

SYLLABUS

1. Information on the study programme

1.1. Higher education institution	West University of Timisoara
1.2. Faculty	Mathematics and Computer Science
1.3. Department	Computer Science
1.4. Study program field	Computer Science
1.5. Study cycle	Master
1.6. Study programme / Qualification	Artificial Intelligence and Distributed Computing

2. Information on the course

2.1. Course title	Metaheuristic Algorithms						
2.2. Lecture instructor	Daniela Zaharie						
2.3. Seminar / laboratory instructor	Daniela Zaharie						
2.4. Study year	2	2.5. Semester	1	2.6. Examination type	E	2.7. Course type	DI

3. Estimated study time (number of hours per semester)

3.1. Attendance hours per week	3	out of which: 3.2 lecture	2	3.3. seminar / laboratory	1
3.4. Attendance hours per semester	42	out of which: 3.5 lecture	28	3.6. seminar / laboratory	14

Distribution of the allocated amount of time*		hours
Study of literature, course handbook and personal notes		15
Supplementary documentation at library or using electronic repositories		16
Preparing for laboratories, homework, reports etc.		40
Exams		6
Tutoring		6
Other activities...		0
3.7. Total number of hours of individual study	83	
3.8. Total number of hours per semester	125	
3.9. Number of credits (ECTS)	5	

4. Prerequisites (if it is the case)

4.1. curriculum	Artificial Intelligence, Numerical Calculus, Programming, Probability and Statistics, Operational Research
4.2. competences	Knowledge of numerical algorithms, statistics, artificial intelligence, optimization and programming abilities

5. Requirements (if it is the case)

5.1. for the lecture	Lecture room with whiteboard and projector
5.2. for the seminar / laboratory	Lab room with computers having Scilab, R and Python installed

6. Specific acquired competences

Professional competences	<ul style="list-style-type: none"> Ability to identify the metaheuristic technique appropriate for a specific problem Ability to implement and validate a computational model based on metaheuristic algorithms Ability to solve a real-world problem using computational intelligence tools.
Transversal competences	<ul style="list-style-type: none"> Ability to conduct research activity and to prepare reports on a given topic Team work ability

7. Course objectives

7.1. General objective	Description of computational intelligence techniques and methods, particularly metaheuristic algorithms for optimization problems.
7.2. Specific objectives	<p><i>Knowledge objectives (OC):</i> (1) to present basic principles of metaheuristic techniques; (2) to describe local search algorithms; (3) to describe global search algorithms; (4) to present examples of metaheuristics for global, multi-modal, multi-criteria and dynamic optimization.</p> <p><i>Abilitation objectives (OAb):</i> (1) to identify the techniques appropriate to a given problem ; (2) to use software tools which are specific for computational intelligence; (3) to implement efficient metaheuristic algorithms;</p> <p><i>Attitude objectives (OAt):</i> (1) to argue the utility of metaheuristic algorithms in solving real-world problems.</p>

8. Content

8.1. Lecture	Teaching methods	Remarks, details
<i>L1. Introduction. Classes of difficult problems</i> (planning, assignment, selection, adaptation, prediction) and corresponding search spaces. Classes of metaheuristics. The overall structure of a metaheuristic algorithm. (OC1, OAb1)	Discourse, conversation, illustration by examples	2 hours ([1]- ch. 0, [4])
<i>L2-3. Trajectory-based metaheuristics.</i> Deterministic local search (Pattern Search, Nelder Mead). Random local search (Matyas and Solis-Wets algorithms). Global search (restarted local search, iterated local search, simulated annealing, tabu search, variable neighborhood search etc).(OC2,OC3, OAb1)	Discourse, conversation, illustration by examples	4 hours ([1]-ch.2; [2]-ch.2)
<i>L4-6. Population-based metaheuristics.</i> Overall structure. Main components (exploration and exploitation operators). Operators for	Discourse, conversation, illustration by examples	6 hours ([1]-ch. 3,4; [2] –ch. 3; [3] – ch. 8-12)

evolutionary algorithms: mutation, crossover, selection. Encoding types. Genetic algorithms, evolution strategies, evolutionary programming, genetic programming. (OC3, OAb1)		
L7. <i>Swarm Intelligence</i> . Ant colony optimization. Particle swarm optimization. Artificial bee colony. (OC3, OAb1)	Discourse, conversation, illustration by examples	2 hours ([1] – ch. 8, [2]-ch. 6, [3] – ch. 16-17)
L8. <i>Difference-based and Probabilistic Algorithms</i> . Differential Evolution, Population Based Incremental Learning, Estimation of Distribution Algorithms, Bayesian Optimization Algorithms. (OC3, OAb1)	Discourse, conversation, illustration by examples	2 hours ([1]-ch. 9; [2]-ch. 5, [3]-ch.13)
L9. <i>Scalability of Metaheuristic Algorithms</i> . Cooperative coevolution. Parallel models for population-based metaheuristics (master-slave, island, cellular). (OC3, OAb3)	Discourse, conversation, illustration by examples	2 hours ([1] – ch. 5,6, [3] – ch. 15)
L10-12. <i>Multi-objective/ multi-modal/ dynamic optimization</i> . Particularities of multi-objective optimization (non-domination, Pareto front etc). Apriori and aposteriori techniques. Quality metrics. Multi-modal optimization and specific approaches (niching, sharing etc). Techniques for dynamic optimization (hyper-mutation, random immigrants, ageing mechanisms). (OC4, OAb3)	Discourse, conversation, illustration by examples	6 hours ([1] – ch. 7, [5])
L13-14. <i>Applications of metaheuristic algorithms for: neural networks design, data mining, scheduling</i> . (OC4, OAb3, Oat1)	Discourse, conversation, illustration by examples	4 hours ([2]-ch. 8; [3] –ch. 2,3)
Recommended literature <ol style="list-style-type: none"> 1. Sean Luke: <i>Essentials of Metaheuristics</i>, Lulu, second edition, 2013, available for free at http://cs.gmu.edu/~sean/book/metaheuristics/ 2. Jason Brownlee: <i>Clever Algorithms. Nature-inspired Programming Recipes</i>, 2011, available at http://www.CleverAlgorithms.com 3. A. Engelbrecht: <i>Computational Intelligence. An Introduction</i>, Wiley, 2007 4. Z. Michalewicz, D. Fogel: <i>How to Solve It. Modern Heuristics</i>. Springer, 1999 5. Coello C.A., van Veldhuizen D.A., Lamont, G.B.: <i>Evolutionary Algorithms for Solving Multi-objective Problems</i>, Kluwer, 2002 6. D. Zaharie: Metaheuristic algorithms (http://www.info.uvt.ro/~dzaharie/ma2017/lecture) 		
8.2. Seminar / laboratory	Teaching methods	Remarks, details
L1. Examples of optimization problems. Getting started with Scilab (Oab1)	Problem-based approach, dialogue, learning through collaboration	2 hours
L2. Combinatorial optimization. Trajectory and population-based metaheuristics (Simulated Annealing, Tabu Search) (OAb1, OAb2)	Problem-based approach, dialogue, learning through collaboration	2 hours
L3. Implementation of evolutionary algorithms: genetic algorithms for combinatorial optimization	Problem-based approach, dialogue, learning through	2 hours

and evolution strategies for continuous optimization. (OAb1, OAb2, OAb2)	collaboration	
L4. Symbolic regression using genetic programming. Combinatorial optimization using Ant Colony Optimization. Continuous optimization using Particle Swarm Optimization. (OAb1, OAb2)	Problem-based approach, dialogue, learning through collaboration	2 hours
L5. Differential evolution, distribution estimation algorithms and cooperative coevolution. (OAb1, OAb2)	Problem-based approach, dialogue, learning through collaboration	2 hours
L6. Multi-objective and multi-modal optimization. (OAb1, OAb2, OAt)	Problem-based approach, dialogue, learning through collaboration	2 hours
L7. Evolutionary design of neural networks and applications of metaheuristics in data mining (OAb1, OAb2, OAt)	Problem-based approach, dialogue, learning through collaboration	2 hours
Recommended literature: <ol style="list-style-type: none"> 1. Michaël Baudin and Vincent Couvert, <i>Optimization in Scilab</i>, 2010 (available online at www.scilab.org) 2. http://web.info.uvt.ro/~dzaharie/ma2017/lab 		

9. Correlations between the content of the course and the requirements of the professional field and relevant employers.

The content is in accordance with the structure of similar courses offered by other universities and it covers the main aspects of using computational intelligence tools, particularly metaheuristic algorithms, in solving real world problems.

10. Evaluation

Activity	10.1. Assessment criteria	10.2. Assessment methods	10.3. Weight in the final mark
10.4. Lecture	Knowledge of the main principles of the metaheuristic algorithms	Written exam (open book)	20%
	The identification and the implementation of an appropriate metaheuristic algorithm for a given problem	Project presentation (report, software application, oral presentation)	60%
10.5. Seminar / laboratory	Usage of software tools and implementation of metaheuristic algorithms	Applications at lab and homework	20%
10.6. Minimum needed performance for passing			

- Knowledge of the main concepts in the field of metaheuristic algorithms
- Ability to implement a simple metaheuristic algorithm
- Ability to identify the optimization technique appropriate to a real-world problema

The final mark is computed as weighted average of the marks corresponding to the components specified at 10.4 and 10.5. The exam is considered passed if the average is at least 5 (it is not required that each mark is at least 5). In each session of exams (including re-examinations) the mark is computed using the same rule. The student can be re-examined only for the components for which the current mark is smaller than 5, excepting the cases when the student asks to be re-examined.

Date of completion
20.09.2017

Signature (lecture instructor)
prof.dr. Daniela Zaharie

Signature (seminar instructor)
prof.dr. Daniela Zaharie

Date of approval

Signature (director of the department)
Conf.dr. Victoria Iordan