COURSE DESCRIPTION CARD - SYLLABUS

Course name

Theory and methods of optimization

Course

Field of study

Automatic Control and Robotics

Area of study (specialization)

Level of study

second-cycle studies

Form of study

full-time

Year/Semester

1/2

Profile of study

general academic

Course offered in

Requirements

compulsory

Number of hours

Lecture

30

Laboratory classes

0

Other (e.g. online)

0

Tutorials

30

Projects/seminars

0

Number of credit points

5

Lecturers

Responsible for the course/lecturer:

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Faculty of Control, Robotics and Electrical Engineering

ul. Piotrowo 3a, 60-965 Poznań

Responsible for the course/lecturer:

Prerequisites

Knowledge: The student starting this course should have basic knowledge of linear algebra, matrix calculus, mathematical analysis, differential calculus..

Skills: Should have the ability to solve basic problems of algebra and geometry and also the ability to gather information from indicated sources.

Social competences: Should understand the necessity of widening his competences. Regarding social competences he/she should have such character traits like honesty, perseverance, curiosity, creativity, personal culture, respect for other people.

Course objective

1. To give basic knowledge of theory and methods of optimization, including linear, nonlinear, and integer programming.

2. Development of skills of formalizing and solving problems of linear programming using Simplex and graphical methods, problems of nonlinear programming using Lagrange, KKT, and gradient methods, problems of integer programming using Gomory's method.

Course-related learning outcomes

Knowledge

1. has knowledge of mathematics including algebra, geometry, elements of mathematical analysis, and elements of discrete mathematics necessary to formalize and solve problems of theory of optimization [K2_W1]
2. has structured and deepened knowledge of modeling and identification of linear and nonlinear systems [K2_W5]
3. has structured, theoretically grounded knowledge of the design and analysis of optimal systems [K2_W8]

Skills

can critically use information from the literature, databases and other sources

can build simple models of systems and processes and also use them for the purposes of analyzing and designing systems for automation and robotics

is able to notice nontechnical aspects while formulating and solving tasks of designing systems for automation and robotics

can critically asses and use appropriate methods and tools for solving tasks of optimization

Social competences

understands the necessity and know possibilities of continuous training - raising of professional, personal, and social competences, can inspire and organize the learning process of other persons

is aware of necessity of professional approach to technical issues, careful getting acquainted with documentation

is ready to think and act in enterprising manner

understands the necessity and possibility of transfer of knowledge and skills

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Summative rating:

a) for the lectures the verification of the assumed effects of learning is realized by:
   - assessment of knowledge and skills demonstrated during the written exam;
b) for the tutorials the verification of the assumed effects of learning is realized by:
   - continuous assessment during each class (oral answers) - bonus for increment of the ability of using the gathered knowledge.

Acquiring additional points for activity during the classes, in particular for:

i. discussion about additional aspects of topics

ii. effectivity of the application of the gathered knowledge during solving the posed problems

iii. showing perceptual difficulties, for the advancement of the didactic process.

Programme content

Programme of the lecture includes:

Introduction to optimization theory. The problems of mathematical programming. Problems of linear and nonlinear optimization. Principles of linear algebra. Systems of linear equations Ax=b. Convex sets and functions. Linear programming problems. Formalizing of linear programming problems. Standard form of linear optimization task. The properties of linear programming

problems in the standard form. Graphical interpretation of linear programming problems. Solving linear programs using the graphical method. Cases of continuous and discrete linear programs. Theoretical basics of Simplex method. Simplex algorithm. Determination of initial base solution. Artificial basis method. Methods with penalty coefficients. Special cases of problems of linear programming (unbounded and contradictory). Duality in linear programming. A pair of symmetric dual problems. Duality theorem.

Discrete optimization. Problem of integer linear programming. The idea of cutting planes, Gommory's algorithm. Solving integer programming problems - examples.

Nonlinear programming. The classification of nonlinear programming problems. The classification of methods of solving nonlinear programs. Nonlinear programs that can be transformed to linear programs. Convex programming problems. Standard nonlinear programming. Lagrange's function. Lagrange theorem. Gradient methods. Optimization methods used in neural networks.

Program of tutorials includes topics from the lectures with emphasis on:

1. Types of linear programs, graphical interpretation. Types of problems that can be solved using linear programming.
2. Simplex method
3. Dual Lagrange linear program
4. Dual simplex method
5. Unconstrained nonlinear optimization problems. Optimality conditions.
6. Unconstrained nonlinear optimization methods, gradient method, line search
7. Steepest descent and Newton's methods.
8. Quasi Newton methods. Conjugate gradient method.
9. Convergence analysis
10. Gradient methods used in neural networks.
11. Nonlinear optimization with equality constraints. Optimality conditions.
12. Nonlinear optimization with inequality constraints.
13. Dual Lagrange task. Quadratic programming.
14. Inner and outer penalty function.
15. Test

Teaching methods

1. Lecture: multimedia presentation, presentation supported with examples showed on the blackboard, solving problems, demonstration
2. Tutorials: solving problems, practical exercises, discussion

Bibliography

Basic

1. Wprowadzenie do optymalizacji, Andrzej Stachurski, Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa, 2009

2. Linear and nonlinear programming, David Luenberger i Yinyu Ye, Springer, 2008

Additional

1. Nonlinear programming, Dimitri Bertsekas, Athena Scientific, Belmont, 2016

Breakdown of average student's workload

	Hours	ECTS
Total workload	100	4
Classes requiring direct contact with the teacher	64	2,5
Student's own work (literature studies, preparation for laboratory classes/tutorials, preparation for tests/exam, project preparation) [1]	36	1,5

[1] delete or add other activities as appropriate