POZNAN UNIVERSITY OF TECHNOLOGY

EUROPEAN CREDIT TRANSFER AND ACCUMULATION SYSTEM (ECTS)

pl. M. Skłodowskiej-Curie 5, 60-965 Poznań

COURSE DESCRIPTION CARD - SYLLABUS

Course name

Nonlinear control systems

Course

Field of study	Year/Semester
Automatic Control and Robotics	1/2
Area of study (specialization)	Profile of study
Smart Aerospace and Autonomous Systems	general academic
Level of study	Course offered in
Second-cycle studies	English
Form of study	Requirements
full-time	compulsory

Number of hours

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

Number of credit points

4

Lecturers

Responsible for the course/lecturer:

prof. dr hab. inż. Krzysztof Kozłowski

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Faculty of Control, Robotics and Electrical Engineering

Piotrowo 3A Street, Poznań

Responsible for the course/lecturer:

Prerequisites

Knowledge: The student starting this subject should have basic knowledge of subjects such as Control Theory, Mathematical Analysis and Algebra.

Skills: Should have the ability to solve basic problems covered by the required knowledge and the ability to obtain information from the indicated sources. He should also understand the need to expand his competences.

Social Competences: In addition, in terms of social competences, the student must present attitudes such as honesty, responsibility, perseverance, cognitive curiosity, creativity, personal culture, respect for other people.

Course objective

1. To provide students with knowledge of nonlinear control systems, in particular knowledge related to the use of Lie groups and algebras in controlling nonlinear systems. As a consequence, students will be prepared to solve problems related to the stability of these systems and their synthesis.

2. Developing students' ability to solve problems of the synthesis of nonlinear systems using the latest mathematical tools as well as the ability to connect theory with practice.

Course-related learning outcomes

Knowledge

1.has extended and in-depth knowledge of mathematics including algebra, geometry, analysis, probability and elements of discrete mathematics and logic, including mathematical methods and numerical methods necessary for the description and analysis of the properties of linear and basic nonlinear dynamic and static systems, description and analysis complex quantities, - [K_W1]

2.description of random processes and uncertain quantities, description and analysis of combinational and sequential logic systems, description of control algorithms and analysis of the stability of dynamic systems, description, analysis and methods of signal processing in the time and frequency domains, numerical simulation of dynamic systems in the domain of continuous and time discreet; - [K_W1]

3. has an ordered, theoretically founded, detailed knowledge of methods of analysis and design of control systems; - [K_W7]

4. has theoretically founded detailed knowledge related to control systems and control and measurement systems; - [K_W11]

5. has knowledge of development trends and the most important new achievements in the field of automation and robotics and related scientific disciplines; - [K_W12]

Skills

1. obtain information from literature, technical documentation and other sources, also in English; - [K_U1]

2. is able to simulate and analyze the operation of complex auto-matics systems and plan and carry out experimental verification; - [K_U9]

3. is able to designate models of simple systems and processes, and to use them for the purposes of analysis and design of automation and robotics systems; - [K_U10]

4. is able to make a critical analysis of the operation of control systems or robotics systems; also has the ability to select automation systems with the use of programmable controllers; - [K_U19]

5. can critically evaluate and select appropriate methods and tools to solve tasks in the field of automation and robotics; is able to use innovative and unconventional tools in the field of automation and robotics and shape dynamic properties of measurement paths; - [K_U22]

Social competences

1. is aware of the responsibility for their own work and is ready to submit to the principles of teamwork and be responsible for jointly performed tasks; is able to lead a team, set goals and define priorities leading to the implementation of the task; - [K_K3]

2. is aware of the need for a professional approach to technical issues, scrupulous reading of the documentation and environmental conditions in which the devices and their components may function; - [K_K4]

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Formative assessment:

a) in the field of lectures:

based on answers to questions about the material discussed in previous lectures,

b) in the field of laboratory exercises:

based on the assessment of the current progress of the solved laboratory tasks,

Summative assessment:

a) in the field of lectures, verification of the assumed learning outcomes is carried out by:

i. assessment of the knowledge and skills shown in the written exam in the subject, which consists of 4 problem tasks for which 20 points can be obtained (5 points for each problem).

ii. assessment of knowledge and skills on the basis of individual discussion of the results of the written exam (additional control questions),

b) in the field of laboratory exercises, verification of the assumed learning outcomes is carried out by:

assessment of the student's preparation for individual laboratory exercises and assessment of skills related to the implementation of laboratory exercises,

Obtaining additional points for activity during classes, especially for:

i. discuss additional aspects of the issue,

ii. the effectiveness of applying the acquired knowledge while solving a given problem,

iii. comments related to the improvement of teaching materials,

iv. identifying students' perceptual difficulties enabling ongoing improvement of the teaching process.

Programme content

The lecture program covers the following topics:

1. Algorithm of dynamic expansion for a nonlinear system in general form:

a.detailed discussion of a calculation example,

2. Crane dynamics model and control algorithm synthesis:

a. Derivation of dynamics equations for the crane along with the transferred load,

b. dynamics equations in the form of state equations,

c. trajectory generator for the crane - derivation of general formulas,

d. linearization of the gantry equations in the vicinity of the operating point and controllability,

e. linearization algorithm of the input-output crane equations,

f. derivation of the dynamic extension algorithm for the crane.

g. simulation analysis of the derived equations.

3. Definition of algebra and Lie group:

a.formal definition of Lie algebra with examples (e.g. SO (2), SO (3)),

b. analysis of Lie algebra properties,

c. formal definition of the Lie group and discussion of their basic properties,

d. examples of Lie groups and their analysis,

e. detailed analysis of the exponential mapping to SO (3),

f. detailed analysis of the exponential mapping to SE (3),

g. definition of an attached operation and its examples in robotics.

4. Definition of the left-alternating and non-volatile operation:

a.examples of invariant operations,

b. basic properties of invariant operations,

5. Definition of a system on the Lie group:

a.example of the description of the system on the Lie group, b.definition of the error on the Lie group for a two-wheel robot with a differential drive,

c. derivation of the error differential equation for the two-wheeled robot described on the Lie group,

d. derivation of the control algorithm to the point and the recovery of the trajectory for the system described in the Lie group.

Laboratory exercises are conducted in the form of seven 2-hour lessons and include the following practical exercises (the last exercise is a credit).

1. Introduction to modeling with the symbolic computation package in Matlab.

2. The use of symmetry to design a controller and an observer of the state of kinematic systems.

3. The method of dynamic linearization in unicycle robot control.

4. The singular perturbation method and inverted pendulum linearization.

5. Furuta pendulum control algorithm.

6. Using linearization and differential flatness to control a gantry crane? approximate method.

Teaching methods:

1. Lecture: traditional presentation on the board illustrated with examples.

2. Laboratory exercises: a series of six practical exercises and laboratory completion.

Teaching methods

Bibliography

Basic

Additional

Breakdown of average student's workload

	Hours	ECTS
Total workload	100	4,0
Classes requiring direct contact with the teacher	49	2,0
Student's own work (literature studies, preparation for laboratory classes/tutorials, preparation for tests/exam, project preparation) [1]	51	2,0

[1] delete or add other activities as appropriate