**Syllabus**

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| --- | --- | --- | --- | --- | --- | --- |
| Discipline’s code | Discipline’s title |  | | | Number of ECTS | SWST  Self-work of student with teacher in hours |
| Lect. | Pract. | Lab. |
| CMU 3 | Optimizing computer vision algorithms | 40 | 35 | - | 4 | 45 |

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| Academic presentation of the course | **Aim of course:**  Identificarea si formularea generala a problemelor de optimizare. Adaptarea modelelor teoretice la specificul aplicatiilor de optimizare.  Formularea criteriilor de optimizare functie de natura problemei. Cunoasterea metodelor reprezentative, frecvent utilizate, de rezolvare a problemelor de optimizare: analitice, numerice, bazate pe forme canonice si pentru politici optime, precum si a aplicatiilor soft specifice disponibile. Optimizarea unor procese complexe cu ajutorul de tehnici adecvate.  Identification and general formulation of optimization problems. Adaptation of theoretical models to the specifics of optimization applications.  Formulation of optimization criteria depending on the nature of the problem. Knowledge of representative methods, frequently used, by solving optimization problems: analytical, numerical, based on canonical forms and for optimal policies, as well as the specific software applications available. Optimization of complex processes with the help of appropriate techniques.  Identificarea problemelor legate de stabilirea criteriilor concrete de optimizare, insusirea lucrului cu programe software specializate in solutionarea problemelor de optimizare, formularea si rezolvarea completa a unor studii de caz cu aplicare in ingineria mediului si analiza rezultatelor calculului.  Identifying problems related to establishing concrete optimization criteria, mastering the work with software programs specialized in solving optimization problems, formulating and solving complete case studies with applications in environmental engineering and analysis of calculation results  **As a result of studying the discipline, students should be able to:**  1. Cunoașterea fundamentelor matematice privind algoritmii de optimizare. Utilizarea unor biblioteci de metode numerice de optimizare.  1. Knowledge of the mathematical fundamentals regarding optimization algorithms. Using libraries of numerical optimization methods.  2. Înțelegerea modul de utilizare a tehnicilor și algoritmilor de optimizare pentru rezolvarea unor aplicații.  Understanding how to use optimization techniques and algorithms to solve applications.  3. Modelarea problemelor de optimizare folosind teoria grafurilor.  3. Modeling optimization problems using graph theory.  4. Cunoasterea principiilor de functionare a algoritmilor genetici si a principalelor aplicatii ale acestora.  4. Knowledge of the principles of operation of genetic algorithms and their main applications.  5. Realizarea de modele si codificarea datelor conform conceptelor algoritmilor genetici.  5. Making models and coding data according to the concepts of genetic algorithms. |
| Prerequisites | 1. Knowledge of the C++ language or of a high level programming language.  2. Basic knowledge of algorithm theory and their complexity.  3. Basic terms from graph theory, artificial intelligence and probability theory |
| Post requisites | Skills for high level programming algorithms and artificial inteligence |
| Information resources | **Literature**:   1. Coello Coello C.A., Lamont G.B., Van Veldhuizen D.A.: Evolutionary Algorithms for Solving Multi-Objective Problems. Springer, 2007. 2. D. Dumitrescu: Algoritmi genetici si strategii evolutive. Aplicatii in inteligenta artificiala si domenii conexe. Editura Albastra, Cluj-Napoca, 2000 3. D. Dumitrescu, B. Lazzerini, L. C. Jain, A. Dumitrescu: Evolutionary computation, CRC Press, New York, 2000 4. F. Herrera, J. L. Verdegay (Eds.): Genetic algorithms and soft computing, Physica Verlang, Heidelberg, 1996 5. T. Jones: Evolutionary algorithms, fitness, landscape and search, Thesis, Univ. of New Mexico, Albuquerque, 1995 6. M. Lalena: Teamwork in genetic programming, Thesis, School of Computer science and technology, Rochester Institute of Technology, 1997 7. H. Horner: A C++ class library for genetic programming, The Vienna Univ. of Economics, 1996 8. H. Luchian, S. Luchian: Clasificare evolutiva, Editura Integral, Iasi, 1999 9. Mitchell M.: An Introduction to Genetic Algorithms. MIT Press, 1998. 10. Michalewicz Z.: Genetic Algorithms + Data Structures = Evolution Programs. Springer, 1996. 11. Nash, S. and Sofer, A. 1996. [Linear and Nonlinear Programming](http://iris.gmu.edu/~snash/nash/books/lp_nlp.html). McGraw-Hill, New York. 12. Nemhauser, G. L. and Wolsey, L. A. 1988. Integer and Combinatorial Optimization. Wiley Interscience, New York. *An advanced text that covers many theoretical and computational topics.* 13. Nering, E. D. and Tucker, A. W. 1993. Linear Programs and Related Problems. Academic Press, Boston. 14. Nocedal, J. and Wright, S. J. 1999. Numerical Optimization. Springer-Verlag, New York. 15. Polli R., Langdon W.B., McPhee N.F.: A Field Guide to Genetic Programming. 2008. 16. R. Polli: Introduction to evolutionary computation, School of Computer science, Univ. of Birmingham, 1996 17. Roos, C., Terlaky, T., and Vial, J.-Ph. 1997. Theory and Algorithms for Linear Optimization: An Interior Point Approach. John Wiley, Chichester. 18. Segaran T.: Programming Collective Intelligence. O’Relly, 2007.   **Internet-resources:**  <http://www.cse.iitm.ac.in/~vplab/optimization.html>  <https://www.youtube.com/watch?v=YdZXCab6k0Q>  <https://link.springer.com/book/10.1007/978-3-642-54774-4>  <https://www.springer.com/series/7412>  uthuli.cs.uiuc.edu/~daf/courses/Optimization/Opt-2.html  <http://luthuli.cs.uiuc.edu/~daf/courses/Optimization/Notes/notes.pdf>  http://luthuli.cs.uiuc.edu/~daf/courses/Optimization/Notes/newrevisedcgnotes.pdf  <http://luthuli.cs.uiuc.edu/~daf/courses/Optimization/Notes/MoreConjGradandPR.pdf>  <http://luthuli.cs.uiuc.edu/~daf/courses/Optimization/20070903171438.pdf>  <https://www.springerprofessional.de/optimization-techniques-in-computer-vision/11911036>  <https://ikomia.com/en/ikomia-computer-vision/?pk_campaign=landingpage-research-cv&gclid=Cj0KCQjw24qHBhCnARIsAPbdtlLuFnuACmWZteGEBIKxCCBBfNsGMfUpdY4e3569RK47ktuBVCsU3T0aAgJ0EALw_wcB>  https://aito.ai/?gclid=Cj0KCQjw24qHBhCnARIsAPbdtlLX\_92krA5iUA0YNul2QGbdpS6Un3fHVS06o5SNgWn9r5OVM0uT\_xgaAkK3EALw\_wcB  <https://omtec.de/en/industrial-pc/artificial-intelligence/?gclid=Cj0KCQjw24qHBhCnARIsAPbdtlI1ogbNk5z9L4bljqKU7FwlOHDhbyfAR-q5zNKor7j7_c2nONYDXW8aAoulEALw_wcB>  <https://omtec.de/en/industrial-pc/artificial-intelligence/?gclid=Cj0KCQjw24qHBhCnARIsAPbdtlL8k9__r_XAZM4fgpeI7y05wOt_XRSVNt2frqyBBFbKwesXsRwh5F0aAtFEEALw_wcB> |

Calendar (schedule) the implementation of the course content**:**

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| --- | --- | --- | --- |
| **Week / date** | **Topic title (lectures, practical classes, Independent work of students, IWS)** | **Number of hours** | **Maximum score** |
| 1 | 2 | 3 | 4 |
| 1 | **Lecture 1.**  Formulation of an optimization problem, mathematical model of process / phenomenon studied, decision variables. Examples of use of optimization methods in experimental data processing and process optimization; associated numerical methods. | 4 | 10 |
| **Practical class 1.**  Simultaneous Linear Equation Systems  Linear Dependence  Convex Sets and n-Dimensional Geometry | 2 | 10 |
| 2 | **Lecture 2.**  Types of objective functions. Forms of objective functions in the processing of experimental data. Objective function forms with specified characters. Geometric aspects regarding the extreme search for restricted objective functions. Associated numerical methods. | 4 | 10 |
| **Practical class 2.**  Canonical and Standard Forms 35  A Graphical Solution to the Linear Programming Problem  Properties of the Feasible Region  Existence and Location of Optimal Solutions  Basic Feasible and Extreme Point Solutions  Solutions and Requirement Spaces | 2 | 10 |
| 3 | **Lecture 3.**  Direct optimization methods: ascent and descent methods, methods for solving restricted problems. Numerical gradient methods. | 4 | 10 |
| **Practical class 3**  The Simplex Method  Improving a Basic Feasible Solution  Degenerate Basic Feasible Solution  Summary of the Simplex Method | 4 | 10 |
| 4. | **Lecture 4.**  Notions of graph theory  Unoriented graph  Oriented graph  Representation and implementation of graphs | 4 | 10 |
| **Practical class 4**  Practical applications modeled using graphs.  Representing them in a programming language.  Chain. Cycle. Road. Circuit. | 4 | 10 |
| 5. | **Lecture 5.**  Scrolling through graphs. Breadth first. Depth First. | 4 | 10 |
| **Practical class 5**  Practical applications. | 4 | 10 |
| 6. | **Lecture 6**  Weighted graph.  Cost matrix. | 4 | 10 |
| **Practical class 6**  Practical applications. Algorithms for determining the minimum (maximum) cost. | 4 | 10 |
| 7. | **Lecture 7**  Issues related to the types of search problems.  Peculiarities of optimization problems encountered in the practice of Methods for solving optimization problems: metaheuristic approaches, as high-level strategies for exploiting the search space. The most important "trajectory" metaheuristics and the most important population metaheuristics, based on evolutionary concepts - Evolutionary Calculus and behavioral patterns inspired by biology - Swarm calculus. | 4 | 10 |
| **Practical class 7**  Applications based on evolutionary calculation.  Applications based on Swarm type calculation. | 4 | 10 |
| 8. | **Lecture 8**  Theoretical investigations on Genetic Algorithms. Aspects related to coding techniques, population sizing. Selection strategies used in a Genetic Algorithm.  Types of operators. cross. Mutation. Choosing parameters for population configuration. Representation of evolutionary operators. | 4 | 10 |
| **Practical class 8**  Optimization using genetic algorithms. Applications. | 4 | 10 |
| 9. | **Lecture 9**  The use of genetic algorithms in optimization problems with constraints. Restriction treatment techniques within a genetic algorithm. | 4 |  |
| **Practical class 9**  The use of genetic algorithms in optimization problems with constraints.Applications. | 4 | 10 |
| 10 | **Lecture 10**  Review. Conclusions. | 4 | 10 |
| **Practical class 10**  Practical applications of optimization in environmental engineering | 3 | 10 |