

Knowledge

Knowledge in mathematics for describing and analyzing dynamic systems properties, describing control algorithms and analyzing the stability of dynamic systems. Knowledge of linear dynamic systems theory, including selected methods of modelling and stability theory; knows and understands the basic properties of linear and nonlinear dynamic systems described in time and frequency domain. Basic synthesis criteria and tuning methods for optimal regulators, tools and techniques for controller synthesis.

Skills

Student can choose and apply methods and tools for designing automation and robotics systems, verify its usefulness. Can design and analyze simple optimal and suboptimal control systems.

Social competences

Student understands the need and knows the possibilities of continuous further education, professional, personal and social competences. He is aware of the need for a professional approach to technical problems. Understands the need and the possibility of further transfer of acquired knowledge and skills.

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

The summary assessment of the lectures concerns the verification of the intended learning outcomes, i.e. the assessment of the knowledge and skills demonstrated in the problem by written examination.

In the field of laboratory exercises, verification of the intended learning outcomes is carried out by continuous evaluation, in each class (oral responses, reports), in addition, by assessing the acquired knowledge and skills through one or two tests in semester.

Programme content

The lecture program covers following topics:

1. Modeling and describing methods for dynamic systems in the state-space. Linear and nonlinear dynamic system modeling - analytical and numerical solution of state-space equations that describe dynamic systems

2. Calculus of variations: Euler-Lagrange equations - necessary conditions and sufficient solutions - integral indicators

3. Dynamic optimization - differential and integral constraints - Lagrange multiplier method

4. Controllability and reachability of dynamic systems

5. Optimal control of linear dynamic systems - Pontriagin maximum principle - Hamilton-Jacobi-Bellman account - optimal control for finite and infinite time horizon problems

6. Application of the Pontriagin maximum principle to time-optimal control.

7. Energy minimum optimal control.

8. Suboptimal control methods for nonlinear systems. SDRE method.

9. Analysis and properties of known control methods in terms of implementation possibilities and industrial applications.

Laboratory exercises are prepared in the form of fifteen 2-hour meetings. Each meeting is prepared from a single topic. During the classes, students solve the received tasks using computers in the indicated virtual environment in the scope of the material presented in the lectures. The curriculum includes:

1.State-space dynamic systems modelling.

2.Control of linear and non-linear systems.

3.Optimal control with constraints of linear dynamic systems.

4.LQR application for finite and infinite time horizon problems.

5. Nonlinear systems modeling. SDC parameterization of these models.

6.SDRE application for finite and infinite time horizon problems.

7.Analysis of the properties above control methods in terms of implementation and practical applications.

Teaching methods

lecture: multimedia lecture with examples assisted by table explanations

laboratories: numerical implementation and analysis, discussion

Bibliography

Basic

1. Daniel Liberzon, Calculus of variations and optimal control theory, Princeton University Press, 2012

2. M. Athans i P. Falb, Optimal Control: An Introduction to the Theory and its Applications, Dover Publications, Inc., New York, 2007.

Additional

1. R. Bellman, Dynamic programming, Dover Publications, Incorporated, 2003

Breakdown of average student's workload

	Hours	ECTS
Total workload	70	3,0
Classes requiring direct contact with the teacher	45	2,0
Student's own work (literature studies, preparation for laboratory classes/tutorials, preparation for tests/exam, project preparation) [1]	25	1,0

[1] delete or add other activities as appropriate