UČNI NAČRT PREDMETA / COURSE SYLLABUS

Predmet:	Algoritmi
Course title:	Algorithms

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Interdisciplinarni magistrski študijski program Računalništvo in matematika	ni smeri	1	drugi
Interdisciplinary Masters study programme Computer Science and Mathematics	none	1	second

Vrsta predmeta / Course type	obvezni

Univerzitetna koda predmeta / University course code:	M2800

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje work	Druge oblike študija	Samost. delo Individ. work	ECTS
45	20	10			105	6

Nosilec predmeta / Lecturer:	Tomaž Dobravec

Jeziki / Languages:	Predavanja / Lectures:	slovenski/Slovene, angleški/English
	Vaje / Tutorial:	slovenski/Slovene, angleški/English

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	Prerequisites:
Osnovno znanje algoritmov in podatkovnih struktur.	

Vsebina:	Content (Syllabus outline):

Vsebina predmeta:	The topics:
1. Računska zahtevnost za algoritme tipa deli in vladaj.	Computational complexity for divide and conquer algorithms.
2. Randomizirani algoritmi in verjetnostna analiza algoritmov.	Randomized algorithms and probabilistic analysis.
3. Amortizirana analiza algoritmov.	Amortized analysis of algorithms.
4. Iskanje v večdimenzionalnih prostorih: k-d drevesa, R drevesa, lokalno občutljivo razprševanje.	Searching in multidimensional spaces: k-d trees, R-trees and locality-sensitive hashing.
5. Sortiranje s predpostavkami: s štetjem, korensko urejanje, sektorsko urejanje.	Sorting with assumptions: counting sort, radix sort, bucket sort.
6. Iskanje s predpostavkami: drevesa van Emde Boats.	Searching with assumptions: van Emde Boats trees.
7. Razpršene tabele: funkcije razprševanja, univerzalno razprševanje, popolno razprševanje, Bloomovi filtri.	Hash tables: hash functions, universal hashing, perfect hashing, Bloom filters.
8. Hevristične metode reševanja problemov: lokalne metode.	Heuristic programming: local methods.
9. Metahevristike pri optimizaciji.	Metaheuristics for optimization.
10. Biološko navdahnjene metode: genetski algoritmi, diferencialna evolucija in metode roja.	Biologically inspired methods: genetic algorithms, differential evolution, swarm intelligence.
11. Računska geometrija: lastnosti daljic, konveksna ovojnica, par najbližjih točk.	Computational geometry: line-segment properties, convex hull, closest pair of points.
12. Večnitni in porazdeljeni algoritmi.	Multithreaded and distributed algorithms.
13. Avtomati in gramatike.	Automata theory and grammars.
Študenti, ki na prvi stopnji še niso osvojili osnovnih algoritmov in podatkovnih struktur, bodo pod mentorstvom izvajalcev v obliki seminarjev in domačih nalog sproti obdelali še manjkajoče predznanje.	Students lacking a required background from the 1st degree courses will gain needed knowledge and skills through additional preparation of seminar papers and programming assignments throughout the course. The topics will be individually selected.

Temeljni literatura in viri / Readings:

1) T. H. Cormen, C.E. Leiserson, R.L. Rivest, C. Stein: Introduction to Algorithms, 3rd edition. MIT Press, 2009.

2) K.A.Berman, J.L. Paul: Algorithms: Sequential, Parallel, and Distributed. Thomson, 2005.

3) J. Kleinberg, E. Tardos: Algorithm Design. Pearson Education, 2006.

Cilji in kompetence:

Cilj predmeta je nadgraditi znanje s področja načrtovanja in analize algoritmov in podatkovnih struktur. Študenti bodo dosegli nivo, ko znajo analizirati večino algoritmov in si razširili orodjarno znanih algoritmov in tehnik za njihov razvoj.

Splošne kompetence:

- sposobnost kritičnega razmišljanja,

- razvoj spretnosti kritičnega, analitičnega in sintetičnega razmišljanja,

- sposobnost razumevanja in reševanja profesionalnih izzivov,

- sposobnost nadgradnje pridobljenega znanja.

Predmetno-specifične kompetence:

- poznavanje mojstrove metode in metode Akra-Bazzi za analizo algoritmov tipa deli in vladaj,

- randomizacija algoritmov

- verjetnostna analiza algoritmov,

- amortizirana analiza algoritmov,

- poznavanje razredov formalnih jezikov in zapis regularnih izrazov ter kontekstno neodvisnih gramatik,

Objectives and competences:

The goal of this course is to upgrade the knowledge of the analysis of algorithms and data structures and algorithm design techniques. A level where most of the algorithms can be analysed will be reached. Students will expand their algorithm toolbox and a set of design approaches.

General competences:

ability of critical thinking,

developing skills in critical, analytical and synthetic thinking,

the ability to understand and solve professional challenges in computer and information science,

the ability to upgrade acquired knowledge.

Subject-specific competences:

use of master theorem and Akra-Bazzi method for analysis of divide-and-conquer algorithms,

randomization of algorithms,

probabilistic analysis of algorithms,

amortized analysis of algorithms,

classes of formal languages, writing regular expressions and context-free grammars,

the role of assumptions in development of

- poznavanje vloge predpostavk pri razvoju učinkovitih algoritmov,	efficient algorithms,
- učinkovito iskanje prostorskih podatkov,	efficient search of spatial data and low-dimensional data,
- uporaba razpršenih tabel, sestava razprševalne funkcije,	use of hash tables, construction of hash functions,
- priprava optimizacijskega problema za reševanje z lokalnimi metodami,	preprocessing problems for optimization based on local search,
- uporaba meta-hevristik v lokalnih metodah: spremenljive okolice, vodeno lokalno iskanje, tabu preiskovanje,	using met heuristics in local search: variable neighbour method, guided local search, tabu search,
- priprava problema za reševanje z biološko navdahnjenimi metodami: genetskimi algoritmi, metodo rojev, diferencialno evolucijo in kolonijo mravelj,	preprocessing problems for biology inspired methods: particle swarm optimization, differential evolution, ant colony optimization
- uporaba tehnik računske geometrije in poznavanje učinkovitih algoritmov za konveksno ovojnico,	using techniques from computational geometry and efficiently finding convex hull,
	analysis of multithreaded algorithms, speed-up
- analiza večnitnih algoritmov, paralelna pohitritev,	turning single threaded algorithms in multi-threaded algorithms,
- spreminjanje enonitnih v večnitne algoritme,	
- poznavanje razvoja porazdeljenih algoritmov.	knowing distributed algorithm development.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Po uspešnem zaključku tega predmeta bo študent:	After the completion of the course a student will be able to:
- znal opredeliti razliko med težkim in lahkim problemom ter med dobrim in slabim algoritmom,	- define the difference between easy and hard problems and between good (efficient) and bad (inefficient) solutions,
- razumel delovanje izbranih algoritmov in jih znal implementirati v izbranem programskem jeziku,	- understand the selected algorithms and implement them in a selected programming language,
- sposoben izkazati algoritmični način razmišljanja in reševanja problemov,	- show the algorithmic way of thinking and solving the problems,

- sposoben samostojno razviti nov algoritem za izbrane probleme, - znal raziskati problem, določiti način reševanja in poiskati ali razviti algoritem, - sposoben ovrednotiti kakovost algoritma za reševanje izbranega problema.	- independently develop algorithms for solving the selected problems, - research the selected problem, find an approach to solve the problem and develop an appropriate algorithm, - evaluate the quality of a selected algorithm.

Metode poučevanja in učenja:

Learning and teaching methods:

Predavanja, laboratorijske vaje in domače naloge, pomembno je sprotno oddajanje domačih nalog. Študenti s šibkim obstoječim znanjem bodo manjkajoče znanje pridobili z dodatnimi individualnimi seminarskimi nalogami in programerskimi projekti.	Lectures and homework, assignments are assigned regularly and shall be delivered on time. For students with low prior knowledge individual work (seminal papers and programming assignments) will be assigned.

	Delež (v %) / Weight (in %)	
Načini ocenjevanja:		**Assessment:**
Način: pisni in ustni izpit, naloge. Sprotno preverjanje: domače naloge, seminarsko delo. Končno preverjanje: pisni in ustni izpit. Ocene: 6-10 pozitivno, 5 negativno (v skladu s Statutom UL).	 50% 50%	Type: written and oral examination, coursework. Continuing: homework, seminars. Final: written and oral exam. Grading: 6-10 pass, 5 fail (according to the Statutes of University of Ljubljana).

Reference nosilca / Lecturer's references:

Tomaž Dobravec:

– DOBRAVEC, Tomaž, ROBIČ, Borut, ŽEROVNIK, Janez. Permutation routing in double-loop networks : design and empirical evaluation. Journal of Systems Architecture, ISSN 1383-7621. [Print ed.], 2003, vol. 48, str. 387-402, ilustr. [COBISS.SI-ID 3475796]

– DOBRAVEC, Tomaž, ŽEROVNIK, Janez, ROBIČ, Borut. An optimal message routing algorithm for circulant networks. Journal of Systems Architecture, ISSN 1383-7621. [Print ed.], 2006, vol. 52, no. 5, str. [298]-306, ilustr. [COBISS.SI-ID 5323348]

– DOBRAVEC, Tomaž, ROBIČ, Borut. Restricted shortest paths in 2-circulant graphs. Computer communications, ISSN 0140-3664. [Print ed.], March 2009, vol. 32, no. 4, str. 685-690, ilustr. [COBISS.SI-ID 6966356]

– BULIĆ, Patricio, DOBRAVEC, Tomaž. An approximate method for filtering out data dependencies with a sufficiently large distance between memory references. The journal of supercomputing, ISSN 0920-8542, 2011, vol. 56, no. 2, str. 226-244, ilustr. [COBISS.SI-ID 7412820]

– ČEŠNOVAR, Rok, RISOJEVIĆ, Vladimir, BABIĆ, Zdenka, DOBRAVEC, Tomaž, BULIĆ, Patricio. A GPU implementation of a structural-similarity-based aerial-image classification. The journal of supercomputing, ISSN 0920-8542, Aug. 2013, vol. 65, no. 2, str. 978-996, ilustr [COBISS.SI-ID 9619028]

– MIHELIČ, Jurij, DOBRAVEC, Tomaž. SicSim : a simulator of the educational SIC/XE computer for a system-software course. Computer applications in engineering education, ISSN 1061-3773. [Print ed.], Jan. 2015, vol. 23, no. 1, str. 137-146, ilustr. [COBISS.SI-ID 10241620]