COURSE DESCRIPTION CARD - SYLLABUS

Course name
Intelligent optimization methods [S2Inf1-SzInt>IMO]

Course

Field of study
Computing

Year/Semester
1/1

Area of study (specialization)
Artificial Intelligence

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
16

Laboratory classes
16

Other
0

Tutorials
0

Projects/seminars
0

Number of credit points

2,00

Coordinators

prof. dr hab. inż. Andrzej Jaszkiewicz
andrzej.jaszkiewicz@put.poznan.pl

Lecturers

Prerequisites

Student entering this course should have a basic knowledge about discrete mathematics, algorithms and data structures or practical algorithmics, operational research, combinatorial optimization, statistics and data analysis, programming.

Course objective

The objective of this course is to give the students knowledge about intelligent optimization methods with a focus on discrete/combinatorial problems. After completion of this course student should have skills allowing designing and implementing an efficient optimization method for a given optimization problem. The student should also be able to seek possibilities for further improvements of this method in the scientific and technical literature.

Course-related learning outcomes

Knowledge:
after completion of this course the student:
has advanced, in-depth knowledge about widely understood information systems, theoretical basis of their construction, methods, tools and programming environments used for their implementation in the

area of intelligent optimization methods [k2st_w1]
has orderly and theoretically grounded knowledge related to key aspects in the area of intelligent optimization methods [k2st_w2]
has advanced, detailed knowledge about selected aspects inr the area of intelligent optimization methods [k2st_w3]
has knowledge about current trends and major recent achievements in the area of intelligent optimization methods [k2st_w4]
knows advanced methods, techniques and tools used for solving complex engineering tasks and in research projects in the area of intelligent optimization methods [k2st_w6]

Skills:
is able to search information in the literature, data bases and other sources (in polish and english), integrate, interprete, critically evaluate, draw conclusions, formulate and justify conclusions based on this information in the area of intelligent optimization methods [k2st_u1]
is able to plan and perform experiments, including measurements and computer simulations, interprete results, draw conclusions, formulate and verify hypotheses related to complex engineering and simple research problems in the area of intelligent optimization methods [k2st_u3]
is able to apply analytical, simulation and experimental methods for formulation and solution of engineering and simple research problems in the area of intelligent optimization methods [k2st_u4]

Social competences:
understands that in the area of intelligent optimization methods knowledge and skills quickly become obsolete [k2st_k1]
understands the importance of using recent knowledge in the area of intelligent optimization methods for solving research and practical problems [k2st_k2]

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Learning outcomes presented above are verified as follows:
Formative assessment:
a) lectures:
- based on student"s activity during lectures and answers to lecturer"s questions concerning material from the previous classes,
b) laboratories:
- based on student"s activity and assesment of on-goind progress in realization of laboratory tasks
Summary assessment:
a) lectures:
- assessment of knowledge and skills through a written colloquium composed of open and closed questions, and tasks,
- discussion on colloquium results
b) laboratories:
- constant assesment during each class (oral answers), special bonuses for improvement of skills in applying learned rules and methods
- assesment of reports preaperd partially during classes and partially after classes, this assesment involves also assesing team work skills
Additional points could be obtained for additional activity during classes, in particular
- demonstration of additional interesting skills beyond course program,
- discussion about additional aspects of tasks,
- remarks and improvemnt suggestions about didactic materials,
- team work skills during laboratory tasks.

Programme content

Elements of optimization tasks. Classification of optimization methods. Sources of difficulty of optimization tasks. Examples of optimization problems with the focus on discrete/combinatorial problems. Exhaustive search. The idea of branch-and-bound method. Complexity of black box search with quantum computers. Random search. Greedy heuristics. Randomization of greedy heuristics. Regret heuristics. The ida of neighborhood. Local search in greedy and steepest versions. Improvements of local search efficiency: using delta of objectve function, the use of moves evaluations from previous

iterations, candidate moves, global memory of (components of) moves evaluations, advanced techniques. Multiple start local search. Variable neighborhood local search. Iterated local search. Adaptive local search. Large scale neigjborhood search. Simulated annealing and related algorithms. Tabu search. Long term memory.
Population and biologically inspired algorithms. Ant colony algoithms. Genetic and evolutionary algorithms. Crossover and recombination. The idea and role of schemata. Selection methods. Solutions encoding. Indirect encoding. Hybrid evolutionary algorithms. Hyper-heuristics and genetic hyper-heuristics. Approaches for handling constratints.
General scheme of intellignet optimization methods. No free lunch theorem - assumptions, outline of the proof, scope. practical conclusions. Measures of optimization tasks difficulty. Objective function landscape analysis. Systematic design of optimization methods for particular problems. Examples of applications of this systematic approach. Experimental evaluation of intelligent optimization methods. Recent trends in intelligent optimization methods..

Course topics

Approximate optimization methods for complex optimization problems, in particular combinatorial optimization, including multiobjective optimization methods. Theoretical foundations of such methods.

Teaching methods

1. Lectures: multimedia presentations, demonstration, discussion
2. Laboratory classes: oral introduction, programming, realization and analysis of results of computational experiments, discussion. During laboratory classes students work in pairs on a selected optimization problem elaborating more and more advanced intelligent optimization methods, based on results from a previous classes.

Bibliography

Basic
1. Jarosław Arabas, Wykłady z algorytmów ewolucyjnych, WNT, 2006.
2. Zbigniew Michalewicz, Algorytmy genetyczne + struktury danych = programy ewolucyjne, Helion, 2003.
3. Z. Michalewicz, Jak to Rozwiązać, czyli Nowoczesna Heurystyka, WNT, 2006
Additional
1. Jaszkiewicz A., Distance preserving recombination operator for earth observation satellites operations scheduling, Journal of Mathematical Modelling and Algorithms, Volume 7, Issue 1, March 2008, Pages 25-42.
2. Lust, T., Jaszkiewicz, A., Speed-up techniques for solving large-scale biobjective TSP, 2010, Computers and Operations Research, 37(3), pp. 521-533.

Breakdown of average student's workload

	Hours	ECTS
Total workload	50	2,00
Classes requiring direct contact with the teacher	32	1,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	18	1,00