SYLLABUS
Academic year 2024-2025

Dean,
Prof. Dr. Eng. Vasile-Ion Manta

1. Program data

1.1 Higher education institution	"Gheorghe Asachi" Technical University of Iași
1.2 Faculty	Automatic Control and Computer Engineering
1.3 Department	Computers
1.4 Field of studies	Computers and Information Technology
1.5 The cycle of studies[1]	Master
1.6 Study program	Artificial Intelligence

2. Subject data

2.1 Name of the subject / Code				**Optimization and Constraint Satisfaction** (*Optimizare și satisfacerea constrângerilor*) / **AI.111**			
2.2 Course coordinator				Lecturer Dr. Eng. Elena Niculina Dragoi			
2.3 Application instructor				Lecturer Dr. Eng. Elena Niculina Dragoi			
2.4 Year of study[2]	1	2.5 Semester[3]	1	2.6 Type of assessment[4]	*Colloquium*	2.7 Type of subject[5]	DA

3. Estimated total time of daily activities (hours per semester)

3.1 Number of hours per week	2	3.2 lectures	1	3.3a sem.		3.3b laboratory	1	3.3c project	
3.4 Total hours in curriculum[6]	28	3.5 lectures	14	3.6a sem.		3.6b laboratory	14	3.6c project	

Distribution of the time fund[7]	No. hours
Study by textbook, course support, bibliography and notes	20
Additional documentation in the library, on specialist electronic platforms and in the field	28
Preparation of seminars/labs/projects, assignments, reports and portfolios	20
Tutorial[8]	
Examinations[9]	4
Other activities:	

3.7 Total hours of individual study[10]	72
3.8 Total hours per semester[11]	100
3.9 Number of credits	4

4. Prerequisites (where applicable)

4.1 curriculum[12]	
4.2 competences	

5. Conditions (where applicable)

5.1 conducting the lectures[13]	• Blackboard, video projector
5.2 conducting the seminar / laboratory / project[14]	• Laboratory room with computers and Internet access • Python (free/academic license); Visual Studio

6. Specific competences accumulated[15]

		Number of credits assigned to the subject[16]: **4**	Distribution of credits per competences[17]
Professional competences	CP1	Knowledge of advanced concepts of computer science and information technology and the ability to work with these concepts.	0.8
	CP2	Scientific and practical research in the field of optimization.	0.7
	CP3	Design and development of optimization algorithms.	0.8
	CP4	Problem solving using methods and techniques specific to optimization.	0.8
	CP5	Utilization of tools and technologies.	0.4
	CP6		
	CPS1		
	CPS2		
Transversal competences	CT1	Legislation compliant application of the intellectual property rights and of the principles, norms and values of the professional ethics code within their own strategies for rigorous, effective and responsible work.	0.2
	CT2	Application of communication techniques and effective group work; developing empathic interpersonal communication skills and assuming leadership roles/functions in a multi-specialized team.	0.2

	CT3	Creating opportunities for continuous training and the effective utilization of learning resources and techniques for personal development.	0.1
	CTS		

7. Objectives of the subject (resulting from the grid of specific competences accumulated)

7.1 General objective of the subject	The course is designed to provide students with the skills and knowledge necessary applying optimization techniques to a variety of systems.
7.2 Specific objectives	The goal of this course is to familiarize the students with the general concepts and to provide the basis that allow their applications to specific use-cases. Specific objectives focus on: • Understanding the types of problems and the main optimizations strategies associated with them • Identifying the specific alterations that must be performed to a general optimization algorithm to fit to the characteristics of the problem being solved (local/global search; constraint handling, etc..). • Learning to develop optimization applications in Python/ Visual Studio. • Designing new optimization algorithms.

8. Contents

8.1 Course[18]	Teaching methods[19]	Remarks
1. **Introduction to optimization methods** (4 hours): Overview of optimization methods and applications in artificial intelligence, Types of optimization problems. Classification of optimization methods. General Principles (function evaluations, noise, curse of dimensionality, stop criteria). Comparison of optimization methods in terms of efficiency, accuracy, and robustness. Performance measurement metrics and convergence measurement 2. **Deterministic and stochastic optimization** (2 hours) Deterministic-Steepest descent (with and without noise). Deterministic/exact-Branch & Bound. Random Search (simple, localized, enhanced). Comparison between the 3 versions for a use-case **3. Evolutionary and Biologically-inspired optimization** (4 hours) Overview of evolutionary algorithms and of biologically-inspired optimization. Common terminology and sources of inspiration. Genetic algorithms: representation, selection, crossover, mutation, and fitness evaluation. Differential Evolution: differentiation, adaptation, and recombination. Ant Colony Optimization: ants, pheromones, colony, and objective function. Artificial Fish Swarm: fish, school, behavior, and fitness 4. **Constraint Satisfaction Problems** (4 hours) Overview of the different techniques used to solve CSPs. Characteristics of CSPs, such as consistency and completeness. Backtracking algorithms, search trees, breadth-first search, and A*. Arc consistency and path consistency algorithms. Constraint propagation algorithms, including constraint-based reasoning and the forward checking algorithm. Local search algorithms for CSPs, including hill climbing, simulated annealing, and tabu search. Hybrid methods for solving CSPs, including the hybrid backtracking algorithm, the constraint-based local search algorithm, and the hybrid constraint propagation and local search algorithm **TOTAL: 14 hours**	The presentation of course-related materials using video-projected PowerPoint slides. Drawing connections with concepts from adjacent disciplines from both undergraduate and graduate programs of study, and verifying how the novel elements introduced are assimilated. Discussing the presented methods using numerous case studies and relevant examples.	

Course references:

1. Törn, Aimo, and Antanas Žilinskas. Global Optimization. Vol. 350: Springer, 1989.
2. Weise, Thomas. "Global Optimization Algorithms-Theory and Application." Self-Published Thomas Weise 361 (2009).
3. Andréasson, Niclas, Anton Evgrafov, and Michael Patriksson. An Introduction to Continuous Optimization: Foundations and Fundamental Algorithms: Courier Dover Publications, 2020.
4. Diwekar, Urmila M. Introduction to Applied Optimization. Vol. 22: Springer Nature, 2020.
5. Yang, Xin-She. Nature-Inspired Optimization Algorithms: Academic Press, 2020.
6. Jin, Yaochu, Handing Wang, and Chaoli Sun. Data-Driven Evolutionary Optimization: Springer, 2021.
7. Martins, Joaquim RRA, and Andrew Ning. Engineering Design Optimization: Cambridge University Press, 2021.
8. Chong, Edwin KP, Wu-Sheng Lu, and Stanislaw H Zak. An Introduction to Optimization: With Applications to Machine Learning: John Wiley & Sons, 2023.

8.2a Seminar	Teaching methods[20]	Remarks
8.2b Laboratory	Teaching methods[21]	Remarks
1. The main optimization tools and frameworks (2h) 2. Simple use case- unconstraint problem (2h) 3. Branch &Bound and Random Search algorithms. (2h) 4. Genetic Algorithms and Differential Evolution (2 hr) 5. Ant Colony Optimization variants. (2h) 6. Backtracking algorithms for CSP (2h) 7. Hill Climbing and hybrid methods for CSP. (2h) **TOTAL: 14 hours**	General and individual explanations, individual computer work	
8.2c Project	Teaching methods[22]	Remarks
Applications references: See "Course references"		

9. Corroboration of the contents of the subject with the expectations of representatives of the epistemic community, professional associations and representative employers in the field related to the program[23]

- The course content was created in accordance with the syllabuses of related courses from prestigious international universities.
- The significance of the course's theoretical and practical concepts is emphasized by its various applications in areas varying from ML to classical engineering.

10. Evaluation

Type of activity	10.1 Evaluation criteria	10.2 Evaluation methods		10.3 Weight in the final grade
10.4a Colloquium	Acquired theoretical and practical knowledge (quantity, correctness, accuracy)	Periodic tests[24]:		50% (minimum 5)
		Homework:		
		Other activities[25]:		
		Final evaluation: Written test, with problems and questions related to some study cases	100%	
10.4b Seminar				
10.4c Laboratory	Knowledge of equipment, how to use specific tools; evaluation of tools or achievements, processing and interpretation of results	• Written questionnaire • Oral presentation • Laboratory reports • Practical demonstration		50% (minimum 5)
10.4d Project				
10.5 Minimum performance standard[26]: grade 5 in the colloquium and applications.				

Date of completion,
4 December 2023

Signature of course coordinator,
Lecturer Dr. Eng. Elena Niculina Dragoi

Signature of application instructor,
Lecturer Dr. Eng. Elena Niculina Dragoi

Date of approval in the department,
7 December 2023

Director of Department,
Assoc. Prof. Dr. Eng. Andrei Stan

[1] *Bachelor / Master*
[2] *1-4 for Bachelor's, 1-2 for Master's*
[3] *1-8 for Bachelors, 1-3 for Masters*
[4] *Exam, colloquium or VP A/R – from the curriculum*
[5] *DF - fundamental subject, DID - subject in the field, DS - specialized subject or DC - complementary subject - from the education plan*
[6] *It is equal to 14 weeksx number of hours from point 3.1 (similar for 3.5, 3.6abc)*
[7] *The lines below refer to the individual study; the total is completed at point 3.7.*
[8] *Between 7 and 14 hours*
[9] *Between 2 and 6 hours*
[10] *The sum of the values on the previous lines, which refer to the individual study.*
[11] *The sum of the number of hours of direct teaching activity (3.4) and the number of hours of individual study (3.7); must be equal to the*

number of credits allocated to the subject (point 3.9)x 24 hours per credit.
[12]Mention the subjects that must be passed previously or equivalent
[13]Blackboard, video projector, flipchart, specific teaching materials, etc.
[14]Computing technique, software packages, experimental stands, etc.
[15]Competencies from the G1 and G1bis Grids of the study program, adapted to the specifics of the subject, for which credits are allocated (www.rncis.ro or the faculty website)
[16] From the education plan
[17]The credits allocated to the subject are distributed on professional and transversal competences according to the specifics of the subject
[18]Chapter and paragraph headings
[19]Exposition, lecture, blackboard presentation of the studied issue, use of video projector, discussions with students (for each chapter, if applicable)
[20]Discussions, debates, presentation and/or analysis of papers, solving exercises and problems
[21]Practical demonstration, exercise, experiment
[22]Case study, demonstration, exercise, error analysis, etc.
[23]The connection with other subjects, the usefulness of the subject on the labor market
[24]The number of tests and the weeks in which they will be held will be specified.
[25]Scientific circles, professional competitions, etc.
[26]The minimum performance standard from the competences grid of the study program is customized to the specifics of the subject, if applicable.