UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Stohastične optimizacijske metode
Course title:	Stochastic Optimization Methods

Študijski program in stopnja Study programme and level	Modul Module	Letnik Academic year	Semester Semester
Informacijske in komunikacijske tehnologije, 2. stopnja	Inteligentni sistemi in robotika	1	2
Information and Communication Technologies, 2nd cycle	Intelligent Sytems and Robotics	1	2

Vrsta predmeta / Course type Izbirni / Elective

Univerzitetna koda predmeta / University course code: IKT2-614

Predavanja Lectures	Seminar Seminar	Sem. vaje Tutorial	Lab. vaje Laboratory work	Druge oblike	Samost. delo Individ. work	ECTS
30	**30**			**30**	**210**	**10**

**Navedena porazdelitev ur velja, če je vpisanih vsaj 15 študentov. Drugače se obseg izvedbe kontaktnih ur sorazmerno zmanjša in prenese v samostojno delo. / This distribution of hours is valid if at least 15 students are enrolled. Otherwise the contact hours are linearly reduced and transfered to individual work.*

Nosilec predmeta / Lecturer: Prof. dr. Bogdan Filipič

Jeziki / Languages:		
	Predavanja / Lectures:	slovenščina, angleščina / Slovenian, English
	Vaje / Tutorial:	

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites:**
Zaključen študijski program prve stopnje s področja naravoslovja, tehnike ali računalništva.	Student must complete first-cycle study programmes in natural sciences, technical disciplines or computer science.

Vsebina:	**Content (Syllabus outline):**
Uvod: Optimizacija, optimizacijski problemi, dualnost minimizacije in maksimizacije. Vrste optimizacije: eksaktna in stohastična, analitična in empirična, zvezna in diskretna, statična in dinamična ter enokriterijska in večkriterijska. Optimizacija na osnovi numeričnih modelov. Primeri optimizacijskih problemov in vzroki za njihovo zahtevnost Stohastična optimizacija: Stohastičnost podatkov in optimizacijskih postopkov, motivacija za stohastično optimizacijo, prednosti in slabosti stohastičnih optimizacijskih metod. Enostavni stohastični metodi: naključno preiskovanje in lokalna	Introduction: Optimization, optimization problems, duality of minimization and maximization. Types of optimization: exact and stochastic, analytical and empirical, continuous and discrete, static and dynamic, single- objective and multi-objective. Optimization based on numerical models. Examples of optimization problems and sources of their difficulty. Stochastic optimization: Stochasticity of data and optimization procedures, motivation for stochastic optimization, advantages and disadvantages of stochastic optimization methods. Simple stochastic methods: random search and

optimizacija.

Stohastični optimizacijski algoritmi:

Simulirano ohlajanje. Evolucijski algoritmi: genetski algoritmi, evolucijske strategije, evolucijsko programiranje, genetsko programiranje in diferencialna evolucija. Iskanje s tabuji, optimizacija z roji delcev, optimizacija s kolonijami mravelj. Lastnosti in primerjava algoritmov, primeri uporabe.

Vrednotenje rezultatov:

Statistična analiza rezultatov stohastičnih algoritmov, mere učinkovitosti in predstavljanje rezultatov.

Razlike med načrtovalskimi in rutinskimi problemi ter testnimi in realnimi problemi.

Uporabni vidiki:

Nastavljanje vrednosti parametrov stohastičnih optimizacijskih algoritmov, hibridizacija algoritmov, večkriterijsko optimiranje in optimiranje s subjektivnim vrednotenjem rešitev. Značilna področja uporabe in študije praktičnih primerov iz načrtovanja in modeliranja, analize empiričnih podatkov, časovnega razporejanja opravil in upravljanja z viri.

local optimization.

Stochastic optimization algorithms:

Simulated annealing. Evolutionary algorithms: genetic algorithms, evolution strategies, evolutionary programming, genetic programming and differential evolution. Tabu search, particle swarm optimization, ant colony optimization. Characteristics of the algorithms and their comparison, examples of application.

Evaluation of results:

Statistical analysis of stochastic algorithm results, performance measures and presentation of results. Differences between design and routine problems, and between synthetic test problems and real-world problems.

Applied aspects:

Setting parameter values in stochastic optimization algorithms, hybridization of algorithms, multi-objective optimization and optimization with subjective evaluation of solutions. Typical domains of application and practical case studies from design and modeling, empirical data analysis, scheduling and resource management.

Temeljna literatura in viri / Readings:

Izbrana poglavja iz naslednjih knjig: / Selected chapters from the following books:

- A. E. Eiben, and J. E. Smith. *Introduction to Evolutionary Computing*, 2nd edition. Springer, 2015. ISBN 978-3-662-44873-1
- A. Kaveh. *Advances in Metaheuristic Algorithms for Optimal Design of Structures*. Springer, 2014. ISBN 978-3-319-05548-0
- F. Neumann, and C. Witt. *Bioinspired Computation in Combinatorial Optimization*. Springer, 2010. ISBN 978-3-642-16543-6
- G. Rozenberg, Th. Bäck, and J. N. Kok (Eds.). *Handbook of Natural Computing*. Springer, 2012. ISBN 978-3-540-92909-3
- E.-G. Talbi. *Metaheuristics: From Design to Implementation*. Wiley, 2009. ISBN 978-0-470-27858-1

Cilji in kompetence:

Cilji predmeta so (a) posredovati temeljna znanja o stohastičnih optimizacijskih metodah, (b) predstaviti vrste stohastičnih optimizacijskih algoritmov ter njihove prednosti in slabosti, (c) predstaviti metodologijo vrednotenja rezultatov stohastičnih optimizacijskih algoritmov in njihovega prilagajanja za reševanje specifičnih vrst problemov, (d) pokazati njihovo praktično uporabnost.

Študenti, ki bodo uspešno končali ta predmet, bodo obvladali osnove stohastične optimizacije in

Objectives and competences:

The course objectives are to (a) to give essential knowledge on stochastic optimization methods, (b) present the types of stochastic optimization algorithms, and their advantages and drawbacks, (c) present the methodology of evaluating the results of stochastic optimization algorithms and their adaptation for solving specific types of problems, (d) show their practical potential.

The students who will successfully complete this course will master the basics of stochastic

bodo usposobljeni za uporabo stohastičnih algoritmov v reševanju zahtevnih optimizacijskih problemov in spremljanje nadaljnjega razvoja na tem področju.	optimization and will be capable of applying stochastic algorithms in solving demanding optimization problems and following further development in this field.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Študenti bodo z uspešno opravljenimi obveznostmi tega predmeta pridobili: • Poznavanje metodologije stohastičnega optimiranja, njene uporabnosti, prednosti in slabosti • Sposobnost identifikacije optimizacijskih problemov in prepoznavanja primernosti uporabe stohastičnih metod pri njihovem reševanju • Sposobnost izbire ustreznega stohastičnega optimizacijskega algoritma in njegovega prilagajanja danemu problemu • Obvladovanje uglaševanja parametrov optimizacijskih algoritmov in vrednotenja njihovih rezultatov • Usposobljenost za samostojno reševanje zahtevnih realnih optimizacijskih problemov s stohastičnimi algoritmi	Students successfully completing this course will acquire: • Knowledge of stochastic optimization methodology, its applicability, strengths and weaknesses • Ability to identify optimization problems and recognize suitability of applying stochastic methods in solving optimization problems • Ability to select an appropriate stochastic optimization algorithm and adjust it to a given problem • Mastering the setting of optimization algorithm parameters and evaluation of their results • Ability to solve demanding real-world optimization problems using stochastic algorithms

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja, seminar, konzultacije, samostojno delo	Lectures, seminar, consultancy, individual work

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Seminarska naloga	50 %	Seminar work
Pisni ali ustni izpit	50 %	Written or oral exam

Reference nosilca / Lecturer's references:

- T. Tušar, and **B. Filipič**. “Visualization of Pareto front approximations in evolutionary multiobjective optimization: A critical review and the prosection method.” *IEEE Transactions on Evolutionary Computation*, vol. 19, no. 2, pp. 225-245, 2015.
- M. Mlakar, D. Petelin, T. Tušar, and **B. Filipič**. “GP-DEMO: Differential evolution for multiobjective optimization based on Gaussian process models.” *European Journal of Operational Research*, vol. 243, no. 2, pp. 347-361, 2015.
- E. Dovgan, M. Javorski, T. Tušar, M. Gams, and **B. Filipič**. “Discovering driving strategies with a multiobjective optimization algorithm.” *Applied Soft Computing*, vol. 16, no. 1, pp. 50-62, 2014.
- M. Depolli, R. Trobec, and **B. Filipič**. “Asynchronous master-slave parallelization of differential evolution for multiobjective optimization.” *Evolutionary Computation*, vol. 21, no. 2, pp. 261-291, 2013.
- P. Korošec, J. Šilc, and **B. Filipič**. “The differential ant-stigmergy algorithm.” *Information Sciences*, vol. 192, no. 1, pp. 82-97, 2012.