COURSE DESCRIPTION CARD - SYLLABUS

Course name
Theory and methods of optimization [S2AiR2-SW>TiMO]

Course

Field of study
Automatic Control and Robotics

Year/Semester
1/2

Area of study (specialization)
Vision 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
15

Laboratory classes
30

Other
0

Tutorials
0

Projects/seminars
0

Number of credit points

3,00

Coordinators

dr hab. Szymon Drgas
szymon.drgas@put.poznan.pl

Lecturers

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
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]
has structured and deepened knowledge of modeling and identification systems [K2_W5]
has structured, theoretically grounded knowledge of the design and analysis of optimal systems [K2_W8]
Skills
A student:
1. can critically use information from the literature, databases and other sources – [K2_U1]
2. can build simple models of systems and processes and also use them for the purposes of analyzing and designing systems for automation and robotics – [K2_U10]
3. is able to notice nontechnical aspects while formulating and solving tasks of designing systems for automation and robotics – [K2_U14]

4. can critically asses and use appropriate methods and tools for solving tasks of optimization – [K2_U22]

Social competences
A student:
1. 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 – [K2_K1]
2. is aware of necessity of professional approach to technical issues, careful getting acquainted with documentation – [K2_K4]
3. is ready to think and act in enterprising manner – [K2_K5]
4. understands the necessity and possibility of transfer of knowledge and skills – [K2_K6]

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Learning outcomes presented above are verified as follows:

Summative rating:
for the lectures the verification of the assumed effects of learning is realized by:
assessment of knowledge and skills demonstrated during the written exam;
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.

Course topics

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 laboratory classes includes topics from the lectures with emphasis on:
Types of linear programs, graphical interpretation. Types of problems that can be solved using linear programming.
Simplex method
Dual Lagrange linear program
Dual simplex method
Unconstrained nonlinear optimization problems. Optimality conditions.
Unconstrained nonlinear optimization methods, gradient method, line search
Steepest descent and Newton's methods.
Quasi Newton methods. Conjugate gradient method.
Convergence analysis
Gradient methods used in neural networks.
Nonlinear optimization with equality constraints. Optimality conditions.
Nonlinear optimization with inequality constraints.
Dual Lagrange task. Quadratic programming.
Inner and outer penalty function.
Test

Teaching methods

Lecture: multimedia presentation, presentation supported with examples showed on the blackboard, solving problems, demonstration
Laboratory classes: 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	75	3,00
Classes requiring direct contact with the teacher	45	2,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	30	1,00