UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Iskanje in ekstrakcija podatkov s spleta
Course title:	Web Information Extraction and Retrieval

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Magistrski študijski program druge stopnje Računalništvo in informatika Interdisciplinarni magistrski študijski program 2. stopnje Računalništvo in matematika Interdisciplinarni magistrski študijski program 2. stopnje Multimedija	ni smeri	1, 2	poletni / zimski
Master study program Computer and Information Science, level 2 Interdisciplinary Master study program Computer Science and Mathematics, level 2 Interdisciplinary Master study program Multimedia, level 2	none	1, 2	spring / fall

Vrsta predmeta / Course type	**strokovni izbirni predmet / specialist elective course** Tematski sklopi / Thematic set: Informacijski sistemi in sistemi za upravljanje/Information and management systems

Umetna inteligenca/ Artificial Intelligence **obvezni predmet / compulsory course**

Univerzitetna koda predmeta / University course code:	63551

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

Nosilec predmeta / Lecturer:	prof. dr. Marko Bajec

Jeziki / **Languages:**		
	Predavanja / Lectures:	slovenščina in angleščina Slovene and English
	Vaje / Tutorial:	slovenščina in angleščina Slovene and English

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisits:**

Vsebina:	**Content (Syllabus outline):**
Vsebina predavanj: Predmet bo pokrival naslednje vsebine: • Poizvedovanje in iskanje po spletu ▪ Osnovni koncepti poizvedovanja ▪ Modeli poizvedovanja ▪ Odziv ustreznosti ▪ Mere za ocenjevanje točnosti poizvedb ▪ Predobdelava besedil in spletnih strani ▪ Inverzni index in njegova kompresija	**Content of the course**: This course will cover the following topics: • Information Retrieval and Web Search ▪ Basic Concepts of Information Retrieval ▪ Information Retrieval Models ▪ Relevance Feedback ▪ Evaluation Measures ▪ Text and Web Page Pre-Processing ▪ Inverted Index and Its Compression

▪ Latentno semantično indeksiranje ▪ Iskanje po spletu ▪ Meta iskanje po sletu: kombiniranje različnih načinov rangiranja • Spletno pregledovanje in indeksiranje ▪ Osnovni algoritem spletnega pajka ▪ Univerzalni spletni pajek ▪ Fokusirani spletni pajki ▪ Domenski spletni pajki • Ekstrakcija strukturiranih podatkov ▪ Indukcija ovojnice ▪ Generiranje ovojnice na osnovi primera ▪ Samodejna izdelava ovojnice ▪ Ujemanje glede na obliko besede ali drevesne strukture ▪ Večkratna poravnava ▪ Gradnja DOM dreves ▪ Ekstrakcija glede na stran s seznamom ali več strani • Integracija podatkov ▪ Ujemanje glede na podatkovno shemo ▪ Ujemanje glede na domeno in primere ▪ Združevanje podobnosti ▪ Ujemanje 1:m ▪ Integracija iskalnikov po spletnih straneh ▪ Izgradnja globalnega iskalnika po spletnih straneh • Rudarjenje mnenja in analiza sentimenta ▪ Klasifikacija dokumentov po sentimentu ▪ Ugotavljanje subjektivnosti v stavkih in klasifikacija sentimenta ▪ Slovarji besed in fraz, nosilcev mnenja ▪ Aspektno orientirano rudarjenje mnenja ▪ Iskanje in extrakcija mnenja	▪ Latent Semantic Indexing ▪ Web Search ▪ Meta-Search: Combining Multiple Rankings • Web Crawling ▪ A Basic Crawler Algorithm ▪ Implementation Issues ▪ Universal Crawlers ▪ Focused Crawlers ▪ Topical Crawlers • Structured Data Extraction ▪ Wrapper Induction ▪ Instance-Based Wrapper Learning ▪ Automatic Wrapper Generation ▪ String Matching and Tree Matching ▪ Multiple Alignment ▪ Building DOM Trees ▪ Extraction Based on a Single List Page or Multiple Pages • Information Integration ▪ Schema-Level Matching ▪ Domain and Instance-Level Matching ▪ Combining Similarities ▪ 1:m Match ▪ Integration of Web Query Interfaces ▪ Constructing a Unified Global Query Interface • Opinion Mining and Sentiment Analysis ▪ Document Sentiment Classification ▪ Sentence Subjectivity and Sentiment Classification ▪ Opinion Lexicon Expansion ▪ Aspect-Based Opinion Mining ▪ Opinion Search and Retrieval

Temeljni literatura in viri / Readings:

1. Bing Liu, Web Data Mining: Exploring Hyperlinks, Contents, and Usage Data (Data-Centric Systems and Applications, Springer, August 2013
2. Ricardo Baeza-Yates , Berthier Ribeiro-Neto: Modern Information Retrieval: The Concepts and Technology behind Search, 2nd Edition, ACM Press Books, 2010

Cilji in kompetence:

Cilj predmeta je študente naučiti, kako sprogramirati iskanje po spletu (po indeksiranem in neindeksiranem delu spleta) ter kako razviti programe za ekstrakcijo strukturiranih podatkov s statičnih in dinamičnih spletnih strani. Študentje bodo spoznali osnovne koncepte spletnega iskanja in ekstrakcije podatkov s spleta ter se naučili potrebnih tehnik, ki so za to potrebne. Po uspešno opravljene predmetu bodo sposobni samostojnega razvoja aplikacij, ki avtomatizirajo spletno iskanje in ekstrahirajo podatke s spletnih strani, vključno z ekstrakcijo podatkov iz on-line socialnih medijev.

Objectives and competences:

The main objective of this course is to teach students about how to develop programs for web search (including surface web and deep web search) and for extraction of structural data from both, static and dynamic web pages. Beside basic concepts of the web search and retrieval, students will learn about relevant techniques and approaches. After the course, if successful, students will be able to develop programs for automatic web search and structured data extraction from web pages (including search and extraction from on-line social media).

Predvideni študijski rezultati:

Po uspešno zaključenem modulu bodo študenti zmožni:

- Povzeti najpomembnejše pristope in tehnike s področja iskanja in ekstrakcije podatkov s spleta
- presoditi, kateri pristopi s področja iskanja in ekstrakcije podatkov s spleta so najbolj primerni za reševanje posameznih problemov,
- razviti aplikacije za zajem in analizo podatkov s spleta,
- konstruirati lastne algoritme za ekstrakcijo podatkov s spleta,
- pojasniti delovanje in časovno kompleksnost algoritmov iskanja po spletu,
- uporabiti in integrirati različne odprto-kodne rešitve s področja iskanja in ekstrakcije podatkov s spleta

Intended learning outcomes:

After successful completion of the module, students will be able to:

- summarize the most important approaches and techniques for searching and extracting data from the web
- to select approaches and techniques that are most suitable for individual problems in web information extraction and retrieval.
- to develop applications for data acquisition and analysis,
- to construct new algorithms for web data search and extraction,
- to explain behavior and time complexity of specific web search algorithms,
- to integrate and employ different open-source solutions from the field.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja, računske vaje z ustnimi nastopi, projektni način dela pri domačih nalogah in seminarjih.	Lectures, seminars, homeworks, oral presentations, project work.

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

Reference nosilca / Lecturer's references:

Pet najpomembnejših del:

1. ŠUBELJ, Lovro, BAJEC, Marko. Group detection in complex networks : an algorithm and comparison of the state of the art. Physica. A, 2014
2. ŽITNIK, Slavko, ŠUBELJ, Lovro, LAVBIČ, Dejan, VASILECAS, Olegas, BAJEC, Marko. General context-aware data matching and merging framework. Informatica, 2013
3. LAVBIČ, Dejan, BAJEC, Marko. Employing semantic web technologies in financial instruments trading : Dejan Lavbič and Marko Bajec. International journal of new computer architectures and their applications, 2012
4. ŠUBELJ, Lovro, FURLAN, Štefan, BAJEC, Marko. An expert system for detecting automobile insurance fraud using social network analysis. Expert systems with applications, 2011
5. ŠUBELJ, Lovro, JELENC, David, ZUPANČIČ, Eva, LAVBIČ, Dejan, TRČEK, Denis, KRISPER, Marjan, BAJEC, Marko. Merging data sources based on semantics, contexts and trust. The IPSI BgD transactions on internet research, 2011

Celotna bibliografija je dostopna na SICRISu:

http://sicris.izum.si/search/rsr.aspx?lang=slv&id=9270.

UČNI NAČRT PREDMETA / COURSE SYLLABUS

Predmet:	Obvladovanje informatike
Course title:	IT Governance

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Magistrski študijski program druge stopnje Računalništvo in informatika Interdisciplinarni magistrski študijski program druge stopnje Pedagoško računalništvo in informatika	ni smeri	1, 2	poletni
Master study program Computer and Information Science, level 2 Interdisciplinary Master study program Computer Science Education, level 2	none	1, 2	spring

Vrsta predmeta / Course type	**strokovni izbirni predmet / specialist elective course** Informacijski sistemi in sistemi za upravljanje / Information and management systems
Univerzitetna koda predmeta / University course code:	63526

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

Nosilec predmeta / Lecturer:	prof. dr. Marko Bajec
Jeziki / Predavanja / Lectures:	slovenščina in angleščina Slovene and English

Languages:	**Vaje / Tutorial:**	slovenščina in angleščina Slovene and English

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites:**

Vsebina:	**Content (Syllabus outline):**
Poslovno-informacijska arhitektura (PIA): • izzivi sodobnih poslovnih sistemov in vloga IKT • deležniki in njihovi interesi pri prenovi PS • Obstoječi pristopi, vloga strateškega planiranja • Vloga PIA pri razvoju poslovnih-informacijskih sistemov • Opredelitev in definicije PIA (metamodel PIA, poslovna, aplikativna in tehnološka plast) • Zorni koti in pogledi deležnikov • Arhitekturni modeli • Proces vzpostavitve PIA • Organiziranost za vzpostavitev in vzdrževanje PIA • Ogrodja, metodologije in orodja za PIA (Zachman, Archimate, TOGAF… Upravljanje informatike: • Procesi informatike • Podpora storitvam • Zagotavljanje storitev • Upravljanje storitev • upravljanje varnosti • obvladovanje infrastrukture • upravljanje z aplikacijami • obvladovanje tveganj • upravljanje sprememb Vodenje informatike	**Enterprise architecture (EA):** • Challenges of modern enterprises and the role of ICT • Stakeholders and their interests in business renovations • The existing approaches, the role of strategic IS/IT planning • The role of enterprise architecture in the development of business and information systems, • Identification and definition of EA (EA metamodel, business, application and technology layer), • Views and viewpoints of different stakeholders, • Enterprise Architecture Methods, • The process of EA development, • Organizing the architecture function for development and maintenance of EA, • EA frameworks, methodologies and tools (Zachman, Archimate, TOGAF ...) **IT Governance:** • IT processes • Service support • Acquiring of services • Service Management • Security management • Infrastructure management • Applications management • Risk Management

	• Change management **IT Management**

Temeljni literatura in viri / Readings:

- C. Finkelstein: Enterprise Architecture for integration, Artech House, Boston, 2006
- M. Lankhorst et al.: Enterprise Architecture at Work:Modelling, Communication and Analysis, Springer, Dordrecht, 2005.
- R.H. Sprague, B.C. McNurlin: Information Systems Management in Practice (7th edition), Prentice Hall 2005.
- M. Op't Land et al.: Enterprise Architecture, Springer, 2009

Internetni viri:

- ArchiMate Resource Tree: http://www.telin.nl/NetworkedBusiness/Archimate/ART/index.html
- ITIL: www.itil-officialsite.com

COBIT: www.isaca.org/cobit

Cilji in kompetence:	**Objectives and competences:**
Celostno obvladovanje informatike v poslovnih sistemih v skladu s poslovno strategijo, vzpostavitev in vzdrževanje poslovno-informacijske arhitekture, strateško planiranje, razvoj in zagotavljanje storitev informatike, upravljanje procesov informatike, vodenje informatike, obvladovanje tveganj	IT governance in enterprises consistent with a business strategy, development and maintenance of enterprise architecture, strategic information systems planning, development and delivering of IT services, governance of IT processes, IT management, risk management.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Po uspešnem zaključku predmeta bo študent: -spoznal pristope, metode, vzpostavitev poslovno-informacijske arhitekture ter instrumentov in mehanizmov upravljanja in organiziranja informatike. -uporabljal znanja PIA in metod upravljanja informatike za njeno celovito obvladovanje pri delu informatikov in vodenju, -razumel skladnosti med teorijo	After the completion of the course a student will: -be familiar with approaches and methods for development of EA, instruments and mechanisms for managing IT and organizing IT function, -be able to use EA knowledge and methods of IT management for the overall IT governance at the work of IT professionals, -understand the consistency between theory of IT management and practical dealing on the basis of concrete examples of

upravljanja informatike in praktičnim ravnanjem na podlagi konkretnih primerov uporabe v poslovnih sistemih ter najboljših praks, -uporabljal metode sistemskega pristopa,upravljanja, vodenja, razumevanja poslovanja in vloge IKT v praksi	use in enterprises and best practices, -be able to apply methods of systems approach, IT management, leadership, understanding of business and the role of ICT in practice.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja in laboratorijske vaje ter seminarji.. V okviru laboratorijskih vaj in seminarjev gre za skupinsko delo.	Lectures, laboratory exercises and seminars. A team work is used by laboratory exercises and seminars.

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

Reference nosilca / Lecturer's references:

Pet najpomembnejših del:

6. ŠUBELJ, Lovro, BAJEC, Marko. Group detection in complex networks : an algorithm and comparison of the state of the art. Physica. A, 2014
7. ŽITNIK, Slavko, ŠUBELJ, Lovro, LAVBIČ, Dejan, VASILECAS, Olegas, BAJEC, Marko. General context-aware data matching and merging framework. Informatica, 2013

8. LAVBIČ, Dejan, BAJEC, Marko. Employing semantic web technologies in financial instruments trading : Dejan Lavbič and Marko Bajec. International journal of new computer architectures and their applications, 2012
9. ŠUBELJ, Lovro, FURLAN, Štefan, BAJEC, Marko. An expert system for detecting automobile insurance fraud using social network analysis. Expert systems with applications, 2011
10. ŠUBELJ, Lovro, JELENC, David, ZUPANČIČ, Eva, LAVBIČ, Dejan, TRČEK, Denis, KRISPER, Marjan, BAJEC, Marko. Merging data sources based on semantics, contexts and trust. The IPSI BgD transactions on internet research, 2011

Celotna bibliografija je dostopna na SICRISu:

http://sicris.izum.si/search/rsr.aspx?lang=slv&id=9270

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	E-izobraževanje
Course title:	E-teaching and E-learning

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Magistrski študijski program druge stopnje Računalništvo in informatika Interdisciplinarni magistrski študijski program druge stopnje Pedagoško računalništvo in informatika	ni smeri	1, 2 2	zimski
Master study program Computer and Information Science, level 2 Interdisciplinary Master study program Computer Science Education, level 2	none	1, 2 2	fall

Vrsta predmeta / Course type	**strokovni izbirni predmet / specialist elective course** Medijske tehnologije / Media technologies **obvezni predmet / compulsory course**
Univerzitetna koda predmeta / University course code:	63518

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

Nosilec predmeta / Lecturer:	izr. prof. dr. Zoran Bosnić
Jeziki / Predavanja / Lectures:	slovenščina in angleščina Slovene and English

Languages:	**Vaje / Tutorial:**	slovenščina in angleščina Slovene and English

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites:**

Vsebina:	**Content (Syllabus outline):**
Predavanja • Modeli izobraževanja s poudarkom na e-izobraževanje	**Lectures** • Learning models with the emphasis on e-teaching and e-learning
• Spletne tehnologije v izobraževanju • Računalniško podprte animacije in simulacije v izobraževanju • Računalniško podprto eksperimentiranje • Računalniško podprte tehnologije sodelovanja • Prenosljivi in ponovno uporabljivi učni objekti • Sistemi za upravljanje učenja (LMS) • Adaptivni izobraževalni sistemi • Problemi skladnosti gradnikov e-gradiv in programskih orodij • Digitalne knjižnice • Izobraževalni metapodatki • Elektronsko preverjanje znanja • Elektronske spletne ankete • Vrednotenje kakovosti e-izobraževalnih gradiv	• Internet technologies in education • Computer supported animations and simulations in education • Computer supported experiments • Computer supported collaboration technologies • Reusable learning objects • Learning management systems (LMS) • Adaptive learning systems • Compatibility problems of e-learning assets and software tools • Digital libraries • Educational metadata • Electronic knowledge assessment • Electronic internet questionnaires • Evaluation of the quality of e-learning materials
Vaje	**Exercises**

Namen vaj pri predmetu e-izobraževanje je naslednji: 1. Utrjevanje pri predavanjih obravnavane snovi s konkretnimi primeri ob uporabi sodobnih računalniških orodij in IK infrastrukture 2. kvalitativna in kvantitativna predstavitev nekaterih primerov dobre prakse. Pri vajah študenti vzpostavljajo primere učnih objektov, manjših e-gradiv in sodelavnih okolij za e-učenje **Domače naloge**: Namen domačih nalog je ponuditi študentom priložnost za povsem samostojno izvedbo seminarskih nalog, ki terjajo analizo učnega problema in implementacijo rešitve s pomočjo sodobnih računalniških tehnologij.	The goal of the exercises in this subject is the following: 1. Fortifying of the lectured contents with concrete examples, supported with advanced computer tools and IC infrastructure 2. Qualitative and quantitative presentation of some typical case study examples. Within exercises the student will setup examples of learning objects, small e-learning materials and collaborative environments for e-learning **Home work**: The aim of home assignments is to offer to the students the opportunity for complete autonomous realisation of student projects that require the analysis of given problem and implementation of the solution supported by advanced computer technologies.

Temeljni literatura in viri / Readings:

Temeljna literatura:

1. Terry Anderson, The Theory and Practice of Online Learning, second edition, eBook: http://www.aupress.ca/books/120146/ebook/99Z_Anderson_2008-Theory_and_Practice_of_Online_Learning.pdf
2. David Brooks, Diane Nolan, Susan Gallagher: Web-Teaching, 2nd Edition, eBook: http://dwb.unl.edu/Book/Contentsw.html
3. Saša Divjak: e-Izobraževanje: e-gradiva predavanj: http://lgm.fri.uni-lj.si/el/

Dodatna literatura:

4. Clarc Aldrich: Learning by Doing: A Comprehensive Guide to Simulations, Computer Games, and Pedagogy in e-Learning and Other Educational Experiences (Wiley Desktop Editions), ISBN-10: **0787977357** | ISBN-13: **978-0787977351** | Publication Date: **May 5, 2005** | Edition: **1**
5. Michael W. Allen : *Designing Successful e-Learning, Michael Allen's Online Learning Library: Forget What You Know About Instructional Design and Do Something Interesting (Michael Allen's E-Learning Library)* ; ISBN-10: **0787982997** | ISBN-13: **978-0787982997** | Publication Date: **May 25, 2007** | Edition: **1**
6. A.W. (Tony) Bates: Technology, e-learning and Distance Education (Routledge Studies in Distance Education) , ISBN-10: 0415284376 | ISBN-13: 978-0415284370 | Publication Date: July 21, 2005 | Edition: 2
7. Jeff Cobb: Learning 2.0 for associations, eBook: http://www.tagoras.com/docs/Learning-20-Associations-2ed.pdf

Cilji in kompetence:

Cilj predmeta je študentom računalništva in informatike predstaviti sodobne koncepte in metode s področja e-izobraževanja in izobraževanja na daljavo v luči informacijsko komunikacijskih tehnologij, ki tako izobraževanje podpirajo.

Objectives and competences:

The goal of the subject is to present to the students advanced concepts and methods in the domain of e-teaching /e-learning and distance education from the viewpoint of information/communication technologies supporting such education.

Predvideni študijski rezultati:

Po uspešnem zaključku tega predmeta bo študent:

- Razumel teorije izobraževanja in sodobne modele e-izobraževanja
- Poznal metode in tehnike za pripravo spletnih izobraževalnih gradiv
- Razumel pomen in strukturo ponovno uporabljivih učnih objektov.

Intended learning outcomes:

After successful completition of the course student will:

- Know and understand theories of education and modern e-learning models
- know the methods and techniques for preparing online educational materials
- understand the importance and the structure of reusable learning objects.

- Poznal postopke za sestavljanje učnih objektov v izobraževalne pakete. - Poznal sodobne standarde, potrebne pri pripravi platformno neodvisnih izobraževalnih gradiv - Sposoben kvalitativno ovrednotiti obstoječa gradiva za e-izobraževanje vključno z mobilnim izobraževanjem. - Sposoben ovrednotiti, izbirati in uporabljati tipična orodja za pripravo in uporabo gradiv za mobilno in e-izobraževanje. - Sposoben samostojnega razvoja gradiv za e- in mobilno izobraževanje	- know the procedures for integration of learning objects into educational packages. - Know the current standards required in the preparation of platform-independent educational materials - Be able to qualitatively evaluate existing e-learning materials, including mobile learning. - Be able to evaluate, select and apply typical tools for the development and use of e-learning and mobile learning courseware. - Be able to autonomous development of e-learning and mobile learning material

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja, praktične demonstracije in samostojne seminarske naloge, Poseben poudarek je na sprotnem študiju in na skupinskem delu pri vajah in seminarjih.	Lectures, practical demonstrations and autonomous student projects, A specific emphasis to simultaneous study and group-work within exercises and student projects.

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

Reference nosilca / Lecturer's references:

Pet najpomembnejših del:

1. ZUPANC, Kaja, BOSNIĆ, Zoran. Advances in the field of automated essay evaluation. *Informatica*, ISSN 0350-5596, Dec. 2015, vol. 39, no. 4, str. 383-396, ilustr.

2. OCEPEK, Uroš, BOSNIĆ, Zoran, NANČOVSKA ŠERBEC, Irena, RUGELJ, Jože. Exploring the relation between learning style models and preferred multimedia types. Computers & Education, ISSN 0360-1315. [Print ed.], Nov. 2013, vol. 69, str. 343-355.

3. BOSNIĆ, Zoran, KONONENKO, Igor. Estimation of individual prediction reliability using the local sensitivity analysis. Applied intelligence, ISSN 0924-669X. [Print ed.], Dec. 2008, vol. 29, no. 3, str. 187-203.

4. BOSNIĆ, Zoran, KONONENKO, Igor. Comparison of approaches for estimating reliability of individual regression predictions. Data & Knowledge Engineering, ISSN 0169-023X. [Print ed.], Dec. 2008, vol. 67, no. 3, str. 504-516.

5. ZUPANC, Kaja, BOSNIĆ, Zoran. Automated essay evaluation augmented with semantic coherence measures. V: 14th IEEE International Conference on Data Mining, 14-17 December 2014, Shenzhen, China. KUMAR, Ravi (ur.). ICDM 2014 : proceedings, (Proceedings (IEEE International Conference on Data Mining), ISSN 1550-4786). Los Alamitos (CA) [etc.]: The Institute of Electrical and Electronics Engineers: = IEEE, cop. 2014, str. 1133-1138.

Celotna bibliografija je dostopna na SICRISu:

http://sicris.izum.si/search/rsr.aspx?lang=slv&id=31318.

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Funkcijsko programiranje
Course title:	Functional programming

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Magistrski študijski program druge stopnje Računalništvo in informatika Interdisciplinarni magistrski študijski program druge stopnje Računalništvo in matematika Interdisciplinarni magistrski študijski program druge stopnje Pedagoško računalništvo in informatika Interdisciplinarni magistrski študijski program druge stopnje Multimedija	ni smeri	1, 2	zimski
Master study program Computer and Information Science, level 2 Interdisciplinary Master study program Computer Science and Mathematics, level 2 Interdisciplinary Master study program Computer Science Education, level 2 Interdisciplinary Master study program Multimedia, level 2	none	1, 2	fall

Vrsta predmeta / Course type	**obvezni predmet / compulsory course** **strokovni izbirni predmet / specialist elective course** Tematski sklopi / Thematic set: FRI A / FRI A
Univerzitetna koda predmeta / University course code:	**63507**

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

Nosilec predmeta / Lecturer:	izr. prof. dr. Zoran Bosnić

Jeziki / Languages:	**Predavanja / Lectures:**	slovenščina in angleščina Slovene and English
	Vaje / Tutorial:	slovenščina in angleščina Slovene and English

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites:**

Vsebina:	**Content (Syllabus outline):**
Predmet poučuje koncept in uporabo paradigme funkcijskega programiranja, skozi katero se dotika teorije programskih jezikov in poglobljenega razumevanja njihovih lastnosti. Poglavja pri predmetu vsebujejo: 1. Uvod v funkcijsko programiranje. 2. Pojem okolja, leksikalnega in semantičnega dosega. 3. Osnove funkcijskega jezika Standard ML (sintaksa, semantika, enostavni in sestavljeni	The course teaches the concept and use of a functional programming paradigm and connects it to the programming language theory through a deeper understanding of programming language concepts. The content contains: 1. Introduction to functional programming. 2. Concepts of: environment, lexical and semantic scope.

podatkovni tipi, opcije, lastni tipi) in osvajanje naslednjih pojmov:
- ujemanje vzorcev,
- funkcije višjega reda, currying,
- delo z moduli.

4. Osnove funkcijskega jezika Racket in osvajanje naslednjih pojmov:
   - takojšnja in lena evalvacija,
   - tokovi,
   - zakasnitev in sprožitev,
   - gradnja podatkovnih tipov,
   - funkcije z dinamičnim številom argumentov,
   - izdelava interpreterja.
5. Primerjava funkcijskega in objektno usmerjega programiranja.
6. Vrste tipiziranj (statično/dinamično, močno/šibko, implicitno/eksplicitno) in trdnost/polnost sistema tipov.

3. Basics of Standard ML (syntax, semantics, basic and complex data types, options, custom types) and concepts:
   - pattern matching,
   - higher order functions, currying,
   - working with modules.
4. Basics of Racket programming language and concepts:
   - eager and lazy evaluation,
   - streams,
   - delay and force,
   - building custom datatypes,
   - functions with variable number of arguments,
   - making an interpreter.
5. Comparison of functional and object-oriented programming.
6. Different types of typing (static/dynamic, weak/strong, implicit/explicit) and soundness/completeness of a type system.

Temeljni literatura in viri / Readings:

1. R. Pucella: Notes on Programming SML/NJ, Cornell, 2001
2. Matthew Flatt, Robert Bruce Findler et al.: The Racket Guide, 2015.
3. Ravi Sethi: Programming Languages: concepts & constructs. Addison-Wesley, 1996.
4. A. Tucker, R. Noonan: Programming Languages: Principles and Paradigms. McGraw-Hill, 2007.

Cilji in kompetence:

Študenti, ki so dokončali prvostopenjski študij RI, so opravili predmete s področja osnov programiranja in pretežno spoznali objektno-usmerjeno paradigmo programiranja. Cilj tega predmeta predstaviti drugačne tehnike programiranja s poudarkom na funkcijskem programiranju. Predmet bo študentom omogočil razvoj veščin kritičnega, analitičnega in sintetičnega mišljenja pri uporabi in razumevanju delovanja

Objectives and competences:

Students who finished the undergraduate study of computer science already completed courses on basics of programming and mostly used the object-oriented programming paradigm. The objective of this course is to present alternative programming techniques with the emphasis on functional programming. The course will help develop students' skills in critical, analytical and synthetic thinking for use and understanding of

programskih jezikov kot temeljnih orodij vsakega programerja.	programming languages as basic tools of each programmer.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Po uspešnem zaključku predmeta bo študent: - razlikoval paradigme objektno-usmerjenega in funkcijskega programiranja, - znal opisati prednosti izogibanja mutaciji in stranskim učinkom, - sposoben uporabljati ujemanje vzorcev, funkcije višjega reda, lastne podatkovne tipe, zakasnjeno evalvacijo, - razločeval med statično/dinamično, impliticno/eksplicitno, šibko/močno tipiziranimi programskimi jeziki, - sposoben načrtovati lastni preprost programski jezik, - sposoben argumentirati, katera programerska paradigma je bolj primerna za reševanje danega problema.	After the completion of the course the student will be able to: - differentiate between the object-oriented and functional programming paradigms, - describe advantages of avoiding mutation and program side-effects, - use pattern matching, higher-order functions, own data types and lazy evaluation, - differentiate between statically/dynamically, implicitly/explicitly, weakly/strongly typed programming languages, - design own simple programming language, - argue which programming paradigm is the most suitable for solving a given problem.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja, domače naloge in seminarske naloge. Poseben poudarek je na individualnem delu študentov.	Lectures, homeworks and seminar works with special emphasis on individual work.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Način (pisni izpit, ustno izpraševanje, naloge, projekt): **Sprotno preverjanje** (seminarske nal.) **Končno preverjanje** (pisni ali ustni izpit) Ocene: 6-10 pozitivno, 5 negativno (v skladu s Statutom UL).	**50%** **50%**	Type (examination, oral, coursework, project): **Continuing** (homework) **Final** (written or oral exam) Grading: 6-10 pass, 5 fail (according to the rules of University of Ljubljana).

Reference nosilca / Lecturer's references:

1. OCEPEK, Uroš, RUGELJ, Jože, BOSNIĆ, Zoran. Improving matrix factorization recommendations for examples in cold start. Expert systems with applications, ISSN 0957-4174. [Print ed.], Nov. 2015, vol. 42, no. 19, str. 6784-6794.
2. BOSNIĆ, Zoran, KONONENKO, Igor. Estimation of individual prediction reliability using the local sensitivity analysis. Appl. intell. (Boston). [Print ed.], Dec. 2008, vol. 29, no. 3, p. 187-203, ilustr.
3. BOSNIĆ, Zoran, KONONENKO, Igor. Comparison of approaches for estimating reliability of individual regression predictions. Data knowl. eng.. [Print ed.], Dec. 2008, vol. 67, no. 3, p. 504-516
4. BERDAJS, Jan, BOSNIĆ, Zoran. Extending applications using an advanced approach to DLL injection and API hooking. Software, ISSN 0038-0644, 2010, vol. 40, no. 7, str. 567-584.
5. BOSNIĆ, Zoran, KONONENKO, Igor. Automatic selection of reliability estimates for individual regression predictions. Knowl. eng. rev., 2010, vol. 25, no. 1, p. 27-47

Celotna bibliografija je dostopna na SICRISu:

http://sicris.izum.si/search/rsr.aspx?lang=slv&id=31318.

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Umetna inteligenca
Course title:	Artificial Intelligence

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Magistrski študijski program druge stopnje Računalništvo in informatika	**ni smeri**	**1, 2**	**poletni**
Master study program Computer and Information Science, level 2	**none**	**1, 2**	**spring**

Vrsta predmeta / Course type	**strokovni izbirni predmet / specialist elective course** Umetna inteligenca/ Artificial intelligence
Univerzitetna koda predmeta / University course code:	63510

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

Nosilec predmeta / Lecturer:	akad. prof. dr. Ivan Bratko	
Jeziki / Languages:	**Predavanja / Lectures:**	slovenščina in angleščina Slovene and English
	Vaje / Tutorial:	slovenščina in angleščina Slovene and English

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites:**

Vsebina:	**Content (Syllabus outline):**
Pregled osnovnih metod reševanja problemov in zahtevnejše metode hevrističnega preiskovanja: prostorsko učinkovite metode, reševanje problemov v realnem času. Metode planiranja po principu sredstev in ciljev: robotsko planiranje, sestavljanje urnikov in planiranje opravil, princip sredstev in ciljev, delno urejeno planiranje, planirni grafi. Strojno učenje: pregled osnovnih metod (Bayesov klasifikator, učenje dreves in pravil); ocenjevanje verjetnosti; princip minimalne dolžina opisa (MDL); ocenjevanje uspešnosti učenja; principi poenostavljanja pravil in odločitvenih dreves; koncept naučljivosti in teoretične meje učenja. Nekatere druge paradigme strojnega učenja: induktivno logično programiranje,spodbujevano učenje, konstruktivno učenje in odkrivanje novih konceptov s funkcijsko dekompozicijo. Predstavitev in obravnavanje negotovega znanja: sklepanje in učenje v bayesovskih mrežah, konstrukcija mrež in predstavitev vzročnosti Kvalitativno sklepanje in modeliranje: kvantitavno in kvalitativno modeliranje, modeliranje brez števil, kvalitativna simulacija. Genetski algoritmi, genetsko programiranje, in druge alternativne paradigme reševanja problemov.	Problem solving and search: review of problem solving techniques; advanced heuristic search techniques, space efficient techniques, real-time search. Means-ends planning: robot planning, task planning and scheduling, means-ends planning, partial order planning, planning graphs and GRAPHPLAN. Machine learning: review of basic methods (Bayes and naive Bayes classifier, learning of trees and rules, handling noise, pruning of trees and rules); MDL principle; Support Vector Machines; evaluating success of learning and comparing learning algorithms; learnability and theoretical limits for learning. Other paradigms of machine learning: inductive logic programming, reinforcement learning, constructive learning and discovering new concepts with functional decomposition. Reasoning with uncertainty: reasoning and learning in Bayesian networks, construction of networks and causality. Qualitative reasoning and modelling:

	qualitative and quantitative modelling, modelling without numbers, qualitative simulation of dynamic systems. Genetic algorithms, genetic programming and other problem-solving paradigms.

Temeljni literatura in viri / Readings:

1.) S. Russell, P. Norvig*, Artificial Intelligence: A Modern Approach*, 3rd edition, Prentice-Hall 2009, ISBN-013:978-0-13-604259-4.
2.) I. Witten, E. Frank, M.A. Hall, C. Pal, *Data Mining*, 4th edition, Morgan Kaufmann, 2016, ISBN: 978-0128042915.
3.) I. Bratko, *Prolog Programming for Artificial Intelligence*, Fourth edition, Pearson Education, Addison-Wesley 2011, ISBN: 0201403757.

Cilji in kompetence:	**Objectives and competences:**
Poglobljeno znanje o metodah in tehnikah umetne inteligence. Sposobnost reševanja zahtevnih konkretnih praktičnih problemov z metodami umetne inteligence. Zmožnost kompetentne uporabe metod in orodij umetne pri raziskovalnem delu, vključno s seminarskimi nalogami pri drugih predmetih in pri diplomskem delu. Usposobljenost za raziskovalno delo na področju umetne inteligence.	In-depth knowledge of methods and techniques of Artificial Intelligence (AI). Ability of solving complex practical problems with AI methods. Competence in using methods and tools of AI in research, including projects in other courses and in the final graduation project. Ability of conducting research in Artificial Intelligence.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Po zaključku tega predmeta bo študent: - Razumel napredne preiskovalne algoritme in kompromise med njihovo časovno in prostorsko zahtevnostjo ter kvaliteto dobljenih hevrističnih rešitev - Razumel algoritme za konstruiranje paralelnih planov in metode delno urejenega planiranja kot zadoščanja omejitev	After the completion of the course the student will be able to: - Understand advanced search algorithms, and trade-offs between their time and space complexity, and quality of heuristic solutions produced - Understand algorithms for constructing parallel plans, and methods for partial-order planning as constraint satisfaction

- Sposoben analizirati praktične probleme preiskovanja in planiranja v konkretnih aplikacijah - Razumel pristop in metode spodbujevanega učenja za zaporedno verjetnostno odločanje - Razumel pristop k strojnemu učenju na osnovi matematične logike in njegove praktične prednosti in slabosti - Razumel principe in algoritme kvalitativnega sklepanja, modeliranja in simulacije - Sposoben kombiniranja in uporabe metod umetne inteligence v industriji, robotiki, medicini, biologiji itd. ter v znanosti	- Analyse practical questions of search and planning methods when applied to concrete application problems - Understand the framework and methods of reinforcement learning for sequential probabilistic decision making - Understand the logic-based approach to machine learning, and its practical advantages and drawbacks - Understand the principles and algorithms of qualitative modelling, reasoning and simulation - Able to competently combine and apply AI methods in the implementation of applications in industry, robotics, medicine, biology, etc., and in research

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja, seminarske naloge in avditorne ter laboratorijske vaje.	Lectures, laboratory work and projects.

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

Reference nosilca / Lecturer's references:

Pet najpomembnejših del:

1. I. Bratko, *Prolog Programming for Artificial Intelligence*, 4th edition, Pearson Education – Addison-Wesley, 2011.

2. M. Možina, J. Žabkar, I. Bratko. Argument based machine learning. *Artificial Intelligence*. Vol. 171 (2007), no. 10/15, 922-937.

3. M. Luštrek, M. Gams, I. Bratko. Is real-valued minimax pathological?. *Artificial Intelligence*.Vol. 170 (2006), 620-642.

4. D. Šuc, D. Vladušič, I. Bratko. Qualitatively faithful quantitative prediction. *Artificial Intelligence*. Vol. 158, (2004) no. 2, str. [189]-214,

5. I. Bratko, S. Muggleton. Applications od inductive logic programming. *Commun. ACM*, 1995, vol. 38 (1995), no. 11, 65-70.

Celotna bibliografija je dostopna na SICRISu:

http://sicris.izum.si/search/rsr.aspx?lang=slv&id=4496.

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Digitalna forenzika
Course title:	Digital forensics

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Magistrski študijski program druge stopnje Računalništvo in informatika Interdisciplinarni magistrski študijski program druge stopnje Računalništvo in matematika	**ni smeri**	**1, 2**	**poletni**
Master study program Computer and Information Science, level 2 Interdisciplinary Master study program Computer Science and Mathematics, level 2	**none**	**1, 2**	**spring**

Vrsta predmeta / Course type	**strokovni izbirni predmet / specialist elective course** Omrežja in varnost / Computer networks and security
Univerzitetna koda predmeta / University course code:	63530

Predavanja **Lectures**	**Seminar** **Seminar**	**Vaje** **Tutorial**	**Klinične vaje** **Laboratory work**	**Druge oblike študija** **Field work**	**Samost. delo** **Individ. work**	**ECTS**
45	/	30	/	/	105	6

Nosilec predmeta / Lecturer:	doc. dr. Andrej Brodnik
Jeziki / Predavanja / Lectures:	slovenščina in angleščina Slovene and English

Languages:	**Vaje / Tutorial:**	slovenščina in angleščina Slovene and English

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites:**

Vsebina:	**Content (Syllabus outline):**
Uvod in pravne osnove: • uvod • digitalni dokazi in računalniški kriminal • tehnologija in pravo: evropska perspektiva, ameriška perspektiva • preiskovalni proces in rekonstrukcija • modus operandi, motivi in tehnologija • digitalni dokazi na sodišču	**Introduction and legal basis:** • introduction • digital evidence and computer crime • technology and legal framework: European perspective, North American perspective • investigating procedure and reconstruction • modus operandi, motifs and technology • a digital evidence and a court of law
Računalniki: • osnove: delovanje, predstavitev podatkov, datotečni sistemi, enkripcija • forenzična znanost in računalniki: avtorizacija, razpoznava, dokumentiranje, zbiranje in ohranjanje, preiskava in analiziranje, rekonstrukcija • forenzična analiza sistemov Windows: datotečni sistem, pridobivanje podatkov iz računalnika, register, zabeležke (*log*), sledi datotek, omrežno dostopanje, programi • forenzična analiza sistemov Unix: datotečni sistem, pridobivanje podatkov iz računalnika, register, zabeležke (log), sledi datotek, omrežno dostopanje, programi • forenzična analiza sistemov Macintosh: datotečni sistem, pridobivanje podatkov iz računalnika, register, zabeležke (*log*), sledi datotek, omrežno dostopanje, programi	**Computers:** • basics: operation, data representation, file systems, encryption • forensic science and computers: authorization, recognition, documentation, collecting and saving data, investigation and analysis, reconstruction • forensic analysis of Windows systems: file system, collecting data from the computer, registry, logs, traces of files, network access, programs • forensic analysis of Unix systems: file system, collecting data from the computer, registry, logs, traces of files, network access, programs • forensic analysis of Mac computers: file system, collecting data from the computer, registry, logs, traces of files, network access, programs

- forenzična analiza dlančnih sistemov: pomnilnik, Palm OS, Windows CE, RIM Blackberry, mobilni telefoni

Omrežja:

- osnove: plasti in njihove storitve ter protokoli
- forenzična znanost in omrežja: razpoznava, dokumentiranje, zbiranje, ohranjanje podatkov; filtriranje in združevanje podatkov
- digitalni dokazi na fizični in povezavni plasti
- digitalni dokazi na omrežni in prednosti plasti
- digitalni dokazi v Internetu: splet, e-pošta, pogovorni programi; uporaba interneta kot preiskovalnega orodja

Preiskovanje računalniškega kriminala:

- vdori in rekonstrukcija
- spolni zločini
- nadlegovanje
- digitalni dokazi kot alibi

- forensic analysis of palm computers: memory, Palm OS, Windows CE, RIM Blackberry, mobile phones

Networks:

- basics: layers and their services with protocols
- forensic science and networks: recognition, documentation, collecting and saving data; data filtering and event matching
- digital evidences on a physical layer
- digital evidences on a link layer
- digital evidences on a network layer
- digital evidences in Internet: web, e-mail, chats; use of Internet as an investigation tool

Investigation of a computer crime:

- intrusion and reconstruction
- sexual crimes
- harassment
- digital evidence as an alibi

Temeljni literatura in viri / Readings:

a) Digital Evidence and Computer Crime, Second Edition, Eoghan Casey, Academic Press (2004), ISBN-10: 0121631044, ISBN-13: 978-0121631048
b) Cyber Crime: The Investigation, Prosecution and Defense of a Computer-Related Crime. 2nd Edition. Edited by Clifford, R., Carolina Academic Press, ISBN 159460150X
c) Computer Forensics: Incident Response Essentials, Kruse, W., & Heiser, J, Addison Wesley, ISBN 201707195

Cilji in kompetence:

Študent se spozna s tem, kako se uporablja računalništvo in informatika v forenzičnih postopkih.

Objectives and competences:

Student learns how to use knowledge and skills of Computer Science in forensic procedures.

Predvideni študijski rezultati:

Intended learning outcomes:

Po uspešnem zaključku predmeta bo študent: - sposoben izkazati razumevanje osnovnih pojmov forenzike; - sposoben opredeliti v podrobnosti delovanja računalniških sistemov; - znal povezovati obe področji.	After the successful completion of the course the student will be able to: - understand basic terms in forensic science; - explain details of computer systems, and - combine knowledge from both areas.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja, vaje, domače naloge, seminarji, konzultacije, laboratorijsko delo.	Lectures, exercises, lab work, assignments, seminars, consulting.

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

Reference nosilca / Lecturer's references:

Pet najpomembnejših del:

1. BRODNIK, Andrej, IACONO, John. Unit-time predecessor queries on massive data sets. Lect. notes comput. sci., part 1, str. 133-144. [COBISS.SI-ID 8178260]
2. BRODNIK, Andrej, GRGUROVIČ, Marko. Speeding up shortest path algorithms. V: 23rd international symposium, 23rd international symposium, ISAAC 2012, (Lecture notes in computer science, ISSN 0302-9743, 7676), 2012, str. 156-165. [COBISS.SI-ID 1024498772]
3. TRČEK, Denis, BRODNIK, Andrej. Hard and soft security provisioning for computationally weak pervasive computing systems in e-health. IEEE wireless communications, ISSN 1536-1284. [Print ed.], Aug. 2013, vol. 20, no. 4. [COBISS.SI-ID 10091092]
4. BRODAL, Gerth Stølting, BRODNIK, Andrej, DAVOODI, Pooya. The encoding complexity of two dimensional range minimum data structures. 21st Annual European Symposium: proceedings, (Lecture notes in computer science, ISSN 0302-9743, Theoretical computer science and general issues, 8125). [COBISS.SI-ID 10148692]

5. KRIŽAJ, Dejan, BRODNIK, Andrej, BUKOVEC, Boris. A tool for measurement of innovation newness and adoption in tourism firms. International journal of tourism research, ISSN 1522-1970, 2014, vol. 16, no. 2, str. 113-125. [COBISS.SI-ID 1500126]

Celotna bibliografija je dostopna na SICRISu: http://sicris.izum.si/search/rsr.aspx?lang=slv&id=5281.

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Digitalno procesiranje signalov
Course title:	Digital signal processing

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Magistrski študijski program druge stopnje Računalništvo in informatika Interdisciplinarni magistrski študijski program 2. stopnje Računalništvo in matematika	ni smeri	1, 2	zimski
Master study program Computer and Information Science, level 2 Interdisciplinary Master study program Computer Science and Mathematics, level 2	none	1, 2	fall

Vrsta predmeta / Course type	**strokovni izbirni predmet / specialist elective course** Medijske tehnologije / Media technologies Strojna oprema / Hardware
Univerzitetna koda predmeta / University course code:	63516

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

Nosilec predmeta / Lecturer:	izr. prof. dr. Patricio Bulić
Jeziki / Predavanja / Lectures:	slovenščina in angleščina Slovene and English

Languages:	**Vaje / Tutorial:**	slovenščina in angleščina Slovene and English

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites:**

Vsebina:	**Content (Syllabus outline):**
1. Zvezni in diskretni signali, zaporedja, enotin impulz. 2. Diskretni linearni časovno-invariantni sistemi, lastna funkcija, kavzalnost, stabilnost. 3. Diferenčne enačbe in z-transformacija. 4. Vzorčenje zveznih signalov, posplošeno vzorčenje, decimacija in interpolacija. 5. Analiza diskretnih sistemov v frekvenčnem prostoru, idealni filtri, sistemi z minimalno in linearno fazo. 6. Strukture za realizacijo diskretnih sistemov: direktna, kaskadna in paralelna. 7. Metode za načrtovanje digitalnih filtrov z neskončnim enotinim odzivom: bilinearna transformacija analognih filtrov, načrtovanje z uporabo linearnega programiranja. 8. Metode za načrtovanje digitalnih filtrov s končnim enotinim odzivom: okenske funkcije, frekvenčno vzorčenje, Remezov algoritem. 9. Diskretna Fourierova transformacija in FFT algoritem. 10. Hitro računanje diskretne konvolucije in korelacije.	1. Continuous and discrete signals, sequences, unit impulse. 2. Discrete linear time-invariant systems, eigenfunction, causality, stability. 3. Difference equations and z-transform. 4. Sampling of continuous signals, sampling generalization, decimation and interpolation. 5. Analysis of discrete systems in the frequency domain, ideal filters, systems with minimal and linear phase. 6. Structures for discrete system: direct, cascade and parallel forms. 7. Methods for infinite impulse response digital filter design: bilinear transformation of analog filters, design with linear programming. 8. Methods for finite impulse response digital filter design: window functions, frequency sampling, Remez algorithm. 9. Discrete Fourier transform and FFT algorithm. 10. Fast discrete convolution and correlation. 11. Spectral analysis: nonparametric and parametric methods. LPC analysis. 12. Signal processors: properties, special functions and application.

11. Spektralna analiza: neparametrične in parametrične metode. LPC analiza. 12. Signalni procesorji: lastnosti, posebnosti, programiranje in uporaba. 13. Uporaba digitalnega procesiranja signalov pri govornih in video signalih.	13. Application of digital signal processing speech and video signals.

Temeljni literatura in viri / Readings:

1. A.V. Oppenheim, R.W. Shafer: *Discrete-Time Signal Processing*, 2nd Edition, Prentice Hall, 1999, poglavja 1 do 10.

Dodatna literatura:

1. J. G. Proakis, D.G. Manolakis: *Digital Signal Processing*, 4th Edition, Prentice Hall, 2006.

Cilji in kompetence:	**Objectives and competences:**
Cilj predmeta je predstaviti področje obdelave signalov z digitalnimi metodami in še posebej uporabo računalnikov na tem področju. Poleg teoretičnih znanj, ki so osnova za razumevanje uporabljenih metod, je predmet namenjen tudi pridobivanju praktičnih izkušenj na resničnih problemih. Poseben poudarek je dan pregledu naprav in dejavnosti, pri katerih se uporabljajo metode iz digitalnega procesiranja signalov.	The objective is to present the processing of signals by digital techniques, including the application of computers in this area. The theory which is the basis for understanding the processing methods is combined with practical projects that are derived from the real world problems. Special attention is given to devices and activities that use the digital signal processing methods.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Po uspešnem zaključku predmeta bo študent: -razumeval principe digitalnega procesiranja signalov vključno s primerjavo in oceno različnih metod, ki se v njem uporabljajo, -digitalno procesiranje signalov je danes prisotno v mnogih izdelkih, od mobilnih telefonov do računalnikov, študent bo razumeval delovanje in sposoben presoje kvalitete različnih rešitev v mnogih primerih,	After the completion of the course a student will be able to: -understand the principles of digital signal processing including the comparison and evaluation of different methods, -as digital signal processing is the basis of many products manufactured today, from mobile phones to computers, a student will understanding it and be able to evaluate the quality of different solutions in many cases.

-povezoval matematično-teoretične metode s praktičnimi izkušnjami in s tem povečal možnosti za poklicni uspeh, -uspešno dopolnjeval znanja s predmeti s področja algoritmov, programiranja in arhitekture.	-combine mathematical-theoretical methods with practical experience which will increase the chances for his successful career, -complement the knowledge from this course with courses from the area of algorithms, programming and architecture.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja, laboratorijske vaje in domače naloge. Poseben poudarek je na praktičnem laboratorijskem delu. Študenti s pomočjo programskih orodij in signalnih procesorjev spoznavajo digitalno procesiranje signalov in njegovo uporabnost.	Lectures, laboratory and homework. Special emphasis is given to practical laboratory work. Students use programming tools and digital signal processors to get hands on knowledge of digital signal processing and its application.

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

Reference nosilca / Lecturer's references:

Pet najpomembnejših del: / **Five most important works:**

1. AVRAMOVIĆ, Aleksej, BABIĆ, Zdenka, RAIČ, Dušan, STRLE, Drago, BULIĆ, Patricio. An approximate logarithmic squaring circuit with error compensation for DSP applications. *Microelectronics journal*, 2014, vol. 45, iss. 3, str. 263-271.
2. ČEŠNOVAR, Rok, RISOJEVIĆ, Vladimir, BABIĆ, Zdenka, DOBRAVEC, Tomaž, BULIĆ, Patricio. A GPU implementation of a structural-similarity-based aerial-image classification. *J. supercomput*., Aug. 2013, vol. 65, no. 2, str. 978-996.
3. BULIĆ, Patricio, GUŠTIN, Veselko, ŠONC, Damjan, ŠTRANCAR, Andrej. An FPGA-based integrated environment for computer architecture. *Comput. appl. eng. educ.*, Mar. 2013, vol. 21, no. 1, str. 26-35.
4. LOTRIČ, Uroš, BULIĆ, Patricio. Applicability of approximate multipliers in hardware neural networks. *Neurocomputing*, Nov. 2012, vol. 96, str. 57-65.

5. BABIĆ, Zdenka, AVRAMOVIĆ, Aleksej, BULIĆ, Patricio. An iterative logarithmic multiplier. *Microprocess. microsyst.*. , 2011, vol. 35, no. 1, str. 23-33.

Celotna bibliografija izr. prof. Patricia Bulića je dostopna na SICRISu:

http://sicris.izum.si/search/rsr.aspx?lang=slv&id=4520.

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Poučevanje algoritmičnega razmišljanja
Course title:	Teaching algorithmic thinking

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Magistrski študijski program druge stopnje Računalništvo in informatika	ni smeri	1,2	zimski
Master study program Computer and Information Science, level 2	none	1,2	fall

Vrsta predmeta / Course type	**strokovni izbirni predmet / specialist elective course** Algoritmika / Algorithmics
Univerzitetna koda predmeta / University course code:	63547

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

Nosilec predmeta / Lecturer:	prof. dr. Janez Demšar	
Jeziki / Languages:	**Predavanja / Lectures:**	slovenščina Slovene
	Vaje / Tutorial:	slovenščina Slovene

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites:**

Vsebina:

Namen predmeta je izuriti prihodnje učitelje za poučevanje algoritmičnega razmišljanja. Didaktični pristop, ki ga bomo učili, temelji na načelih opisanih na http://csunplugged.org. Primeri konkretnih tem, ki jih bomo jemali za zgled, v grobem sledijo IEEE/ACMovem kurikulu za osnovne in srednje šole:

- binarna predstavitev podatkov, predstavitev slik in zvoka,
- stiskanje podatkov, teorija informacij, zaznavanje napak
- kriptografija,
- preiskovalni algoritmi, algoritmi za urejanje
- usmerjanje in smrtni objem, končni avtomati in algoritmi na grafih

in druge.

Poleg konkretnih pristopov k poučevanju teh tem bodo študenti spoznavali predvsem splošna didaktična načela, ki jim je potrebno slediti pri poučevanju algoritmičnega razmišljanja.

Študenti bodo poleg praktičnega dela v razredih na šolah, s katerimi so sklenjeni sporazumi o sodelovanju pod ustreznim mentorstvom nabirali praktične didaktične izkušnje tudi tako, da bodo pomagali pri izvedbi poletnih šol za dijake in osnovnošolce, vodili računalniške krožke, pripravljali osnovnošolce na tekmovanje Računalniški bober in podobno.

Content (Syllabus outline):

The goal of the course is to train the future teachers for teaching algorithmic thinking. The approach is based on principles described on http://csunplugged.org. Concrete illustrations will roughly follow the list of topics proposed in the IEEE/ACM K12 curriculum for computer science:

- binary presentation of data, representation of images and sound,
- data compression, information theory, error detection,
- cryptography,
- searching algorithms, sorting algorithms,
- routing and deadlock, finite state automata, and algorithms on graphs

and others.

Besides these concrete examples, students will learn about general didactical principles that need to be observed when teaching algorithmic thinking.

In addition to practice classes in partner schools under appropriate supervision, the students will gain practical experience by helping in the summer schools at the faculty, by teaching computer groups at schools, preparing school children for the international Bebras competition *etc*.

Temeljni literatura in viri / Readings:

1. O. Hazzan, T. Lapidot, N. Ragonis: Guide to Teaching Computer Science: An Acticity-Based Approach, Springer, 2011.
2. T. Bell, I. H. Witten, M. Fellows: Computer Science Unplugged, http://csunplugged.org/sites/default/files/activity_pdfs_full/CS_Unplugged-en-10.2006.pdf, 2006.
3. R. Sedgewick, K. Wayne: Algorithms, 4th edition. Addison-Wesley, 2011.

Cilji in kompetence:

Slušatelji bodo na teoretičnem nivoju in prek praktičnih primerov osvojili primeren način za

Objectives and competences:

Students will learn, both theoretically and through concrete examples, how to teach algorithmic

poučevanje algoritmičnega razmišljanja v osnovnih in srednjih šolah.	thinking using methods that are appropriate for primary and high schools.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Študenti bodo razumeli osnove računalniške znanosti (od kodiranja ter algoritmov in podatkovnih struktur do bolj specifičnih tem) na intuitivnejšem nivoju.	Students will understand the basics of computer science (from coding to algorithms and data structures to more specific topics) in a more intuitive way.
Zmožni bodo uporabiti to globje razumevanje za poučevanje računalništva na razumljivejši in privlačnejši način.	They will be able to apply this deeper understanding of CS to teach computer science in an approachable and attractive way.
Naučili se bodo pripravljati učne aktivnosti, opazovati reakcije ciljne publike, analizirati in ocenjevati aktivnosti ter jih izboljševati.	They will learn how to prepare teaching activities, observe reactions of target audience, analyse and evaluate the activity and improve it.
Študenti bodo spoznali osnove psihologije s poudarkom na razvojni psihologiji in to uporabljali pri svojem poučevanju.	Students will gain basic understanding of psychology, in particular developmental psychology, and apply it to their teaching practice.
Z nekaj treninga v govorjenju in predstavljanju bodo študenti postali sposobnejši javno podajati računalniško znanost različnim ciljnim občinstvom.	With some training in speaking and presentation, students will be more capable to give public presentations of computer science to different target audiences.
Kot potencialni bodoči učitelji bodo poznali in razumeli pasti rigidnih taksonomij, kot je Bloomova taksonomija -- ki je znana kot neprimerna za računalniško znanost -- in njihovih uporabi za birokratizacijo šolstva, ter se izogibali njeni uporabi za načrtovanje, analizo in ocenjevanje svojega dela.	As potential future teachers, students will know and understand the pitfalls of rigid taxonomies like the Bloom taxonomy - which is known to be a particularly bad fit for CS -- and its application for bureaucratization of school system, and hence avoid its use for planning, analysis and evaluation of their work.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja in domače naloge. Poseben poudarek je na intuitivnem razumevanju snovi in na pridobivanju praktičnih pedagoških izkušenj.	Lectures and homeworks with special emphasis on intuitive understanding and gaining practical experience.

Delež (v %) /

Načini ocenjevanja:	Weight(in %)	**Assessment:**
Način (pisni izpit, ustno izpraševanje, naloge, projekt): **Sprotno preverjanje** (domače naloge, praktično delo) **Končno preverjanje** (pisni izpit) Ocene: 6-10 pozitivno, 5 negativno (v skladu s Statutom UL).	**50%** **50%**	Type (examination, oral, coursework, project): **Continuing** (homework, practical work) **Final** (written exam) Grading: 6-10 pass, 5 fail (according to the rules of University of Ljubljana).

Reference nosilca / Lecturer's references:

Pet najpomembnejših del:

1. DEMŠAR, Janez. Algorithms for subsetting attribute values with Relief. Mach. learn.. [Print ed.], Mar. 2010, vol. 78, no. 3, str. 421-428, graf. prikazi. [COBISS.SI-ID 7550548], [JCR, WoS, št. citatov do 9. 3. 2010: 0, brez avtocitatov: 0, normirano št. citatov: 0]
2. ŠTAJDOHAR, Miha, MRAMOR, Minca, ZUPAN, Blaž, DEMŠAR, Janez. FragViz : visualization of fragmented networks. BMC bioinformatics, 2010, vol. 11, str. 1-14, ilustr. [COBISS.SI-ID 7964756], [JCR, WoS, št. citatov do 6. 10. 2011: 1, brez avtocitatov: 1, normirano št. citatov: 1]
3. ZUPAN, Blaž, DEMŠAR, Janez. Open-source tools for data mining. Clin. lab. med., 2008, vol. 28, no. 1, str. 37-54, ilustr. [COBISS.SI-ID 6280532], [JCR, WoS, št. citatov do 6. 9. 2011: 2, brez avtocitatov: 2, normirano št. citatov: 1]
4. DEMŠAR, Janez, LEBAN, Gregor, ZUPAN, Blaž. FreeViz-An intelligent multivariate visualization approach to explorative analysis of biomedical data. Journal of biomedical informatics, 2007, vol. 40, no. 6, str. 661-671, ilustr. [COBISS.SI-ID 6188116], [JCR, WoS, št. citatov do 9. 3. 2010: 2, brez avtocitatov: 2, normirano št. citatov: 2]
5. DEMŠAR, Janez. Statistical comparisons of classifiers over multiple data sets. J. mach. learn. res.. [Print ed.], Jan. 2006, vol. 7, str. [1]-30, graf. prikazi. [COBISS.SI-ID 5134420], [JCR, WoS, št. citatov do 6. 11. 2011: 365, brez avtocitatov: 365, normirano št. citatov: 412]

Celotna bibliografija je dostopna na SICRISu:

http://sicris.izum.si/search/rsr.aspx?opt=1&lang=slv&id=9383.

Nosilec je objavil tudi več kot 60 strokovnih člankov v revijah Programer in Monitor. Ti članki obravnavajo teme s podobno vsebino in v podobni obliki, kot jo predvideva pričujoči predmet.

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**
Magistrski študijski program druge stopnje Računalništvo in informatika Interdisciplinarni magistrski študijski program druge stopnje Računalništvo in matematika Interdisciplinarni magistrski študijski program druge stopnje Pedagoško računalništvo in informatika	ni smeri	1	poletni
Master study program Computer Science and Informaticss, level 2 Interdisciplinary Master study program Computer Science and Mathematics, level 2 Interdisciplinary Master study program Computer Science Education, level 2	none	1	spring

Vrsta predmeta / Course type	**obvezni predmet / compulsory course**
Univerzitetna koda predmeta / University course code:	63508

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

Nosilec predmeta / Lecturer:	doc. dr. Tomaž Dobravec

Jeziki / Languages:	**Predavanja / Lectures:**	slovenščina in angleščina Slovene and English
	Vaje / Tutorial:	slovenščina in angleščina Slovene and English

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites:**
Osnovno znanje algoritmov in podatkovnih struktur.	Basic knowledge of algorithms and data structures.

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

domačih nalog sproti obdelali še manjkajoče predznanje.	

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:	**Objectives and competences:**
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, • poznavanje vloge predpostavk pri razvoju učinkovitih algoritmov, • učinkovito iskanje prostorskih podatkov,	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 efficient algorithms,

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

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

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**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:

Pet najpomembnejših del/ Five most important works:

KLOBOVES, Klemen, MIHELIČ, Jurij, BULIĆ, Patricio DOBRAVEC, Tomaž. FPGA-Based SIC/XE Processor and Supporting Toolchain. International Journal of Engineering Education, 2017, vol. 33, no. 6(A), pp. 1927–1939

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, 2015, vol. 23, no. 1, pp. 137-146

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, 2013, vol. 65, no. 2, pp. 978-996

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, pp. 226-244

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Diskretna matematika
Course title:	Discrete mathematics

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Magistrski študijski program druge stopnje Računalništvo in informatika	ni smeri	1, 2	poletni
Master study program Computer and Information Science, level 2	none	1, 2	spring

Vrsta predmeta / Course type	**strokovni izbirni predmet / specialist elective course** Algoritmika / Algorithmics Računske metode / Computational methods
Univerzitetna koda predmeta / University course code:	63532

Predavanja **Lectures**	**Seminar** **Seminar**	**Vaje** **Tutorial**	**Klinične vaje** **Laboratory work**	**Druge oblike študija** **Field work**	**Samost. delo** **Individ. work**	**ECTS**
45	/	30	/	/	105	6

Nosilec predmeta / Lecturer:	prof. dr. Gašper Fijavž	
Jeziki / Languages:	**Predavanja / Lectures:**	slovenščina in angleščina Slovene and English
	Vaje / Tutorial:	slovenščina in angleščina Slovene and English

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites:**

Vsebina:

1. Povezanost grafov in dekompozicije, bloki, 3-povezane komponente, povečanje povezanosti.
2. Mengerjev izrek, Hallov izrek, pretoki, Ford-Fulkersonov izrek, prirejanja.
3. Ravninski grafi, 5-barvanje, različna barvanja ravninskih grafov, postopek prenosa naboja.
4. Drevesna dekompozicija in drevesna širina grafov, igra policajev in roparja, grafi z omejeno drevesno širino.
5. Posebni razredi grafov, lastnosti, razpoznavanje, optimizacija.
6. Problemi na usmerjenih grafih.
7. Grafovski minorji, problem disjunktnih poti.
8. Računska geometrija: algoritmi pometanja.
9. Osnovni problemi z mnogokotniki. Triangulacije mnogokotnikov.
10. Voronoievi diagrami in Delaunayeve triangulacije.

Content (Syllabus outline):

1. Graph connectivity, decompositions, blocks, 3-connected components.
2. Menger and Hall theorems, flows, Ford-Fulkerson theorem, matchings.
3. Planar graphs, 5-colorings, colorings of planar graphs, discharging algorithms.
4. Tree decompositions and tree width, cops and robbers game, graphs with bounded tree width.
5. Graph classes, properties, recognition, optimization.
6. Problems on directed graphs.
7. Graph minors, disjoint paths problems.
8. Computational geometry, sweeping algorithms.
9. Basic problems on polygons, triangulation.
10. Voronoi diagrams, Delaunay triangulations.

Temeljni literatura in viri / Readings:

1. M. de Berg, O. Cheong, M. van Kreveld, M. Overmars,Computational Geometry: Algorithms and Applications, Springer Verlag, 2008.
2. S. Even, Graph Algorithms, CS Press, 1979.
3. G. Valiente, Algorithms on trees and graphs, Springer Verlag, 2002.
4. G. Fijavž, Discrete mathematics, Ljubljana, 2014, http://matematika.fri.uni-lj.si/dm/dm.pdf.

Cilji in kompetence:

Objectives and competences:

Možnost definiranja, razumevanja in reševanja kreativnih strokovnih nalog iz področja računalništva in informatike. Zmožnost strokovne komunikacije v materinem in tujem jeziku. Cilj predmeta je poglobiti znanje iz teorije grafov v povezavi z algoritmi na grafih. Del tečaja je namenjen geometrijskim konfiguracijam, ki jih ravno tako študiramo z algoritmičnega stališča.	The ability to define, understand and solve creative professional challenges in computer and information science; The ability of professional communication in the native language as well as a foreign language. Major part of the course is devoted to graph theory emphasizing on graph algorithms. In part the course covers problems in geometric configurations, again focusing on the algorithmic perspective.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Po uspešnem zaključku predmeta bo študent: - uporabljal algoritme za izračun pretokov pri iskanju velikih disjunktnih družin poti v grafih, - razumel pojem povezanosti grafa in poznal lastnosti in strukture, ki jih porodi vse večja povezanost grafa, - razumel in znal implementirati postopke prenosa naboja v ravninskih grafih, - razumel koncept seznamskega barvanja grafa z uporabo na ravninskih grafih, - obvladal razpoznavanje in reševanje nekaterih težkih optimizacijskih problemov v posebnih razredih grafov, - poznal in razumel nekaj dinamičnih algoritmov za težke probleme na grafih omejene drevesne širine, - razumel in uporabljal Delaunayave triangulacije in Voronoieve diagrame kot primera geometrijskih diskretnih struktur.	After the completion of the course a student will be able to: - use flow algorithms for lookig for large families of disjoint paths in graphs, - understand the notion of graph connectivity and know properties and structures that follow from incresing connectivity in graphs, - understand and implement discharging algorithms in planar graphs, - understand the concept of list coloring and its usage in the class of planar graphs, - be able to recognize and solve several computationally hard problems in special graph classes, - understand several dynamical algoriths for hard problems on graphs of bounded treewidth,

	- understand and use Delaunay triangulations and Voronoi diagrams as examples of geometric discrete structures.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja in vaje z reševanjem problemov, problemske domače naloge. Domače naloge so delno časovno nezahtevne in služijo za utrjevanje snovi. Delno pa so lahko domače naloge tudi manjši projekti, ki jih študentje izdelajo v majhnih skupinah in so časovno bolj zahtevne.	Lectures and exercise groups, homework assignments. Frequent homework assignments shall not be time consuming. Some of the homework assignments will be more demanding – projects – which may be distributed to students divided in groups.

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

Reference nosilca / Lecturer's references:

1. FIJAVŽ, Gašper, WOOD, David Richard. Graph minors and minimum degree. The Electronic journal of combinatorics, ISSN 1077-8926. [Online ed.], 2010, vol. 17, no. 1, r151 (30 str.).

2. DUJMOVIĆ, Vida, FIJAVŽ, Gašper, JORET, Gwenaël, SULANKE, Thom, WOOD, David Richard. On the maximum number of cliques in a graph embedded in a surface. European journal of combinatorics, ISSN 0195-6698, 2011, vol. 32, no. 8, str. 1244-1252.

3. ALAM, Muhammad Jawaherul, CHAPLICK, Steven, FIJAVŽ, Gašper, KAUFMANN, Michael, KOBOUROV, Stephen G., PUPYREV, Sergey. Threshold-coloring and unit-cube contact representation of graphs. V: BRANDSTÄDT, Andreas (ur.), JANSEN, Klaus (ur.), REISCHUK, Rüdiger (ur.). Graph-theoretic concepts in computer science : 39th International Workshop, WG 2013, Lübeck, Germany, June 19-21, 2013 : revised

papers, WG 2013, 39th International Workshop on Graph-Theoretic Concepts in Computer Science, June 19 - 21, 2013, Lübeck, Germany, (Lecture notes in computer science, ISSN 0302-9743, 8165). Heidelberg [etc.]: Springer. cop. 2013, str. 26-37.

4. FIJAVŽ, Gašper, PISANSKI, Tomaž, RUS, Jernej. Strong traces model of self-assembly polypeptide structures. MATCH Communications in Mathematical and in Computer Chemistry, ISSN 0340-6253, 2014, vol. 71, no. 1, str. 199-212.

5. FIJAVŽ, Gašper, NAKAMOTO, Atsuhiro. Odd complete minors in even embeddings on surfaces. Discrete Mathematics, ISSN 0012-365X. [Print ed.], 2016, vol. 339, iss. 1, str. 165-178.

Celotna bibliografija je dostopna na SICRISu:

http://www.sicris.si/search/rsr.aspx?lang=slv&id=9390.

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Komunikacija človek računalnik
Course title:	Human-Computer Interaction

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Magistrski študijski program druge stopnje Računalništvo in informatika Interdisciplinarni magistrski študijski program druge stopnje Multimedija	ni smeri	1, 2	zimski
Master study program Computer and Information Science, level 2 Interdisciplinary Master study program Multimedia, level 2	none	1, 2	fall

Vrsta predmeta / Course type	**strokovni izbirni predmet / specialist elective course** Tematski sklopi / Thematic set: Programska oprema / Software FRI 1 / FRI 1 FRI A / FRI A FRI B / FRI B
Univerzitetna koda predmeta / University course code:	63550

Predavanja **Lectures**	**Seminar** **Seminar**	**Vaje** **Tutorial**	**Klinične vaje** **Laboratory work**	**Druge oblike študija** **Field work**	**Samost. delo** **Individ. work**	**ECTS**
45	/	30	/	/	105	6

Nosilec predmeta / Lecturer:	prof. dr. Franc Jager

Jeziki / Languages:	**Predavanja / Lectures:**	angleščina in slovenščina / English and Slovene
	Vaje / Tutorial:	angleščina in slovenščina English and Slovene

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisits:**

Vsebina:	**Content (Syllabus outline):**
Predavanja: 1. Sposobnosti človeka (spomin in učenje, zaznavanje, poznavanje). 2. Vrste komunikacije človek računalnik (KČR) (vhodni modeli, izhodni modeli). 3. Pravila načrtovanja za KČR (principi, navodila). 4. Vzorec model-pogled-nadzornik. 5. Glasovni vmesniki. 6. Komunikacija možgani računalnik in elektroencefalogram. 7. Načrtovanje neinvazivnega vmesnika možgani računalnik (VMR). 8. Mednarodna referenčna podatkovna baza za načrtovanje VMR (EEGMMI DS - EEG Motor Movement/Imagery DataSet). 9. Izločanje časovno prostorskih značilk. 10. Spektralna analiza (časovno frekvenčne predstavitve, parametrično modeliranje). 11. Klasifikacija časovno prostorskih značilk. 12. VMR s strojnim učenjem. 13. VMR aplikacije (pomikanje kurzorja, črkovanje, komunikacija za hendikepirane). **Vaje**:	**Lectures:** 1. Human capabilities (memory and learning, perception, cognition). 2. Human-Computer Interaction (HCI) types (input models, output models). 3. Design rules for HCI (principles, guidelines). 4. Model-view-controler pattern. 5. Voice interfaces. 6. Brain-computer interaction and electroencephalogram. 7. Design of non-invasive Brain-Computer Interface (BCI). 8. International reference database to design BCI (EEGMMI DS - EEG Motor Movement/Imagery DataSet). 9. Extraction of spatio-temporal features. 10. Spectral analysis (time-frequency representations, parametric modeling). 11. Classification of spatio-temporal features. 12. 13. BCI with machine learning. 14. BCI applications (cursor moving, spelling, communication for the disabled). **Practical work:**

1. Utrjevanje pri predavanjih obravnavane snovi s primeri. 2. Predstavitev tipičnih aspektov načrtovanja aplikacij KČR. **Domače naloge:** Študentje izdelajo tri projekte oziroma aplikacije in vsakega od njih zagovarjajo učitelju. Te projekte lahko študentje opravljajo tudi pri vajah ob pomoči učitelja.	1. Strenghtening of topics from lectures with examples. 2. Representing typical aspects of design of HCI applications. **Homeworks:** Students derive three projects or aplications and each of them has to be defened to teacher. These projects can be derived at laboratory work under teacher supervision.

Temeljna literatura in viri / Readings:

1. Norman K L: Cyberpsychology: *An Introduction to Human-Computer Interaction*, 2008, Cambridge.
2. Norman D A: *The Design of Everyday Things*, 2002, Basic Books.
3. Erickson, McDonald: *HCI Remixed; Essay on Work that Have Influenced the HCI Community*, 2008, The MIT Press.
4. Cooper, Reimann, Cronin: *About Face 3; The Essentials of Interface Design*, 2007, Wiley Publishing, Inc.
5. Benyon, *Designing Interactive Systems; A comprehensive guide to HCI and interaction design*, 2010, Addison Wesley.
6. Sornmo, Laguna: *Biological Signal Processing in Cardiac and Neurological Applications*, 2005, Elsevier, Inc.
7. Sanei, Chambers: *EEG Signal Processing*, 2007, Wiley.
8. Stone, Jarett, Woodroffe, Minocha: *User Interface Design and Evaluation* 2005, Morgan Kaufmann.
9. Selected articles from journals (Schalk, McFarland, Hinterberger, Birbaumer, Wolpaw: BCI2000: *A General-Purpose Brain-Computer Interface (BCI) System,* IEEE TBME, Vol. 51, No. 6, pp. 1034-1043, June 2004.; Wolpaw, McFarland: *Control of a two-dimensional movement signal by a noninvasive brain-computer interface in humans,* PNAS, Vol. 101, No 51, pp. 17849-17854, Dec. 2004.)

Cilji in kompetence:	**Objectives and competences:**
Cilj predmeta je podati splošni vpogled v področje interakcije med človekom in računalnikom. Študentje naj razumejo širok razpon konceptov pri komunikaciji med človekom in računalnikom ter naj so sposobni uporabiti principe, navodila in tehnike načrtovanja za: načrtovanje interaktivnih aplikacij in uporabniških vmesnikov, s posebnim poudarkom na komunikaciji možgani računalnik, za njihovo analizo in evaluacijo.	The goal of the subject is to give common view into the field of interaction between human and computer. Students should understand wide range of concepts in comunication between human and computer, and should be able to use principles, guidelines and designing techniques to design interactive aplications and user interfaces, with special emphasis on brain computer interaction, and to analyse and evaluate them.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Po uspešnem zaključku tega predmeta naj bi bili študenti zmožni:	After the completion of the course, students should be able to:
- poznati osnovne koncepte komunikacije človek računalnik,	- know the basic concepts of human-computer interaction,
- poznati koncepte interakcije, principe, navodila in postopke načrtovanja interaktivnih aplikacij ter uporabniških vmesnikov,	- know the concepts of interactions, principles, guidelines and procedures of designing interactive applications and user interfaces,
- poznati postopke vrednotenja vmesnikov,	- know the procedures for evaluation the interfaces,
- prepoznati slabo in dobro načrtane uporabniške vmesnike in interaktivne aplikacije,	- recognize badly and well designed user interfaces and interactive applications,
- načrtati uporabniške vmesnike in interaktivne aplikacije,	- design user interfaces and interactive applications,
- vrednotiti uporabniške vmesnike in interaktivne aplikacije,	- evaluate user interfaces and interactive applications,
- analizirati in avtomatsko klasificirati možganske valove,	- analyze and automaticaly classify brain waves,
- načrtati vmesnik možgani računalnik.	- design human-computer interface.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja, vaje z ustnimi zagovori, domače naloge. Poseben poudarek je na sprotnem študiju in na samostojnem delu pri vajah in domačih nalogah.	Lectures, practical work with oral defences, homeworks. Special emphasis on continuous and prompt study, and independent practical work and homeworks.

Delež (v %) /

Načini ocenjevanja:	Weight (in %)	**Assessment:**
Način (pisni izpit, ustno izpraševanje, naloge, projekti): **Sprotno** (domače naloge, kolokviji in projektno delo) **Končno** (pisni in ustni izpit) Ocene: 6-10 pozitivno, 5 negativno (v skladu s Statutom UL).	**50%** **50%**	Type (written exam, oral examination, coursework, projects): **Continuing** (homeworks, midterm exams, project work) **Final:** (written and oral exam) Grading: 6-10 pass, 5 fail (According to the rules of University of Ljubljana).

Reference nosilca / Lecturer's references:

Pet najpomembnejših del:

1. AMON, Miha, JAGER, Franc. Electrocardiogram ST-segment morphology delineation method using orthogonal transformations. *PloS one*, Vol. 11, no. 2, str. 1-18, 2016. http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0148814, doi: 10.1371/journal.pone.0148814.
2.JAGER, Franc. Two chapters in *Advanced Methods and Tools for ECG Data Analysis*, Clifford G, Azuaje F, McSharry PE (editors), Artech House, Inc., 2006.
3.JAGER, Franc, TADDEI, Alessandro, MOODY, George B., EMDIN, Michele, ANTOLIČ, Gorazd, DORN, Roman, SMRDEL, Aleš, MARCHESI, Carlo, MARK, Roger G. Long-term ST database: a reference for the development and evaluation of automated ischaemia detectors and for the study of the dynamics of myocardial ischaemia. *Med. biol. eng. Comput.,* Vol. 41, str. 172-182, 2003.
4. DORN, Roman, JAGER, Franc. Semia: semi-automatic interactive graphic editing tool to annotate ambulatory ECG records. *Comput. methods programs biomed*. Vol. 75, no. 3, str. 235-249, 2004.
5. JAGER, Franc, MOODY, George B., MARK, Roger G. Protocol to assess robustness of ST analysers : a case study. *Physiological measurement* Vol. 25, no. 3, str. 629-643, 2004.

Celotna bibliografija je dostopna na SICRISu:

http://sicris.izum.si/search/rsr.aspx?lang=slv&id=4815.

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Obdelava biomedicinskih signalov in slik
Course title:	Biomedical signal and image processing

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Magistrski študijski program druge stopnje Računalništvo in informatika Interdisciplinarni magistrski študijski program druge stopnje Računalništvo in matematika	ni smeri	1, 2	zimski
Master study program Computer and Information Science, level 2 Interdisciplinary Master study program Computer Science and Mathematics, level 2	none	1, 2	fall

Vrsta predmeta / Course type	**strokovni izbirni predmet /specialist elective course** Umetna inteligenca / Artificial intelligence Strojna oprema / Hardware Medijske tehnologije / Media technologies
Univerzitetna koda predmeta / University course code:	63514

Predavanja **Lectures**	**Seminar** **Seminar**	**Vaje** **Tutorial**	**Klinične vaje** **Laboratory work**	**Druge oblike študija** **Field work**	**Samost. delo** **Individ. work**	**ECTS**
45	/	30	/	/	105	6

Nosilec predmeta / Lecturer:	prof. dr. Franc Jager

Jeziki / Languages:	**Predavanja / Lectures:**	slovenščina in angleščina Slovene and English
	Vaje / Tutorial:	slovenščina in angleščina Slovene and English

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites:**

Vsebina:	**Content (Syllabus outline):**
Predavanja: • Predstavitev biomedicinskih signalov in slik kot so: kardiološki signali (EKG), nevrofiziološki signali (EEG, EMG), medicinske slike (CT, MRI, ultrazvok) ter predstavitev modernih računalniških tehnologij v izbranih kliničnih okoljih. • Mednarodne standardizirane referenčne podatkovne baze medicinskih vzorcev (MIT/BIH DB, LTST DB, TPEHG DB, EEGMMI DS, Internetni strežniki). • Izločanje značilk (časovni prostor, Fourierjeva transformacija, valčki, principalne komponente – transformacija Karhunena in Loeveja, predstavitve značilk). • Izločanje motenj (linearni postopki v časovnem prostoru, postopki v prostorih značilk, uteženo povprečenje, robustni pristopi). • Spektralna analiza ter karakterizacija vzorcev in značilk (časovno frekvenčne predstavitve, prostori diagnostičnih in morfoloških značilk). • Analiza časovnih vrst in nestacionarnih signalov.	**Lectures:** • Introduction to biomedical signals and images like: electrocardiographic signals (ECG), neurophysiological signals (EEG, EMG), medical images (CT, MRI, ultrasound) and introduction to modern computer technologies in selected clinical settings. • International standardized reference databases of medical samples (MIT/BIH BD, LTST DB, TPEHG DB, EEGMMI DS, Internet servers). • Feature extraction (time domain, Fourier transform, wavelets, principal components – Karhunen-Loeve transform, feature representations). • Noise extraction (linear procedures in time domain, feature space procedures, weighted averaging, robust approaches). • Spectral analysis and characterization of samples and features (time-frequency representations, spaces of diagnostic and morphologic features). • Analysis of time series and nonstationary signals. • Modelling (linear stochastic and non-linear models, autoregressive modelling).

- Modeliranje (linearni naključni in nelinearni modeli, avtoregresivno modeliranje).
- Odkrivanje dogodkov, rojenje in klasifikacije (tehnike v časovnem prostoru in prostoru značilk).
- Procesiranje slik in 3-dimenzionalnih CT ter MRI slik z namenom redukcije motenj, izločanja kontur ter segmentacije in vizualizacije anatomskih struktur.
- Vrednotenje zmogljivosti biomedicinskih računalniških sistemov (metrike, protokoli, napovedovanje zmogljivosti v realnem svetu, ocene robustnosti, standardi).

Vaje: Vaje bodo potekale v obliki projektnega dela v primerno opremljenih študentskih laboratorijih. Študentje v okviru projektov samostojno implementirajo postopke. Obvezno delo na projektih omogoča poglobljeno in kritično razumevanje obravnavane snovi in spodbuja k samostojnosti in kreativnosti.

- Event detection, clustering and classification (techniques in time domain and in feature space).
- Image processing and processing of 3-dimensional CT and MRI images with the aim of noise reduction, conture extraction, and segmentation and visualization of anatomical structures.
- Performance evaluation of biomedical computer systems (metrics, protocols, predictioning performance in real world, assessing robustness, standards).

Laboratory work:

Practical work will be performed in the form of project work in suitable equipped student laboratories. Students in the scope of projects independently implement procedures. Obligatory work on projects allows deepen and critical understanding of the subject topics and stimulates to independence and creativity.

Temeljni literatura in viri / Readings:

1.) Kayvan Najarian, Robert Splinter, Biomedical Signal and Image Processing, CRC Press., 2012.
2.) Advanced Methods and Tools for ECG Data Analysis, Clifford G, Azuaje F, McSharry PE (editors), Artech House, Inc., 2006.
3.) Sornmo L, Laguna P, Biological Signal Processing in Cardiac and Neurological Applications, Elsevier, Inc., 2005
4.) Gonzales Rafael C., Woods Richard E. Digital Image Processing, Pearson Prentice Hall., 2008.
5.) Selected articles from journals: IEEE Transactions on Biomedical Engineering, Medical and Biological Engineering and Computing, Physiological Measurements, PLOS ONE.

Cilji in kompetence:

Cilj predmeta je študentom računalništva in informatike predstaviti osnovne obdelave biomedicinskih signalov in slik s poudarkom na problemih biomedicinskih raziskav in klinične medicine. Predmet pokriva principe in postopke za obdelavo determinističnih signalov, naključnih signalov in slik. Teme pokrivajo zajemanje signalov, standardizirane podatkovne baze vzorcev signalov, filtriranje, izločanje značilk, vizualizacijo, spektralno

Objectives and competences:

Objectives of the course are to represent students of computer and information science the basics of biomedical signal and image processing with the emphasis on the problems of biomedical researches and clinical medicine. The course covers principles and procedures for processing of deterministic signals, stochastic signals and images. The course topics cover signal acquisition, standardized databases of signal samples, filtering, feature

analizo, modeliranje, odkrivanje dogodkov, rojenje, klasifikacije, analizo slik in vrednotenje zmogljivosti avtomatskih postopkov. **Kompetence:** Sposobnost definiranja, razumevanja in reševanja kreativnih profesionalnih izzivov v računalništvu in informatiki; sposobnost prenosa znanj in pisnih veščin v materinem jeziku kot tudi tujem jeziku; sposobnost uporabe pridobljenega znanja za samostojno delo pri reševanju tehničnih in znanstvenih problemov v računalništvu in informatiki; sposobnost nadgrajevanja pridobljenega znanja; sposobnost razumevanja in uporabe znanj računalništva in informatike na drugih tehničnih in relevantnih področjih.	extraction, visualization, spectral analysis, modelling, event detection, clustering, classification, image analysis and performance evaluation of automatic procedures. **Competences:** The ability to define, understand and solve creative professional challenges in computer and information science; The ability of knowledge transfer and writing skills in the native language as well as a foreign language; The ability to apply acquired knowledge in independent work for solving technical and scientific problems in computer and information science; The ability to upgrade acquired knowledge; The ability to understand and apply computer and information science knowledge to other technical and relevant fields.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Po uspešnem zaključku tega predmeta naj bi bili študenti zmožni: - poznati računalniške tehnologije in avtomatske postopke analize biomedicinskih signalov in slik za razvoj avtomatskih analizatorjev v pomoč pri diagnosticiranju, - analizirati biomedicinske signale (elektrokardiogram, elektromiogram in elektroencefalogram) v frekvenčnem prostoru, - razviti algoritme za odkrivanje in klasifikacijo dogodkov v biomedicinskih signalih, - analizirati biomedicinske 2D in 3D tomografske slike,	After the completion of the course, students should be able to: - know computer technologies and automatic procedures of biomedical signal and image analysis to develop automatic analyzers in help to diagnose, - analyze biomedical signals (electrocardiogram, electromyogram, electroencephalogram) in frequency domain, - develop algorithms for detecting and classifying events in biomedical signals, - analyze biomedical 2D and 3D tomography images,

- razviti algoritme za izločanja kontur ter segmentacijo in vizualizacijo anatomskih struktur v tomografskih slikah, - vrednotiti zmogljivost in robustnost biomedicinskih računalniških sistemov.	- develop algorithms for conture extraction, and segmentation and visualization of anatomic structures in tomographic images, - evaluate performance and robustness of biomedical computer systems.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja, vaje z aktivnim sodelovanjem, seminarski način dela pri individualnih projektih. Poseben poudarek je pri sprotnem študiju in sprotnem delu pri vajah in seminarjih.	Lectures, laboratory work with active cooperation, seminar type of work on individual projects. Special emphasize is given to prompt study and prompt work on laboratory work and seminars.

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

Reference nosilca / Lecturer's references:

Pet najpomembnejših del:

1. AMON, M, JAGER, F. Electrocardiogram ST-segment morphology delineation method using orthogonal transformations. PloS one, Vol. 11(2), pp. 1-18, 2016.
2. TROJNER-BREGAR, A, LUČOVNIK, M, VERDENIK, I, JAGER, F, GERŠAK, K, GARFIELD, R. Uterine electromyography during active phase compared with latent phase of labor at term. Acta obstetricia et gynecologica Scandinavica, Vol. 95(2), pp. 197-202, 2016.
3. PANGERC, U, JAGER, F. Robust detection of heart beats in multimodal records using slope- and peak-sensitive band-pass filters. Physiological measurement, Vol. 36(8), pp. 1645-1664, 2015.
4. JAGER, F. Two chapters in Advanced Methods and Tools for ECG Data Analysis, G. Clifford, F. Azuaje, P.E. McSharry (editors), Artech House, Inc. 2006.

5. JAGER, F, TADDEI, A. MOODY G B, EMDIN, M, ANTOLIČ, G, DORN R, SMRDEL A, MARCHESI, C, MARK, R G. Long-term ST database: a reference for the development and evaluation of automated ischaemia detectors and for the study of the dynamics of myocardial ischaemia. Med. Biol. Eng. Comput., Vol. 41, pp.172-182, 2003.

Celotna bibliografija je dostopna na SICRISu: http://sicris.izum.si/search/rsr.aspx?lang=slv&id=4815.

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Management proizvodnih in storitvenih procesov
Course title:	Operations management

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Magistrski študijski program druge stopnje Računalništvo in informatika	**ni smeri**	**1, 2**	**zimski**
Master study program Computer and Information Science, level 2	**none**	**1, 2**	**fall**

Vrsta predmeta / Course type	**strokovni izbirni predmet / specialist elective course** Programska oprema / Software
Univerzitetna koda predmeta / University course code:	63533

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

Nosilec predmeta / Lecturer:	prof. dr. Matjaž Branko Jurič	
Jeziki / Languages:	**Predavanja / Lectures:**	slovenščina in angleščina Slovene and English
	Vaje / Tutorial:	slovenščina in angleščina Slovene and English

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites:**

Vsebina:	**Content (Syllabus outline):**
1. Strateški okvir odločanja o proizvodnih in storitvenih procesih (konkurenčne prednostne naloge, strateški vzvodi) 2. Analiza procesov (Littlov zakon, analiza zmogljivosti procesov) 3. Teorija repov in management zmogljivosti (obvladovanje stohastičnosti, vzvodi obvladovanja časa čakanja strank) 4. Sistem planiranja in kontrole izdelavne proizvodne ali storitvene poslovne funkcije v podjetju: predvidevanje povpraševanja; dolgoročno planiranje fiksnih zmogljivosti; mesečno planiranje izdelave; operativno planiranje izdelave; uravnavanje zalog povezanih z neodvisnim povpraševanjem; uravnavanje zalog povezanih z odvisnim povpraševanjem; izvajanje izdelave in kontrola izvajanja. 5. Ravno ob pravem času (JIT) v procesih (opredelitev JIT, elementi JIT) 6. Obvladovanje kakovosti (zunanji in notranji vidik kakovosti, vgrajevanje kakovosti (QFD), sposobnost procesa, neprekinjeno izboljševanje) 7. Reinženiring poslovnih procesov (opredelitev, faze reinženiringa poslovnih procesov)	1. Strategic framework for decisions about manufacturing processes (competitive priority tasks, strategic levers). 2. Process analysis (Little's law, capacity analysis of processes) 3. Theory of tails and capacity management (stochastic management, levers for management of client waiting time) 4. Planning and control system of manufacturing business function: demand forecasting, long-term planning of fixed capacity, monthly production planning, operational production planning, stock balancing associated with independent demand, stock balancing related to dependent demand, manufacturing and control mechanisms. 5. Just in time (JIT) in the processes (definition of JIT, JIT elements) 6. Quality management (external and internal quality view, Quality function deployment, process capability, continuous improvement) 7. Business process reengineering (definition, business process reengineering phases)

Temeljni literatura in viri / Readings:

1. Management izdelavnih procesov, Borut Rusjan (v pripravi – leto izida 2009)
2. Izbrana poglavja iz: Managing Business Process Flows, Anupindi, R. et al., Prentice Hall, Upper Saddle River, 1999.
3. Izbrani članki.
4. Študijski primeri (Michigan Manufacturing Corporation, National Cranberry, Sof-Optics, Toyota, Hank Kolb, Analog Devices).

Cilji in kompetence:

Po uspešnem zaključku predmeta bo študent:

- Razumel možnosti učinkovitega analiziranja in obvladovanja materialnih in informacijskih tokov v proizvodnih in storitvenih procesih.

- Spoznal glavne vzvode (zasnova procesov, obvladovanje variabilnosti, zmogljivosti, zaloge, management kakovosti) za delovanje na ključne kriterije učinkovitosti poslovnih procesov (stroški, kakovost, fleksibilnost, dobava).

- Uporabil koncepte, pristope, orodja, metode in tehnike, uporabne za učinkovito obvladovanje izdelavnih procesov.

- Načrtoval poslovne procese in jih pripravil za izvedbo.

- Razumel pomen avtomatizacije poslovnih proceov.

- Integriral poslovne procese z aplikacijami.

- Razvijal rešitve za digitalno preobrazbo.

Objectives and competences:

After successful completion of the course a student will be able to:

- Understand the possibilities of effective analysis and management of material and information flows in manufacturing processes.

- Know the main levers (establishment of process, management of variability, capacity, inventories, quality management) for the operation of the key efficiency criteria of business processes (cost, quality, flexibility, delivery).

- Apply the concepts, approaches, tools, methods and techniques useful for effective management of manufacturing processes.

- Design business processes and prepare them for implementation.

- Understand the importance of automating business processes.

- Integrate business processes with applications.

- Develop solutions for digital transformation.

Predvideni študijski rezultati:

Znanje in razumevanje: Študent pri predmetu spozna vlogo izdelavne tako proizvodne kot storitvene poslovne funkcije za uspešnejše in učinkovitejše poslovanje podjetja ter dobi pregled metod, pristopov tehnik in konceptov, ki mu pomagajo pri učinkovitejšem organiziranju, planiranju in kontroli izdelave proizvodov in storitev. Študent pridobi poglobljeno znanje o temeljnih odločitvah, ki jih je potrebno sprejemati za učinkovito obvladovanje proizvodnje,

Intended learning outcomes:

Knowledge and understanding: Students understand the role of the manufacturing business function for efficient and effective business and get an overview of methods, approaches, techniques and concepts that can assist in more effective organizing, planning and control of manufacturing. Students acquire an in-depth knowledge of the fundamental decisions that need to be taken to effectively control the production, manage supply chains and the production process for service firms.

obvladovanje delovanja oskrbnih verig in izdelavnega procesa v storitvenih podjetjih. **Uporaba:** Študent se usposobi za ugotavljanje temeljnih problemov v izdelavnem procesu proizvodnih in storitvenih podjetij ter za razvijanje alternativnih rešitev teh problemov. Na podlagi pridobljenega znanja lahko sprejema učinkovite odločitve oblikovanja, obvladovanja in izboljševanja izdelavnih procesov. **Refleksija:** Teoretična načela obvladovanja procesov, ki jih študent pridobi s študijem predmeta, mu omogočajo učinkovitejše razumevanje delovanja različnih procesov, ki se izvajajo pri delovanju različnih združb. **Prenosljive spretnosti - niso vezane le na en** **predmet:** Študent bo osvojil spretnosti uporabe domače in tuje literature in uporabe postopkov analize procesa, planiranja zmogljivosti in obvladovanja zalog, časov čakanja in kakovosti. Študent bo z delom na študijskih primerih razvijal sposobnosti identifikacije in reševanja problemov.	**Application:** Students are qualified to detect underlying problems in the production process of manufacturing and service firms and to develop alternative solutions to these problems. On the basis of the acquired knowledge they can take effective decisions about establishment, management and improvement of this process. **Reflection:** Theoretical principles of process management enable students to better understand the operation of different processes that are performed in various organizations. **Transferable skills:** Students will acquire skills for using domestic and foreign literature and knowledge for process analysis, capacity planning, inventory control, waiting times and quality. Students will develop the ability to identify and solve problems with work on case studies.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja in vaje. Skupinska analiza študijskih primerov. Igre vlog.	Lectures and exercises. Group case study analysis. Playing roles.

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

Reference nosilca / Lecturer's references:

Pet najpomembnejših del:

1. Jurič B.M.: Do more with SOA Integration, PACKT Publishing, December 2011, ISBN ISBN 978-1-84968-572-6
2. Jurič B.M., Chandrasekaran, Frece A. Srdić G., Hertiš M.: S., WS-BPEL 2.0 for SOA Composite Applications with IBM WebSphere 7: define, model, implement, and monitor real-world BPEL 2.0 business processes with SOA-powered BPM. Birmingham: Packt Publishing, cop. 2010. 644 str., ilustr. ISBN 978-1-849680-46-2.
3. Jurič B.M, et. Al: Business process execution language for web services: an architect and developer's guide to orchestrating web services using BPEL4WS. Birmingham: Packt Publishing, 2006. X, 353 str., ilustr. ISBN 1-904811-81-7.
4. Jurič M.B., Šaša A.: WS-BPEL extension for versioning. Inf. softw. technol. [Print ed.], 2009, vol. 51, iss. 8, str. 1261-1274.
5. Jurič M.B.: WSDL and BPEL extensions for event driven architecture. Inf. softw. technol. [Print ed.], 2010, vol. 52, iss. 10, str. 1023-1043, doi: 10.1016/j.infsof.2010.04.005.

Celotna bibliografija je dostopna na SICRISu: http://sicris.izum.si/search/rsr.aspx?lang=slv&id=10545.

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Računalniške storitve v oblaku
Course title:	Cloud Computing

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Magistrski študijski program druge stopnje Računalništvo in informatika Interdisciplinarni magistrski študijski program druge stopnje Multimedija	ni smeri	1, 2 2	zimski
Master study program Computer and Information Science, level 2 Interdisciplinary Master study program Multimedia, level 2	none	1, 2 2	fall

Vrsta predmeta / Course type	**strokovni izbirni predmet/ specialist elective course** Tematski sklopi / Thematic set: Programska oprema / Software Informacijski sistemi in sistemi za upravljanje / Information and management systems Omrežja in varnost / Computer networks and security FRI A / FRI A FRI D / FRI D
Univerzitetna koda predmeta / University course code:	63541

Predavanja **Lectures**	**Seminar** **Seminar**	**Vaje** **Tutorial**	**Klinične vaje**	**Druge oblike študija**	**Samost. delo** **Individ. work**	**ECTS**

			Laboratory work	Field work		
45	20	10	/	/	105	6

Nosilec predmeta / Lecturer:	prof. dr. Branko Matjaž Jurič

Jeziki / Languages:	**Predavanja / Lectures:**	slovenščina in angleščina Slovene and English
	Vaje / Tutorial:	slovenščina in angleščina Slovene and English

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites:**

Vsebina:	**Content (Syllabus outline):**
Razvoj aplikacij, ki se izvajajo na strežnikih Definicija računalništva v oblaku: kaj je računalništvo v oblaku, namen, vloga in pomen, cilji Izzivi: upravljanje infrastrukture, arhitektura aplikacij za oblak, shranjevanje podatkov, varnost, ostali vidiki Lastnosti: samo oskrba na zahtevo, elastičnost in skalabilnost, dostop v obliki storitev, nadzor storitev, souporaba virov (pooling), itd. Storitveni modeli: IaaS (Infrastruktura kor storitev), PaaS (Platforma kot storitev), SaaS (Aplikacije kot storitve), XaaS Podrobni pregled IaaS (Infrastruktura kor storitev) • Pregled konceptov, arhitekturni vidik	Developing applications for the server-side Definition of cloud computing: what is cloud computing, purpose, role and importance, objectives Challenges: Infrastructure Management, Application Architecture for cloud, data storage, security, other aspects Features: on demand self-provisioning, elasticity and scalability, access in the form of services, monitoring, sharing of resources (pooling), etc.. Service models: IaaS (Infrastructure-as-a-Service), PaaS (Platform-as-a-Service), SaaS (Software-as-a-Service), XaaS Detailed overview of IaaS: • Overview of concepts, architectural perspective • Private cloud, public cloud, hybrid cloud, virtual cloud

- Privatni oblak, javni oblak, hibridni oblak, virtualni oblak
- Spoznavanje in primerjava najpomembnejših IaaS tehnologij

Podrobni pregled PaaS (Platforma kot storitev)

- Pregled konceptov, arhitekturni vidik
- Spremembe v razvojnih modelih: Trajno stanje: distribuirani datotečni sistemi, nestrukturirane shrambe, NoSQL baze, SQL baze v oblaku; Poslovna logika: spletne storitve, REST storitve, ostale tehnologije; Izvajalno okolje
- Spoznavanje in primerjava najpomembnejših PaaS tehnologij: Java EE, Azure, Google App Engine, itd.

Podrobni pregled SaaS (Aplikacije kot storitve)

- Pregled konceptov, arhitekturni vidik
- Model dostopa, koncept razvoja
- Poslovni model, storitve v oblaku (lokacijske, dostava podatkov, bogatenje podatkov, integracijske storitve, poslovna inteligenca, itd.)

Namestitveni modeli

- Zasebni, javni, hibridni, skupni oblak
- Na lokaciji, pri ponudniku, hibridni model, pregled ponudnikov

Migracija v oblak

Nadzor, upravljanje, SLA in QoS

Praktični del:

- Vzpostavitev lastnega računalniškega oblaka
- Razvoj aplikacij za oblak
  - Tehnološki vidiki
  - Vsebinsko-poslovni vidiki
- Razvoj inovativnih aplikacij, ki delujejo v oblaku
- Konfiguriranje hibridnega računalniškega oblaka
- Spoznavanje najpomembnejših javnih oblakov: Amazon, Google App Engine, Azure, OpenStack, itd.
- Študija prenosljivost oblačnih rešitev med ponudniki
- Razvoj specifičnih razširitev za oblak

- Getting to know and compare the most important IaaS technologies

Detailed overview of PaaS:

- Overview of concepts, architectural perspective
- Changes in development models: data persistence: distributed file systems, unstructured storage, NoSQL database, SQL database in the cloud; Business tier: Web services, REST services, other technology runtime environment
- Understanding and comparison of major PaaS technologies: Java EE, Azure, Google App Engine, etc.

Detailed overview of SaaS:

- Overview of concepts, architectural perspective
- Access Models, Development Concepts
- Business models, Cloud Services (location, data delivery, data enrichment, integration services, business intelligence, etc.).

Deployment models

- Private, public, hybrid, shared cloud
- On premises, remote, hybrid model, overview of providers

Migration to the cloud

Control, management, SLA and QoS

Practical part:

- Deploying, setting up and configuring your own Cloud
- Developing applications for the cloud
  - Technological aspects
  - Content and business aspects
- Development of innovative applications that run in the cloud
- Configuring a hybrid cloud
- Getting to know the most important public clouds: Amazon, Google App Engine, Azure, OpenStack, etc.
- Portability study between cloud solution providers
- Development of cloud-specific extensions

Temeljni literatura in viri / Readings:

1. Barrie Sosinsky, Cloud Computing Bible, Wiley; 2011.
2. George Reese, Cloud Application Architectures: Building Applications and Infrastructure in the Cloud, O'Reilly Media; 2009.
3. David S. Linthicum, Cloud Computing and SOA Convergence in Your Enterprise, Addison-Wesley Professional, 2009.
4. John Rhoton, Risto Haukioja, Cloud Computing Architected: Solution Design Handbook, Recursive Press, 2011.
5. Matjaz B. Juric et al., Do more with SOA Integration, Packt Publishing, 2011.

Cilji in kompetence:

Cilj predmeta je osvojiti poglobljene znanje in poznavanje področja računalništva v oblaku in vseh nivojev storitvene usmerjenosti (XaaS), osvojiti znanje s področja infrastrukture, platforme in aplikacij v obliki storitev, spoznati načrtovalske vzorce, arhitekturne modele in dobre prakse ter razumeti pomen inovativnih aplikacij v oblaku.

Kompetence:

Študentje bodo sposobni vzpostaviti infrastrukturo za delovanje privatnih, hibridnih in zasebnih oblakov, načrtovati in implementirati arhitekturo platforme PaaS, načrtovati in implementirati aplikacije, ki se izvajajo na PaaS, razumeti specifike oblačnih arhitektur in infrastruktur. Usposobljeni bodo za razvoj SaaS aplikacij na najpomembnejših PaaS/IaaS. Razumeli bodo pomen inovacij v oblaku.

Objectives and competences:

The course objective is to provide an in-depth knowledge and understanding of the scope of cloud computing and all levels of service orientation (XaaS), provide knowledge of infrastructure, platforms, and applications in the form of services, get familiar with design patterns, architectural models and best practices and understand the importance of innovative applications in the cloud.

Competences:

Students will be able to deploy the infrastructure for the operation of private, hybrid and private clouds, to design and implement PaaS platform architecture, design and implement applications that are implemented on PaaS, understand the specifics of cloud architectures and infrastructures. Students will be trained to develop SaaS applications on most important PaaS / IaaS platforms and understand the importance of innovation in the cloud.

Predvideni študijski rezultati:

Po uspešnem zaključku predmeta bo študent:

- razvijal programske rešitve za delovanje v oblaku
- poznal lastnostni javnih in zasebnih oblakov
- razumel infrastrukture in arhitekture računalniških oblakov
- razumel cloud-native arhitekturo in jo uporabil pri razvoju
- obvladal razvoj mikrostoritev

Intended learning outcomes:

After successful completion of the course a student will be able to:

- Develop cloud-based software solutions
- Understand the characteristic public and private clouds
- Understand the infrastructures and architecture of computer clouds
- Understand the cloud-native architecture and use it in the development

- razumel in uporabljal vzorce za razvoj mikrostoritev - uporabil vsebnike in orkestracijo vsebnikov - sposoben razvoja SaaS aplikacij	- master the development of microservices - understand and use patterns for the development of microservices - use containers and orchestration of containers - capable of developing SaaS applications

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja, računalniške vaje, projektni način dela pri seminarjih.	Lectures, computer-based workshops, project work, seminars.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Način (pisni izpit, naloge, projekt): **Sprotno preverjanje** (vaje, kolokviji in projektno delo) **Končno preverjanje** (pisni in ustni izpit) Ocene: 6-10 pozitivno, 5 negativno (v skladu s Statutom UL).	**50%** **50%**	Type (examination, coursework, project): **Continuing** (workshops, midterm exams, project work) **Final** (written and oral exam) Grading: 6-10 pass, 5 fail (according to the rules of University of Ljubljana).

Reference nosilca / Lecturer's references:

Pet najpomembnejših del:

- JURIČ, Matjaž B. WSDL and BPEL extensions for event driven architecture. Inf. softw. technol.. [Print ed.], 2010, vol. 52, iss. 10, str. 1023-1043
- JURIČ, Matjaž B., ŠAŠA, Ana, BRUMEN, Boštjan, ROZMAN, Ivan. WSDL and UDDI extensions for version support in web services. J. syst. softw.. [Print ed.], 2009, vol. 82, iss. 8, str. 1326-1343
- JURIČ, Matjaž B., ŠAŠA, Ana, ROZMAN, Ivan. WS-BPEL extensions for versioning. *Inf. softw. technol.*. [Print ed.], 2009, vol. 51, iss. 8, str. 1261-1274
- JURIČ, Matjaž B., PANT, Kapil. *Business process driven SOA using BPMN and BPEL: from business process modeling to orchestration and service oriented architecture*. Birmingham; Mumbai: Packt Publishing, cop. 2008. V, 311 str., ilustr. ISBN 978-1-84719-146-5
- JURIČ, Matjaž B., MATHEW, Benny, SARANG, Poornachandra G., *Business process execution language for web services: an architect and developer's guide to orchestrating web services using BPEL4WS*. Birmingham: Packt Publishing, 2006. X, 353 str., ilustr. ISBN 1-904811-81-7.
- JURIČ, Matjaž B., LOGANATHAN, Ramesh, SARANG, Poornachandra G., JENNINGS, Frank. *SOA approach to integration: XML, web services, ESB, and BPEL in real-world SOA projects*. Birmingham; Mumbai: Packt Publishing, cop. 2007. VIII, 366 str., ilustr. ISBN 978-1-904811-17-6

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Kriptografija in računalniška varnost
Course title:	Cryptography and Computer Security

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Magistrski študijski program druge stopnje Računalništvo in informatika Interdisciplinarni magistrski študijski program druge stopnje Multimedija Multimedija	ni smeri	1, 2 2	poletni / zimski
Master study program Computer and Information Science, level 2 Interdisciplinary Master study program Multimedia, level 2	none	1, 2 2	spring / fall

Vrsta predmeta / Course type	**strokovni izbirni predmet / specialist elective course** Tematski sklopi / Thematic set: Omrežja in varnost / Computer networks and security Algoritmika / Algorithmics FRI D/ FRI D
Univerzitetna koda predmeta / University course code:	63528

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

Nosilec predmeta / Lecturer:	prof. dr. Aleksandar Jurišić

Jeziki / Languages:	**Predavanja / Lectures:**	slovenščina in angleščina Slovene and English
	Vaje / Tutorial:	slovenščina in angleščina Slovene and English

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites:**

Vsebina:	**Content (Syllabus outline):**
Informacijska/*računalniška varnost* opisuje vse preventivne postopke in sredstva s katerimi zagotovimo dostop do informacijskih sistemov in njihove vsebine ter preprečimo njihovo nepooblaščeno uporabo. Med preventivnimi ukrepi nudi *kriptografija* največjo varnost oziroma zaščito glede na svojo prilagodljivost digitalnim medijem in s tem predstavlja osnovo informacijske družbe (cilji: zasebnost, celovitost podatkov, digitalno overjanje/podpisovanje, digitalni denar, in drugi kriptografski protokoli; obseg: matematika, računalništvo, elektrotehnika, finance, poli-tika, obramba, itd.). Vsebina bo med drugim zajemala naslednje teme: • **Simetrična kriptografija** – Klasični tajnopisi in zgodovina kriptografije – Kerckhoffov princip in stopnje napadov na kriptosisteme. – Shannonova teorija informacij in entropija (popolna, računska in dokazljiva varnost) – Bločne šifre (DES/IDEA, AES in finalisti, linearna in diferenčna analiza)	Information/computer security describes means to control access to information systems and their contents in order to prevent unauthorized use. Cryptography provides maximum security while at the same time preserving the flexibility of digital media. It forms the foundation of an information society, enabling privacy, data integrity, digital authentication/signatures, digital cash, and other goals. It incorporates mathematics, computer science, electrical engineering, finance, policy, defence, etc. The course will cover the following topics: • **Symmetric cryptography** – Classical ciphers and history of cryptography – Kerckhoff principle and various attacks on cryptosystems – Shannon theory of information and entropy (perfect, computational and provable security) – Block ciphers (DES/IDEA, AES and finalists, linear and differential analysis) – Stream ciphers/PRNG (RC4, LFSR and Berlekamp-Massey algorithm, ...), – Cryptoanalysis and statistical methods – Hash functions (MD/SHA, HMAC, ...) and authentication codes (MAC), birthday paradox attacks, new attacks, ...

– Tokovne šifre/PRNG (RC4, LFSR in Berlekamp-Masseyjev algoritem,...), – Kriptoanaliza in statistične metode – Zgoševalne funkcije (MD/SHA, HMAC, ...) in kode za avtentikacijo (MAC), napadi s paradoksom rojstnih dni, novi napadi,... • **Kriptografija javnih ključev** oziroma asimetična kriptografija – Kriptosistemi z javnimi ključi, enosmerne funkcije in z njimi povezani problemi iz teorije števil (testiranje praštevilskosti, faktorizacija števil, diskretni logaritem) – Digitalni podpisi (RSA, DSA, enkratni, slepi, skupinski, itd.) – Protokoli za dogovor o ključu (Diffie-Hellman, ElGamal, Kerberos, STS) – Sheme za identifikacijo oseb in naprav (izziv/odgovor, ...) – Drugi protokoli (grb/cifra po telefonu, mentalni poker, sheme za deljenje skrivnosti, kode za overjanje, časovni žigi, vizualna kriptografija, dokaz brez razkritja znanja) – Kvantna kriptografija • **Računalniška varnost** – Varnost programov (hrošči, virusi, zlonamerna koda) – Varnost podatkovnih baz (anonimizacija) – Varnost operacijskih sistemov (MS Win, Unix/Linux, liveCD) – Varnost mrežnih komunikacij (požarni zidovi, VPN, IPSec, SSL) – Zasebnost v računalništvu (žetoni/pametne kartice, RFID kartice) – Upravljanje s ključi (certifikati, CA, PKI, X.509) – Učinkovite in varne implementacije kriptosistemov (napadi s stranskim kanalom in obramba pred njimi) – Upravljanje varnosti v praksi (varnostne politike, nadzor) – Patenti in standardi (ISO, IEEE, IETF)		• **Public-key cryptography** (asymmetric aryptography) – Perfect security (computational, unconditional and provable security) – Public-key cryptosystems, one-way functions and related problems in number theory (primality testing, integer factorization, discrete logarithm problem) – Digital signatures (RSA, DSA, one-time, blind, group, etc.) – Key agreement protocols (Diffie-Hellman, ElGamal, Kerberos, STS) – Identification schemes for humans and devices (challenge/response, ...) – Other protocols (head/tail over the phone, mental poker, secret sharing schemes, authentication schemes, timestamps, visual cryptography, zero-knowledge proofs) – Quantum cryptography • **Computer and information security** – Security of programs (bugs, viruses, malicious code) – Security of databases (anonymization) – Security of OS (MS Win, Unix/Linux, liveCD) – Security of network communication (firewalls, VPN, IPSec, SSL) – Privacy in CS (tokens/smart cards, RFID cards) – Key management (certificates, CA, PKI, X.509) – Efficient and secure implementations of cryptosystems (side channel attacks and defenses against them) – Real time security management (security policy, monitoring) – Patents and standards (ISO, IEEE, IETF)

Temeljni literatura in viri / Readings:

D. Stinson, Cryptography: Theory and Practice, 3rd Ed., Chapman and Hall/CRC, 2006.

A. Menezes, P. van Oorschot in S. Vanstone, Handbook of Applied Cryptography, CRC Press, 1997 (peti ponatis 2001).

C.P. Pfleeger in S.L. Pfleeger, Security in Computing, 4th Ed., Prentice Hall, 2006.

Cilji in kompetence:	**Objectives and competences:**
Študent se spozna z osnovami kriptografije in računalniške varnosti.	Introduction to cryptography and computer security

Predvideni študijski rezultati:	**Intended learning outcomes:**
Po uspešnem zaključku tega predmeta bo študent: - razumel osnovne probleme računalniške varnosti in v podrobnosti delovanje najbolj znanih kriptosistemov sistemov ter bo sposoben povezovati obe področji, predlagati rešitve in implementirati oziroma vzdrževati kriptografske sisteme, - znal uporabiti oz. bil **s**posoben opredeliti (definirati) problem, pravilno ovrednotiti s strokovnega vidika (tako s kriptografskega kot varnostnega) ter predlagati/ovrednotiti učinkovito rešitev, - razumel uglašenosti med teorijo in njeno rabo na konkretnih primerih računalniške varnosti. Predmet je osnova za številne predmete, ki preučujejo računalniške sisteme in mreže, (tele)komunikacijo, digitalno forenziko, elektronsko in mobilno poslovanje,... Med pridobljene spretnosti štejejo teoretične osnove za inženirsko	After successful completition of this course the students will be able to: - master the basic problems of computer security and the detailed structure of the most famous cryptosystems and will be capable to connect these areas, propose specific solutions and implement or maintain cryptosystems, - apply, i.e., be able to define the problem, correctly evaluate it from a professional point of view (both cryptographic and security) and to propose/evaluate an effective solution, - understand the connection between theory and practice applied to specific examples of computer security. This course is a foundation for several courses that study computer systems and networks, telecommunications, digital forensics, electronic and mobile commerce, etc. Students will gain a theoretical foundation for a variety of practical

reševanje različnih praktičnih problemov, ki se pojavljajo v problemih iz računalniške varnosti in kriptografije.	problems that are encountered in the field of computer security and cryptography.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja, vaje, domače naloge, seminarji, konzultacije, laboratorijsko delo. Poseben poudarek je na sprotnem študiju in na skupinskem delu pri vajah in seminarjih. Ogledali si bomo tudi kakšen video.	Lectures, tutorials, assignments, projects, office hours, lab work. There will be a special emphasis on real-time studies and team work (tutorials and seminars). We will occasionally watch video material related to the course.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Način (pisni izpit, ustno izpraševanje, naloge, projekt): **Sprotno preverjanje** (domače naloge, kolokviji in projektno delo) **Končno preverjanje** (pisni in ustni izpit) Ocene: 6-10 pozitivno, 5 negativno (v skladu s Statutom UL).	**50%** **50%**	Type (examination, oral, coursework, projects): **Continuing** (homework, midterm exams, project work) **Final** (written and oral exams) Grading: 6-10 pass, 5 fail (according to the rules of the University of Ljubljana).

Reference nosilca / Lecturer's references:

Pet najpomembnejših del:

1. A. Jurišić and J. Vidali, Restrictions on classical distance-regular graphs, *Journal of Algebraic Combinatorics* **46 (**2017), 571–588.

2. A. Jurišić and J. Vidali, Extremal 1-codes in distance-regular graphs of diameter 3, *Designs Codes and Cryptography* **65** (2012), 29–47.

3. A. Jurišić and J. Koolen, Classification of the family AT4(*qs,q,q*) of antipodal tight graphs, *J. Combin. Theory (A)* **118** (2011), 842–852.

4. A. Jurišić, P. Terwilliger and A. Žitnik, The *Q*-polynomial idempotents of a distance-regular graph, *J. Combin. Theory (B)* **100** (2010), 683–690.

5. A. Jurišić, A. Munemasa and J. Tagami, On graphs with complete multipartite mu-graphs, *Discrete Mathematics* **310** (2010), 1812–1819.

Celotna bibliografija je dostopna na SICRISu: http://sicris.izum.si/search/rsr.aspx?lang=slv&id=6518.

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Strojno učenje
Course title:	Machine Learning

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Magistrski študijski program druge stopnje Računalništvo in informatika	ni smeri	1, 2	zimski
Master study program Computer and Information Science, level 2	none	1, 2	fall

Vrsta predmeta / Course type	**strokovni izbirni predmet / specialist elective course** Umetna intelgienca / Artificial intelligence Računske metode / Computational methods
Univerzitetna koda predmeta / University course code:	63519

Predavanja **Lectures**	**Seminar** **Seminar**	**Vaje** **Tutorial**	**Klinične vaje** **Laboratory work**	**Druge oblike študija** **Field work**	**Samost. delo** **Individ. work**	**ECTS**
45	6	24	/	/	105	6

Nosilec predmeta / Lecturer:	prof. dr. Igor Kononenko

Jeziki / Languages:	**Predavanja / Lectures:**	slovenščina in angleščina Slovene and English
	Vaje / Tutorial:	slovenščina in angleščina Slovene and English

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites:**

Potrebno je poznavanje verjetnostenga računa, statistike, programiranja, osnov strojnega učenja in preiskovalnih algoritmov.	Knowledge of probability calculus, statistics, programming, machine learning basics and search algorithms.

Vsebina:	**Content (Syllabus outline):**
Predavanje: 1. Pregled metod strojnega učenja 2. Kaj je učenje in relacija učenja z inteligenco 3. Pregled potrebnega predznanja 4. Napredne metode za ocenjevanje atributov 5. Napredne metode za ocenjevanje rezultatov in vizualizacije 6. Kombiniranje algoritmov strojnega učenja 7. Bayesovsko učenje 8. Kalibracija verjetnosti, razlaga posameznih predikcij 9. Numerične metode strojnega učenja 10. Umetne nevronske mreže: Hopfieldove nevronske mreže, RBF, globoke nevronske mreže 11. Nenadzorovano učenje: razvrščanje, povezovalna pravila, prostorsko podatkovno rudarjenje 12. Konstruktivna indukcija, zanesljivosti predikcij 13. rudarjenje besedil, matrična faktorizacija, analiza arhetipov 14. Ostali pristopi k strojnemu učenju 15. Uvod v formalno teorijo naučljivosti **Vaje:** Na vajah bodo študenti utrjevali snov, ki so jo obravnavali na predavanjih, tako da jo bodo uporabili pri reševanju praktičnih problemov. Pri tem bodo poudarki na samostojnem delu študentov ob pomoči asistentov. Študenti bodo v	**Lectures:** 1. Overview of ML methods 2. What is learning and relation between learning and intelligence 3. Overview of necessary background 4. Advanced attribute evaluation measures 5. Advanced methods for estimating performance and visualization 6. Combining ML algorithms 7. Bayesian learning 8. Calibration of probabilities, Explanation of individual predictions 9. Numerical ML methods 10. Artificial neural networks: Hopfield NN, RBF, Deep NN 11. Unsupervised learning: clustering, Association rules, spatial DM 12. Constructive induction, reliability of predictions 13. Text mining, Matrix factorization, Arcehtypal analysis 14. Other approaches to ML 15. Introduction to formal learning theory **Lab. Work:** Practical applications of the knowledge gained through lectures. The emphasis is on the autonomous work of students with the help of assistants. Students will, in small groups, independently solve real-life problems under the supervision of different experts in ML and DM. The

manjših skupinah samostojno reševali realen problem pod mentorstvom različnih strokovnjakov s področja strojnega učenja in odkrivanja znanj iz podatkov. Skupine bodo svoje naloge in rešitve opisale v pisnem poročilu in predstavile ostalim v obliki kratke predstavitve, ter s tem dobili oceno iz vaj.	groups will describe their solutions in written reports and present them in short presentations and through those will receive their mark from lab. work.

Temeljni literatura in viri / Readings:

- Igor Kononenko and Matja.ž Kukar: Machine Learning and Data Mining. Horwood Publ., 2007.

Dodatna/Additional:

- David J. Hand, Heikki Mannila, Padhraic Smyth: Principles of Data Mining. The MIT Press, 2001.
- Ian H. Witten, Eibe Frank: Data Mining: Practical Machine Learning Tools and Techniques. Morgan Kaufmann, 1999.

Cilji in kompetence:	**Objectives and competences:**
Cilj predmeta je predstaviti teoretične osnove in osnovne principe metod strojnega učenja, osnovne algoritme strojnega učenja in njihove uporabe v praksi za iskanje zakonitosti iz podatkov ter za učenje klasifikacijskih in regresijskih modelov. Študenti bodo teoretično znanje praktično uporabili na realnih problemih iz znanstvenega in poslovnega okolja. Študenti bodo za dani problem sposobni presoje, katero od predstavljenih tehnik uporabiti, ter sestaviti prototip rešitve.	The goal is to present the basics and the basic principles of machine learning (ML) methods, the basic ML algorithms and their usage in practice for knowledge discovery from data, data mining (DM) and for learning classification and regression models. Students will practically apply the theoretical knowledge on real problems from scientific and business environment. The students shall be able to decide for a given problem which of the presented techniques should be used, and to develop a prototype solution.
Kompetence:	**Competences:**
Kompetence iz računalništva in informatike, ki omogočajo nadaljevanje študija na 3. stopnji (doktorski študij). Zmožnost prenosa znanja na sodelavce v tehnoloških in raziskovalnih skupinah. Zmožnost razumevanja in uporabe znanja iz računalništva in informatike v ostalih tehničnih in relevantnih področjih (ekonomija, organizacijske vede itd.). Zmožnost uporabiti pridobljenega znanja za reševanje tehničnih in znanstvenih problemov v računalništvu in informatiki, zmožnost nadgrajevanja pridobljenega znanja. Zmožnost preiskovanja virov znanja in iskanja virov in kritično oceniti informacijo. Zmožnost kritičnega, analitičnega in sintetičnega razmišljanja.	Competences in computer and information science granting access to further study at 3rd cycle doctoral programmes. The ability to transmit knowledge to co-workers in technology and research groups. The ability to understand and apply computer and information science knowledge to other technical and relevant fields (economics, organisational science, etc); The ability to apply acquired knowledge in independent work for solving technical and scientific problems in computer and information science; the ability to upgrade acquired knowledge. The ability to search knowledge sources and to search for resources and critically evaluate information. Developing skills in critical, analytical and synthetic thinking.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Z uspešno zaključenim predmetom bo študent: - sposoben uporabe različnih tehnik in metod, ki se uporabljajo pri modeliranju podatkov s strojnim učenjem. Sposoben bo za analizo, sintezo in predvidevanje rešitev ter njihovih posledic konkretnih problemov z uporabo znanstvenih metod. - lahko uporabil predstavljene metod na konkretnih problemih iz znanstvenega in poslovnega okolja. Poznal bo in uporabil orodja za modeliranje in podatkovno rudarjenje. Fleksibilno bo lahko uporabljal znanja v praksi. - sposobnen bo povezovanja znanja z različnih področij in jih uporabljal v praksi. - razlikoval bo med različnimi pristop strojnega učenja, med njihovimi prednostmi in slabostmi in bo lahko izbral ustrezen prostop za reševanje konkretnega problema iz podatkovnega rudarjenja. - s principi modelov, naučenih iz podatkov, bo lahko izboljšal uporabnost in uspešnost analiziranega sistema.	With successful completion of this course the student will: - be able to use the expertise of several techniques and methods, used for data modelling with ML, for analysis, synthesis and anticipation of solutions and their consequences for target problems using the scientific methodology. - be able to use of the presented methods on target problems from scientific and business environment. Will understand and use the tools for modelling and data mining. (S)he will flexibly use the knowledge in practice - be able to bind together the knowledge from different fields to apply it in practice. - differentiate among different approaches to machine learning, their advatages and disadvantages and wil be able to select the appropriate method for solving particular data mining problem -be able, using the principles of models, learned from data, to improve the usability and the performance of the analysed system.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja, vaje z ustnimi nastopi in predstavitvami, seminarski način dela in reševanje domačih nalog, ki spodbujajo sprotno učenje. Poseben poudarek je na sprotnem študiju in na samostojnem delu pri vajah in seminarjih.	Lectures, exercises with oral demonstrations and presentations, seminar works and solving of home-works, which stimulate online learning. The emphasis is on an online study and an independent exercises and seminars.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Način (pisni izpit, ustno izpraševanje, naloge, projekt): **Sprotno preverjanje** (domače naloge, kolokviji in projektno delo) **Končno preverjanje** (pisni in ustni izpit)	**50%** **50%**	Type (examination, oral, coursework, project): **Continuing** (homework, midterm exams, project work) **Final** (written and oral exam)

Ocene: 6-10 pozitivno, 5 negativno (v skladu s Statuom UL).		Grading: 6-10 pass, 5 fail (according to the rules of University of Ljubljana).

Reference nosilca / Lecturer's references:

Pet najpomembnejših del:

1. I.Kononenko, M.Kukar: Introduction to Machine Learning and Data Mining: Introduction to Principles and Algorithms, Horwood Publishing, 2007. XIX, 454 pages.
2. E. Štrumbelj, I.Kononenko. An efficient explanation of individual classifications using game theory. *Journal of machine learning research*, ISSN 1532-4435, 2010, vol. 11, no. [1], p. 1-18
3. Z. Bosnić, I. Kononenko. Automatic selection of reliability estimates for individual regression predictions. *Knowledge engineering review*, ISSN 0269-8889, 2010, vol. 25, no. 1, p. 27-47.
4. Robnik-Šikonja, M., Kononenko, I. Theoretical and empirical analysis of ReliefF and RReliefF. *Machine Learn*ing. [Print ed.], 2003, vol. 53, str. 23-69.
5. Machine learning for medical diagnosis: History, state of the art and perspective, Invited paper, Artificial Intelligence in Medicine - ISSN 0933-3657, 23:89-109, 2001.

Celotna bibliografija je dostopna na SICRISu:

http://sicris.izum.si/search/rsr.aspx?lang=slv&id=5066.

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Napredne metode računalniškega vida
Course title:	Advanced topics in computer vision

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Magistrski študijski program druge stopnje Računalništvo in informatika Interdisciplinarni magistrski študijski program druge stopnje Multimedija Interdisciplinarni magistrski študijski program druge stopnje Računalništvo in matematika Interdisciplinarni magistrski študijski program druge stopnje Pedagoško računalništvo in informatika	ni smeri	1, 2	poletni
Master study program Computer and Information Science, level 2 Interdisciplinary Master study program Multimedia, level 2 Interdisciplinary Master study program Computer Science and Mathematics, level 2 Interdisciplinary Master study program Computer Science Education, level 2	none	1, 2	spring

Vrsta predmeta / Course type	**strokovni izbirni predmet/ specialist elective course** Tematski sklopi / Thematic set:

Umetna inteligenca / Artificial Intelligence Medijske tehnologije / Media technologies Računske metode / Computational Methods FRI C/FRI C

Univerzitetna koda predmeta / University course code:	63522

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

Nosilec predmeta / Lecturer:	izr. prof. dr. Matej Kristan

Jeziki / **Languages:**	**Predavanja / Lectures:**	slovenščina in angleščina Slovene and English
	Vaje / Tutorial:	slovenščina in angleščina Slovene and English

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites:**

Vsebina:	**Content (Syllabus outline):**
Predmet vsebuje različne napredne teme s področja zaznavanja gibanja z metodami računalniškega vida. Konkretna vsebina se bo letno prilagajala trendom na tem hitro razvijajočem se področju. Trenutne aktualne teme obsegajo: 1. Pregled področja ocenjevanja gibanja in aplikacije. 2. Ocenjevanje optičnega toka z metodami najmanjših kvadratov. 3. Ocenjevanje optičnega toka z variacijskim računom. 4. Sledenje s parametrično predlogo po postopku Lucas-Kanade.	The course will include selected advanced topics in motion perception using computer vision. Concrete topics will change each year according to trends in this fast developing field. in computer science and industry. Potential topics will include: 1. Overview of the field motion estimation and applications. 2. Optical flow estimation using least-squares. 3. Variational optical flow estimation. 4. Parametric template tracking using Lucas-Kanade. 5. Histogram-based tracking using Mean Shift

5. Sledenje s histogrami po postopku srednjega premika (Mean Shift). 6. Sledenje s stohastično optimizacijo po postopku križne entropije. 7. Rekurzivni Bayesovi filtri za sprotno ocenjevanje stanj. 8. Sledenje s Kalmanovim filtrom. 9. Sledenje s filtri z delci. 10. Sledenje deformabilnih objektov s konstelacijskimi modeli. 11. Metodologije primerjave sledilnikov. 12. Sledenje s klasifikacijo. 13. Metode dolgoročnega sledenja z detekcijo.	6. Tracking as stochastic optimization using cross entropy. 7. Recursive Bayes filter for online state estimation. 8. Tracking by Kalman filter. 9. Tracking by particle filters. 10. Tracking deformable objects by constellation models. 11. Methodologies of tracker comparison. 12. Tracking by classification. 13. Long-term tracking by detection.

Temeljni literatura in viri / Readings:

1. Simon J. D. Prince, Computer Vision: Models, Learning, and Inference, Cambridge University Press, 2012
2. Richard Szeliski, Computer Vision: Algorithms and Applications, Springer, 2010
3. David Barber, Bayesian Reasoning and Machine Learning, Cambridge University Press, 2012

Cilji in kompetence:	**Objectives and competences:**
Primarni namen predmeta je seznanitev z raziskovalno zahtevnim področjem, ki je del računalniškega vida, širše pa umetne inteligence. V tem smislu je snov logično nadaljevanje prvostopenjskih predmetov umetne inteligence, specifično osnovnih tem s področja računalniškega vida, multimedije in strojnega učenja. Sekundarni namen predmeta je osvojitev uporabe analitičnih in numeričnih metod, s katerimi se študentje že spoznajo pri bazičnih predmetih, vendar jih pogosto ne uporabijo v praksi. Študentje bodo ob koncu predmeta seznanjeni z modernimi metodami ocenjevanja gibanja in sledenja z metodami računalniškega vida ter imeli praktične izkušnje iz implementacije teh metod.	The primary objective is obtaining an overview of scientifically challenging topics of computer vision and broader artificial intelligence. In this sense, the course is logical continuation of basic first-level courses in artificial intelligence, specifically, computer vision, multimedia and machine learning. The secondary objective is practical application of analytical and numerical methods that students learn at basic courses, but seldom use in practice. At the end of this course the students will be skilled in modern approaches for motion estimation and tracking using computer vision approaches. The studens will obtain practical experience with these approaches.

Predvideni študijski rezultati:	**Intended learning outcomes:**

Po uspešnem zaključku predmeta naj bi študenti**:** - poznali glavne postopke ocenjevanja gibanja in lokalizacijo premikajočih se objektov, - razumeli koncept ocenjevanja optičnega toka in bili sposobni implementirati osnovne postopke, - razumeli matematično ozadje prileganja predlog s pomočjo metod gradientnega spusta, - razumeli matematično ozadje verjetnostnih Bayesovskih modelov za ocenjevanje položaja objekta v sliki in bili sposobni implementirati osnovne algoritme, ki izhajajo iz te družine metod, - razumeli postopke evalvacije sledilnih algoritmov in bili sposobni kritično analizirati delovanje sledilnika, - razumeli osnove sledilnikov, ki sledijo na dolgi rok in poznali glavne predstavnike s tega področja - sposobni izdelati aplikacije za sledenje objektov v slikah, - sposobni razumevanja modernih algoritmov na področju sledenja objektov.	After completing this course a students will be able to: - know major methods for motion estimation and localization of moving objects, - understand the concept of optical flow estimation and be able to implement basic approaches, - understand mathematical background of template alignment using gradient descent, - understand mathematical background of probabilistic Bayesian models for target position estimation in images and be able to implement the basic algorithms from the family of these approaches, - understand the approaches for tracker evaluation and be able to critically analyze the algorithms, - understand the basics of long-term trackers and know the major representatives from this field, - implement applications for image-based object tracking, - understand modern algorithms in the field of object tracking.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja, laboratorijske vaje, domače naloge in projektna naloga v sklopu vaj. Poseben poudarek je na individualnem delu študentov.	Lectures, laboratory exercises, homeworks and project work. Special emphasis will be given on individual work.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Način (pisni izpit, ustno izpraševanje, naloge, projekt): **Sprotno preverjanje** (laboratorijske vaje, domače naloge, projektna naloga) **Končno preverjanje** (pisni in ustni izpit) Ocene: 6-10 pozitivno, 5 negativno (v skladu s Statutom UL).	**50%** **(30%,20%)**	Type (examination, oral, coursework, project): **Continuing** (lab exercises, homework, project) **Final** (written and oral exam) Grading: 6-10 pass, 5 fail (according to the rules of University of Ljubljana).

Reference nosilca / Lecturer's references:

LUKEŽIČ, Alan, ČEHOVIN ZAJC, Luka, KRISTAN, Matej. Deformable parts correlation filters for robust visual tracking. *IEEE transactions on cybernetics*, ISSN 2168-2267, 2017, vol. , no. , str. 1-13, [COBISS.SI-ID 1537625283],

KRISTAN, Matej, SULIĆ KENK, Vildana, KOVAČIČ, Stanislav, PERŠ, Janez. Fast image-based obstacle detection from unmanned surface vehicles. *IEEE transactions on cybernetics*, ISSN 2168-2267 , 2016, vol. 46, no. 3, str. 641-654, [COBISS.SI-ID 1536310979],

KRISTAN, Matej, MATAS, Jiří, LEONARDIS, Aleš, VOJÍŘ, Tomáš, PFLUGFELDER, Roman, FERNÁNDEZ, Gustavo, NEBEHAY, Georg, PORIKLI, Fatih, ČEHOVIN ZAJC, Luka. A novel performance evaluation methodology for single-target trackers. *IEEE transactions on pattern analysis and machine intelligence*, ISSN 0162-8828. [Print ed.], Nov. 2016, vol. 38, no. 11, str. 2137-2155, [COBISS.SI-ID 1536872643]

ČEHOVIN ZAJC, Luka, LEONARDIS, Aleš, KRISTAN, Matej. Visual object tracking performance measures revisited. *IEEE transactions on image processing*, ISSN 1057-7149, 2016, vol. 25, no. 3, str. 1261-1274, [COBISS.SI-ID 1536812739]

ČEHOVIN, Luka, KRISTAN, Matej, LEONARDIS, Aleš. Robust visual tracking using an adaptive coupled-layer visual model. *IEEE trans. pattern anal. mach. intell.*. [Print ed.], 2012, str. [1-14], [COBISS.SI-ID 9431124]

Celotna bibliografija je dostopna na SICRISu:

http://sicris.izum.si/search/rsr.aspx?lang=slv&id=32801.

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Skupinsko vedenje
Course title:	Collective behaviour

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Magistrski študijski program druge stopnje Računalništvo in informatika	ni smeri	1, 2	zimski
Master study program Computer and Information Science, level 2	none	1, 2	zimski

Vrsta predmeta / Course type	**strokovni izbirni predmet / specialist elective course** Tematski sklopi / Thematic set: Umetna inteligenca / Artificial intelligence, Računske metode / Computational methods
Univerzitetna koda predmeta / University course code:	

Predavanja **Lectures**	**Seminar** **Seminar**	**Vaje** **Tutorial**	**Klinične vaje** **Laboratory work**	**Druge oblike študija** **Field work**	**Samost. delo** **Individ. work**	**ECTS**
45	**/**	**30**	**/**	**/**	**105**	**6**

Nosilec predmeta / Lecturer:	izr. prof. dr. Iztok Lebar Bajec

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

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites:**

Vsebina:	**Content (Syllabus outline):**
Strokovnjaki s področja računalništva navdih za reševanje aktualnih problemov iščejo v različnih virih. Povsem logično je, da inspiracijo za marsikatero rešitev najdejo v naravi, saj so zaradi evolucije organizmi v naravi razvili izjemne metode za reševanje različnih problemov, s katerimi se soočajo vsak dan. Posledica tega je, da mnogo zelo znanih algoritmov za reševanje kompleksnih problemov posnema obnašanje organizmov v naravi. Tako na primer eden od algoritmov za iskanje najkrajše poti posnema obnašanje mravelj, sistem za hitro vzpostavitev mobilnega brezžičnega omrežja pa imitira letenje ptic v jati. Cilj predmeta je študentom predstaviti uporabo znanj o delovanju narave in živih organizmov pri izgradnji računalniških sistemov ali algoritmov. Poleg konkretnega znanja bodo študenti dobili tudi teoretično ozadje, s čimer se bodo lažje prilagajali hitrim spremembam v današnji računalniški industriji. Spretnosti, pridobljene pri predmetu, so prenosljive, saj so predstavljene metode uporabne na zelo širokem spektru področij. Z naučenimi tehnikami si bodo študenti lahko pomagali tudi pri ostalih predmetih študija oziroma pri morebitni nadaljnji računalniški karieri, tako na doktorskem študiju kot v industriji. Pregled vsebine predavanj: 1. Uvodno predavanje (motivacija, mehka logika, skupinsko obnašanje) 2. Programsko okolje Cinder++ (programsk vtičnik za C++ namenjen kreativnemu kodiranju, uporablja OpenGL za vizualizacijo)	Computer scientists seek inspiration for solving current problems from various sources. Many times, they find it in nature, as through evolution living organisms have discovered simple and elegant solutions to common problems. A number of known algorithms uses biomimicry. For example, there is an algorithm that in order to find the shortest path to a destination copies the approach of ants, and an algorithm that in order for a fast wireless network setup emulates the flocking of birds. The goal of the course is to present to students the use of the emulation of nature's time-tested patterns and strategies in order to create products, processes, computer systems and algorithms. Besides the specific knowledge, the students will gain an insight into the theoretical background by means of which they will be able to adapt more easily to the fast changes in current computer and information science. The acquired competences are transferrable as most of the covered topics are applicable to a wide variety of applications. Lectures overview: 1. Introductory lecture (motivation, fuzzy logic, biomimicry, collective behaviour) 2. Cinder++ (C++ API for creative coding, OpenGL) 3.-7. Fuzzy logic (fuzzy sets, membership functions, FIS, time and fuzzy logic, fuzzy arithmetic, fuzzy type 2, use cases)

3.-7. Mehka logika (mehka množica, pripadnostne funkcije, FIS, čas v mehki logiki, mehka aritmetika, mehka logika tipa 2, primeri uporabe) 8-12. Avtonomni agenti in skupinsko obnašanje (modeliranje usklajenega skupinskega obnašanja, osnove sistemov delcev, Boids, SPP model, animati, sistemi zaznavanj, nagoni, izbira akcije, verifikacija modelov) 13-15. Umetno življenje in umetni svetovi (učenje avtonomnih agentov in skupinskega obnašanja, framstics, stickyfeet, mehka evolucija in mehki genetski algoritmi) Vaje: Semestrski skupinski projekt modeliranja in simulacije povezan z vsebino predstavljeno na predavanjih.	8-12. Autonomous agents and collective behaviour (modelling and simulation of collective behaviour, particle systems, boids, SPP model, animats, modelling perception, drives, action selection, verification) 13-15. Artificial life and artificial worlds (learning agents, learning collective behaviour, framstics, stickyfeet, fuzzy evolution and fuzzy genetic algorithms) Lab work: Group project in modelling and simulation related to the topics covered in the course.

Temeljni literatura in viri / Readings:

1. Rijnieks K. *Cinder - Begin creative coding*. Packt Publishing, 2013.
2. Medeira R. & Gorny D. *Cinder Creative Coding Cookbook*. Pakt Publishing, 2013.
3. Tettamanzi A. & Tomassini M. Soft Computing. Springer, 2001.
4. Dobnikar A. *Mehko računanje*. Založba FE in FRI, 2009.
5. Mendel J.M. *Uncertain Rule-Based Fuzzy Logic Systems*. Prentice–Hall, 2001.
6. Shiffman D. *The Nature of Code*. Self-published, 2012.
7. Flake G.W. *The Computational Beauty of Nature*. MIT Press, 1998.
8. Bentley P.J. *Digital biology: How nature is transforming our technology and our lives*. Simon & Schuster, 2002.
9. de Castro L.N. & von Zuben F.J. *Recent Developments In Biologically Inspired Computing*. IGI Global, 2004.
10. Forbes N. *Imitation of Life: How Biology Is Inspiring Computing*. The MIT Press, 2005.
11. Zomya A.Y. *Handbook of Nature-Inspired and Innovative Computing*. Springer, 2006.
12. Sumpter D.J.T. Collective Animal Behavior. Princeton University Press, 2010.
13. Beauchamp G. *Social predation: How group living benefits predators and prey*. Academic Press, 2014.

Dodatno literaturo v obliki člankov in posnetkov predavanj znanih predavateljev dobijo študenti na spletni učilnici.

Cilji in kompetence:	**Objectives and competences:**
Cilj predmeta je študentom predstaviti uporabo znanj o delovanju narave in živih organizmov pri izgradnji računalniških sistemov ali algoritmov oz. uporabo računalniških metod za modeliranje in simulacijo delovanja narave in obnašanja živih organizmov. Študenti bodo razvijali sledeče kompetence: • Sposobnost definiranja, razumevanja in ustvarjalnega reševanja poklicnih izzivov s področja računalništva in informatike. • Sposobnost strokovne komunikacije tako v materinem jeziku, kot tudi tujem. • Sposobnost prenosa znanja v pisni obliki tako v materinem jeziku, kot tudi tujem. • Sposobnost timskega dela v strokovnem okolju; upravljanje majhne skupine strokovnjakov. • Sposobnost prenosa znanja sodelavcem v tehnoloških in raziskovalnih skupinah. • Praktična znanja in spretnosti iz računalniške strojne opreme, programske opreme in informacijske tehnologije, potrebne za uspešno strokovno delo na področju računalništva in informatike. • Sposobnost samostojnega opravljanja tako manj zahtevnih kot tudi kompleksnih inženirskih in organizacijskih nalog na nekaterih ozkih področjih in samostojnega reševanja določenih dobro opredeljenih nalog iz področja računalništva in informatike.	The goal of the course is to present to students the use of the emulation of nature's time-tested patterns and strategies in order to create products, processes, computers systems and algorithms as well as the use of computer and information science approaches for modelling and simulation of natural phenomena. The students will be developing the following competences: • The ability to define, understand and solve creative professional challenges in computer and information science. • The ability of professional communication in the native language as well as a foreign language. • The ability of knowledge transfer and writing skills in the native language as well as a foreign language. • The ability of teamwork within the professional environment; management of a small professional team. • The ability to transmit knowledge to co-workers in technology and research groups. • Practical knowledge and skills of computer hardware, software and information technology necessary for successful professional work in computer and information science. • The ability to independently perform both less demanding and complex engineering and organisational tasks in certain narrow areas and independently solve specific well-defined tasks in computer and information science.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Po uspešnem zaključku predmeta bo študent: • sposoben izkazati znanje in razumevanje osnovnih principov mehkih množic, mehkega sklepanja ter mehkih krmilnih sistemov, • sposoben izkazati znanje in razumevanje osnovnih principov skupinskega vedenja živali, • sposoben izkazati znanje in razumevanje razlik s stališča animata (zaznavanje, nagoni, izbira akcije) med različnimi modeli skupinskega vedenja na osnovi posameznika, • poznal različne tipe in pristope k implementaciji zaznavanja, nagonov in izbire akcije, • poznal različne minimalne modele skupinskega vedenja, ki izhajajo iz statistične fizike, • poznal uporabo evolucijskih metod (genetski algoritmi in umetno življenje) za iskanje odgovorov na kako/zakaj skupinsko vedenje nastane iz sebičnih teženj, • poznal uporabo znanj pridobljenih z modeli skupinskega vedenja za namene računalniške optimizacije.	After the completion of the course a student will be able to: • understand the basic principles of fuzzy set theory, fuzzy logic and fuzzy control systems, • understand the basic principles governing collective animal behaviour, • understand the differences between various individual based models of collective animal behaviour and the animat (perception, drives, action selection) perspective, • know of different types and implementations of perception models, drives and action selection, • know of different minimal models of collective animal behaviour that originate from statistical physics, • know of the application of evolutionary models (genetic algorithms, artificial life) for answering the elusive questions why and how collective animal behaviour emerges from selfish behaviour, • know of the application of knowledge gained from collective animal behaviour models for the purpose of computer optimisation.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja, laboratorijske vaje.	Lectures, lab work.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Način (projekt, kviz):		Type (project, quiz):
Sprotno preverjanje (projektno delo)	**50%**	**Continuing** (project work)
Končno preverjanje (40% projektno delo, 10% kviz)	**50%**	**Final** (40% project work, 10% quiz)
Ocene: 6-10 pozitivno, 5 negativno		

(v skladu s Statutom UL).		Grading: 6-10 pass, 5 fail (according to the rules of University of Ljubljana).

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Matematika II
Course title:	Mathematics II

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Magistrski študijski program druge stopnje Računalništvo in informatika Interdisciplinarni magistrski študijski program druge stopnje Pedagoško računalništvo in informatika	ni smeri	1	zimski
Master study program Computer and Information Science, level 2 Interdisciplinary Master study program Computer Science Education, level 2	none	1	fall

Vrsta predmeta / Course type	**obvezni predmet / compulsory course**
Univerzitetna koda predmeta / University course code:	63506

Predavanja **Lectures**	**Seminar** **Seminar**	**Vaje** **Tutorial**	**Klinične vaje** **Laboratory work**	**Druge oblike študija** **Field work**	**Samost. delo** **Individ. work**	**ECTS**
45	/	30	/	/	105	6

Nosilec predmeta / Lecturer:	izr. prof. dr. Polona Oblak
Jeziki / Predavanja / Lectures:	slovenščina in angleščina Slovene and English

Languages:	**Vaje / Tutorial:**	slovenščina in angleščina Slovene and English

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites:**

Vsebina:	**Content (Syllabus outline):**
• Linearna algebra: vektorski prostori, linearne in afine preslikave, skalarni produkt, aplikacije. • Matematična analiza: potenčne in trigonometrične vrste, integralske in diskretne transformacije, funkcije več spremenljivk, ekstremi in zvezne optimizacijske naloge, dvojni integrali, vektorska analiza.	1. Linear algebra: vector spaces, linear and affine transformations, scalar product, quadratic applications. 2. Calculus: power and trigonometric series, integral and discrete transforms functions of several variables and continuous optimization problems, double integrals, vector calculus.

Temeljni literatura in viri / Readings:

1. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons, 2011.
2. Gilbert Strang, Introduction to Linear Algebra, Cambridge press, 2003.
3. James Stewart, Calculus, Early Transcendentals, Thomson, 2008.
4. Damir Franetič, Polona Oblak, Matematika 2 – zapiski s predavanj, dostopna na: https://ucilnica.fri.uni-lj.si/pluginfile.php/6121/mod_page/content/95/mat2.pdf, 2017

Cilji in kompetence:	**Objectives and competences:**
Zmožnost kritičnega razmišljanja. Razvoj veščin kritičnega , analitičnega in sintetičnega razmišljanja.	Ability of critical thinking. Developing skills in critical, analytical and synthetic thinking.

Zmožnost definiranja, razumevanja in reševanja ustvarjalnih poklicnih izzivov v računalništvu in informatiki. Sposobnost uporabiti pridobljeno znanje za samostojno delo pri reševanju tehničnih in znanstvenih problemov v računalništvu in informatiki; možnost nadgradnje pridobljenega znanja. Cilj predmeta je obnoviti in utrditi matematična znanja, ki so osnovna in nujno potrebna na tej stopnji računalništva in informatike, in študenta usposobiti za uporabo osnovnih matematičnih principov, metod in modelov pri reševanju problemov z različnih področij računalništva in informatike.	The ability to define, understand and solve creative professional challenges in computer and information science; The ability to apply acquired knowledge in independent work for solving technical and scientific problems in computer and information science; the ability to upgrade acquired knowledge. The object of this course is to review the basic mathematical topics which are necessarily at this level of computer and information science and prepare the students for mastering applications of mathematical principles, methods and models in solving specific problems from various domains of computer and information science.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Po uspešnem zaključku tega predmeta bo študent**:** - Sposoben izkazati znanje in razumevanje osnovnih pojmov abstraktne linearne algebre - Razumel in uporabljal razvoj funkcije v Taylorjevo vrsto - Zmožen izračunati lokalne in globalne ekstreme funkcij več spremenljivk - Razumel in uporabljal večkratne in krivuljne integrale - Sposoben aplicirati pojme linearne algebre v računalništvo in informatiko - Sposoben formulirati nekatere probleme računalništva v matematičnem jeziku in rešiti nekatere izmed njih	After the completion of the course a student will be able to - Show the knowledge and understanding of the basic notions of abstract linear algebra - Understand and use the representation of a function as Taylor series - Compute local and global extrema of a function of several variables - Understand and use multiple and curve integrals - Apply the notion of linear algebra into computer and information science - Formulate several problems from computer science to mathematical language and solve some of them

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja in vaje z reševanjem problemov, domače naloge. Poseben poudarek je na sprotnem študiju s testi in na skupinskem delu pri vajah.	Lectures, tutorials and lab work printed to problem solving. Strong emphasis on regular work with tests and group work at tutorials.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**

Način (pisni izpit, ustno izpraševanje, naloge, projekt): **Sprotno preverjanje** (domače naloge, kolokviji in projektno ali seminarsko delo) **Končno preverjanje** (pisni in ustni izpit) Ocene: 6-10 pozitivno, 5 negativno (v skladu s Statutom UL).	**100%**	Type (examination, oral, coursework, project): **Continuing** (homework, midterm exams, project work or seminar paper) **Final** (written and oral exam) Grading: 6-10 pass, 5 fail (according to the rules of University of Ljubljana).

Reference nosilca / Lecturer's references:

Tri najpomembnejša dela:

1. DOLŽAN, David, OBLAK, Polona. Invertible and nilpotent matrices over antirings. *Linear algebra appl.*, 2009, vol. 430, iss. 1, str. 271-278.
2. KOŠIR, Tomaž, OBLAK, Polona. On pairs of commuting nilpotent matrices. *Transform. groups*, 2009, vol. 14, no. 1, str. 175-182.
3. OBLAK, Polona, ŠMIGOC, Helena. The maximum of the minimal multiplicity of eigenvalues of symmetric matrices whose pattern is constrained by a graph. Linear Algebra and its Applications, 2017, vol. 512, str. 48-70.

Celotna bibliografija je dostopna na SICRISu:

http://sicris.izum.si/search/rsr.aspx?lang=slv&id=15808.

Reference nosilca / Lecturer's references:

Pet najpomembnejših del:

1. DEMŠAR, Jure, LEBAR BAJEC, Iztok. Evolution of collective behaviour in an artificial world using linguistic fuzzy rule-based systems. *PloS one*, 2017, vol. 12, no. 1, str. 1-20, doi: 10.1371/journal.pone.0168876.
2. DEMŠAR, Jure, ŠTRUMBELJ, Erik, LEBAR BAJEC, Iztok. A balanced mixture of antagonistic pressures promotes the evolution of parallel movement. *Scientific reports*, 2016, vol. 6, str. 1-11, doi: 10.1038/srep39428.
3. DEMŠAR, Jure, HEMELRIJK, Charlotte Korinna, HILDENBRANDT, Hanno, LEBAR BAJEC, Iztok. Simulating predator attacks on schools : evolving composite tactics. *Ecological modelling*, 2015, vol. 304, str. 22-33, doi: 10.1016/j.ecolmodel.2015.02.018.
4. DEMŠAR, Jure, LEBAR BAJEC, Iztok. Simulated predator attacks on flocks : a comparison of tactics. *Artificial life*, 2014, vol. 20, no. 3, str. 343-359, doi: 10.1162/ARTL_a_00135.
5. LEBAR BAJEC, Iztok, HEPPNER, Frank H. Organized flight in birds. *Animal behaviour*, 2009, vol. 78, no. 4, str. 777-789, doi: 10.1016/j.anbehav.2009.07.007.

Celotna bibliografija je dostopna na SICRISu:

http://splet02.izum.si/cobiss/BibPersonal.jsp?init=t&code=21404

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Računalniški sistemi
Course title:	Computer systems

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Magistrski študijski program druge stopnje Računalništvo in informatika	ni smeri	1	poletni
Interdisciplinarni magistrski študijski program druge stopnje Pedagoško računalništvo in informatika		1	
Interdisciplinarni magistrski študijski program druge stopnje Računalništvo in matematika		1, 2	
Interdisciplinarni magistrski študijski program druge stopnje Multimedija		1	
Master study program Computer and Information Science, level 2	none	1	spring
Interdisciplinary Master study program Computer Science Education, level 2		1	
Interdisciplinary Master study program Computer Science and Mathematics, level 2		1, 2	
Interdisciplinary Master study program Multimedia, level 2			

		1	

Vrsta predmeta / Course type	**obvezni predmet / compulsory course** **strokovni izbirni predmet /elective course**
Univerzitetna koda predmeta / University course code:	63509

Predavanja **Lectures**	**Seminar** **Seminar**	**Vaje** **Tutorial**	**Klinične vaje** **Laboratory work**	**Druge oblike študija** **Field work**	**Samost. delo** **Individ. work**	**ECTS**
45	/	30	/	/	105	6

Nosilec predmeta / Lecturer:	prof. dr. Branko Šter

Jeziki / Languages:	**Predavanja / Lectures:**	slovenščina Slovene
	Vaje / Tutorial:	slovenščina Slovene

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites:**
Poznavanje osnov arhitekture računalniških sistemov	Knowing basics of computer systems architecture

Vsebina:	**Content (Syllabus outline):**

1. Linearna električna vezja: enosmerna analiza, prehodni pojavi. 2. Električne linije: linijske enačbe, odboji, presluhi. 3. Vodila: principi, zgodovina, PCI, PCI Express. 4. Računalniški porti: serijski port, USB, FireWire, Bluetooth. 5. Avdio sistem (digitalni avdio, zvočne kartice, transduktorji) in video sistem (video adapter, vmesniki, monitorji) 6. Magnetni diski in vmesniki (ATA/IDE, SATA), SSD diski (Flash), optični diski (CD, DVD, Blu-ray) 7. Uporaba periferije v mikrokrmilnikih: GPIO, časovniki, prekinitve, flash. Gonilniki. RTOS. 8. Porazdeljeni sistemi in kiber-fizični sistemi. Porazdeljeno računanje, komunikacija in interakcija med heterogenimi vgrajenimi napravami. 9. Aplikacije brezžičnih računalniških sistemov	1. Linear electrical circuits: DC analysis, transient analysis. 2. Electrical transmission lines: line equations, reflections, crosstalk. 3. Buses: principles, history, PCI, PCI Express. 4. Computer ports: serial port, USB, FireWire, Bluetooth. 5. Audio system (digital audio, sound cards, transductors) and video system (video adapter, video interfaces, displays) 6. Magnetic disks and interfaces (ATA/IDE, SATA), SSD disks (Flash), optical disks (CD, DVD, Blu-ray) 7. Using peripherals in microcontrollers: GPIO, timers, interrupts, flash. Device drivers. RTOS. 8. Distributed and cyber-physical systems. Distributed computation, communication and interaction among heterogeneous embedded devices. 9. Applications of wireless computing systems

Temeljni literatura in viri / Readings:

1. S. Mueller: Upgrading and repairing PCs, 21st ed., Que Publishing, 2013.
2. W.L. Rosch: Hardware Bible, Que Publishing, 2003.
3. J. *Mlakar*: *Elektromagnetno valovanje*, Založba FE in FRI, 2002.
4. E.A. Lee, S.A. Seshia: Introduction to embedded systems: A cyber-physical systems approach. MIT Press, 2016.
5. D.P. Agrawal, Q.A. Zeng: Introduction to wireless and mobile systems. Cengage learning, 2015.
6. C.A. Varela, G. Agha: Programming Distributed Computing Systems: A Foundational Approach. MIT Press, 2013.

Cilji in kompetence:	**Objectives and competences:**
Cilj predmeta je študentom, ki so končali 1. stopnjo študija, predstaviti vhodno-izhodne oz. periferne naprave v računalniških sistemih.	The course aims to present to graduate students input/output or peripheral devices in computer systems.
Kompetence:	Competences:
Razvoj veščin kritičnega, analitičnega in sintetičnega mišljenja.	Developing skills in critical, analytical and synthetic thinking.
Zmožnost definiranja, razumevanja in reševanja ustvarjalnih profesionalnih izzivov v računalništvu in informatiki.	The ability to define, understand and solve creative professional challenges in computer and information science.
Zmožnost profesionalne komunikacije v materinem in v tujem jeziku.	The ability of professional communication in the native language as well as a foreign language.

Zmožnost uporabe pridobljenega znanja pri samostojnem delu pri reševanju tehničnih in znanstvenih problemov v računalništvu in informatiki; zmožnost nadgradnje pridobljenega znanja. Osnovne veščine v računalništvu in informatiki. Praktično znanje in veščine, potrebne za uspešno profesionalno delo v računalništvu in informatiki. Zmožnost samostojne izvedbe inženirskih in organizacijskih nalog v določenih ozkih področjih in samostojnega reševanja specifičnih dobro definiranih nalog v računalništvu in informatiki.	The ability to apply acquired knowledge in independent work for solving technical and scientific problems in computer and information science; the ability to upgrade acquired knowledge. Basic skills in computer and information science. Practical knowledge and skills necessary for successful professional work in computer and information science. The ability to independently perform engineering and organisational tasks in certain narrow areas and independently solve specific well-defined tasks in computer and information science.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Po uspešno opravljenem predmetu naj bi bili študenti zmožni: - razložiti osnovne principe delovanja različnih vrst perifernih naprav v računalniških sistemih - poznavanja in vrednotenja široke palete perifernih naprav - uporabiti to znanje pri načrtovanju računalniških sistemov, kakor tudi pri administraciji le-teh - posredno uporabiti znanje o perifernih napravah tudi pri načrtovanju in izdelavi sistemske in uporabniške programske opreme - razumevanja, uporabe in načrtovanja porazdeljenih računalniških sistemov	After the completion of the course a student will be able to: - explain basic principles of operation of different types of peripherals in computer systems - know and evaluate wide variety of computer peripherals - apply this knowledge directly in computer systems design, as well as in their administration - apply this knowledge indirectly also in design and making of systems software and application software - understand, apply and design of distributed computing systems

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja, računske vaje, laboratorijske vaje, domače naloge.	Lectures, calculation exercises, laboratory exercises, homeworks.

Delež (v %) /

Načini ocenjevanja:	Weight (in %)	**Assessment:**
Sprotno preverjanje: laboratorijske vaje, domače naloge, kolokviji.	**1/3**	**Midterm work:** laboratory exercises**,** homeworks, midterm exams.
Končno preverjanje: pisni in teoretični izpit.	**1/3 + 1/3**	**Final exam**: written and theoretical exam.
Ocene: 6-10 pozitivno, 5 negativno (v skladu s Statutom UL).		Grading: 6-10 pass, 5 fail (according to the rules of University of Ljubljana).

Reference nosilca / Lecturer's references:

Pet najpomembnejših del:

1. Branko Šter: Selective recurrent neural network. *Neural processing letters*, 38(1): 1-15, 2013.
2. Dominik Olszewski, Branko Šter: Asymmetric clustering using the alpha–beta divergence. *Pattern Recognition,* 47(5): 2031-2041, 2013.
3. Rok Gaber, Tina Lebar, Andreja Majerle, Branko Šter, Andrej Dobnikar, Mojca Benčina, Roman Jerala: Designable DNA-binding domains enable construction of logic circuits in mammalian cells. *Nature Chemical Biology*, 10(3): 203-208, 2014.
4. Andrej Dobnikar, Branko Šter: Structural properties of recurrent neural networks. *Neural processing letters*, 29(2): 75-88, 2009.
5. Jernej Zupanc, Damjana Drobne, Branko Šter: Markov random field model for segmenting large populations of lipid vesicles from micrographs. *Journal of liposome research*, 21(4): 315-323, 2011.

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Odkrivanje znanj iz podatkov
Course title:	Data mining

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Magistrski študijski program druge stopnje Računalništvo in informatika Interdisciplinarni magistrski študijski program druge stopnje Računalništvo in matematika Interdisciplinarni magistrski študijski program druge stopnje Pedagoško računalništvo in informatika Interdisciplinarni magistrski študijski program druge stopnje Multimedija	ni smeri	1, 2	poletni
Master study program Computer and Information Science, level 2 Interdisciplinary Master study program Computer Science and Mathematics, level 2 Interdisciplinary Master study program Computer Science Education, level 2 Interdisciplinary Master study program Multimedia, level 2	none	1, 2	spring

Vrsta predmeta / Course type	**strokovni izbirni predmet / specialist elective course** Tematski sklopi / Thematic set: Umetna inteligenca / Artificial intelligence FRI 2 / FRI 2
Univerzitetna koda predmeta / University course code:	63525

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

Nosilec predmeta / Lecturer:	prof. dr. Blaž Zupan

Jeziki / Languages:	**Predavanja / Lectures:**	slovenščina in angleščina Slovene and English
	Vaje / Tutorial:	slovenščina in angleščina Slovene and English

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites:**
Vpis predmeta Uvod v odkrivanje znanj iz podatkov iz predhodnih semestrov.	The following subject from previous semesters Introduction to Data Mining.

Vsebina:

Content (Syllabus outline):

Predmet bo v teoriji in na praktičnih primerih predstavil sledeče vsebine:

1. Predstavitev področja in klasifikacija tehnik za odkrivanje znanj iz

podatkov, pregled značilnih aplikacij

2. Tehnološke platforme in razvojne metodologije (skriptna okolja, okolja za analizo podatkov z vizualnim programiranjem)

3. Predobdelava podatkov: iskanje osamelcev, zmanjševanje dimenzij (metoda glavnih komponent), izbor in konstrukcija značilk, permutacijski pristopi, diskretizacija

4. Uvrščanje v skupine, s poudarkom na tehnikah, ki lahko obravnavajo velike množice podatkov in podatkov z velikim naborom značilk, metode podpornih vektorjev, iskanje in vizualizacija interakcij

5. Tehnike razvrščanja v skupine (metode hierarhičnega združevanja, metode voditeljev), s poudarkom na tehnikah, ki lahko obravnavajo

velike množice podatkov, določanje števila skupin (metoda silhuete)

6. Ocenjevanje uspešnosti napovednih modelov, kalibracijske in diskriminantne metode, ROC analiza, permutacijski pristopi

7. Vizualizacija podatkov in modelov, tehnike gradnje, analize in vizualizacije mrež

8. Tehnike odkrivanj znanj iz zbirk besedil in spletnih strani

9. Integrativni pristopi (uporaba predznanja, integracija povezav, pridobljenih iz različnih naborov podatkov)

10. Tipične napake pri snovanju pristopov ali uporabi tehnik odkrivanja znanj iz podatkov in kako se jim izognemo

Na predavanjih bodo študenti spoznavali ključne tehnologije in orodja, s katerimi bodo tekom semestra na vajah in v okviru projektov oz. seminarskih nalog reševali praktične probleme. Poudarek bo na uporabi odprtokodnih, prosto dostopnih orodij, ki za analizo podatkov

The course will cover theoretical and practical aspects of the following data mining approaches:

1. Introduction to data mining, taxonomy of data mining approaches and tasks
2. Data mining programming environments (scripting, visual programming)
3. Data preprocessing (dimensionality reduction, feature construction, identification of outliers)
4. Classification, including support vector machines and feature interaction discovery
5. Clustering, with emphasis on techniques that can consider very large data sets, and techniques for to determine an appropriate number of clusters
6. Evaluation, including permutation-based and cross-validation approaches, statistical scoring of models
7. Data and model visualization techniques, visualization of networks
8. Text mining, text-based kernels for support vector machines
9. Integrative aspects, including ensemble methods and mining with inclusion of prior knowledge
10. Typical mistakes in data mining and how to avoid them

The course will be composed of lectures in core data mining techniques and tools, which will then be employed on practical problems during lab work. We will focus on open source solutions and modern scripting languages (e.g., Python). Students will use scripting to access various data mining techniques which they, in a programming framework, will combine into their own data mining procedures.

uporabljajo moderne skriptne jezike (npr. Python). V skriptnih okoljih bodo študenti z uporabo že obstoječih komponent razvijali lastne metode, uporabo teh preverjali na različnih podatkih, ter poročali o ocenah njihove uporabnosti in napovedne točnosti. Vaje se bodo izvajale v računalniški učilnici opremljeni z ustrezno strojno in programsko opremo.	

Temeljni literatura in viri / Readings:

1. Tan P-N, Steinbach M, Kumar V (2006) Introduction to data mining. Pearson Education, Boston.

2. Leskovec J, Rajaraman A, Ullman J (2014) Mining of Massive Datasets, Cambridge University Press; 2 edition.

3. Chollet F (2018) Deep learning with Python, Manning Publications.

Cilji in kompetence:	**Objectives and competences:**
Cilj predmeta je študente seznaniti z osnovnimi in naprednimi metodami odkrivanja znanj iz podatkov, s poudarkom na njihovi praktični uporabi. Pri predmetu se bodo naučili uporabljati moderna skriptna orodja za analizo podatkov. Spoznali bodo, kako je z njimi moč implementirati nove metode za odkrivanje znanj, oziroma kako je moč obstoječe tehnike prilagoditi za obravnavo konkretnih podatkov.	Students will learn a number of core techniques for data mining. The course will include an introduction to data mining as well as a detailed study of several selected methods. It will also focus on practical use of these methods on real-life problems. The course will use a scripting data mining environment, where students will learn how to use the existing data mining libraries and design and implement in code their own data mining solutions.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Po uspešnem zaključku predmeta bo študent: - sposoben preproznati probleme, kjer bi si pri rešitvi pomagal s tehnikami strojnega učenja, - sposoben predstaviti problemsko znanje oziroma podatke v obliki primerne za strojno učenje, - razumel razliko med različnimi tehnikami odkrivanja znanj iz podatkov, - iz problema in podatkov prepoznal priložnosti in koristi uporabe posameznih tehnik podatkovne analitike, - sposoben izdelati program za analizo podatkov in uporabo knjižnic za podatkovno analitiko v jeziku Python,	After the completion of the course the student will be able to: - recognize problems where one can apply machine learning, - understand the process of transformation of the problem-specific data to the form suitable for data mining, - understand the difference of various techniques of data mining in application to the real-world data, - identify what kind of advantages of different machine learning techniques provide for specific data sets,

- razumel uporabo knjižnic za globoko učenje, - sposoben samostojno uporabiti knjižnice za globoko učenje, - razumel matematične osnove glavnih metod podatkovne analitike.	- be able to write Python scripts for data analytics and within them integrate various data mining libraries, - use libraries for deep learning, - understand the mathematics behind most of the data mining approaches.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja s podporo avdio-vizualne opreme, sprotni razvoj programskih rešitev, laboratorijske vaje v računalniški učilnici z ustrezno programsko opremo. Delo posamezno in v skupinah. Velik poudarek na praktičnem delu (npr. razvoj skript za pregledovanje in analizo podatkov) in reševanju praktičnih problemov.	Combined lecturing with simultaneous use of the blackboard and computer projection (coding, visualization of models, results). Lab work in computer-equipped lecture rooms. Individual and work in team. Emphasis on practical problem solving.

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

Reference nosilca / Lecturer's references:

Pet najpomembnejših del:

Stajdohar M, Rosengarten RD, Kokosar J, Jeran L, Blenkus D, Shaulsky G, Zupan B (2017) dictyExpress: a web-based platform for sequence data management and analytics in Dictyostelium and beyond, BMC Bioinformatics. 2017 Jun 2;18(1):291.

Zitnik M, Zupan B (2016) Jumping across biomedical contexts using compressive data fusion, *Bioinformatics* 15;32(12):i90-i100.

Zitnik M, Nam EA, Dinh C, Kuspa A, Shaulsky G, Zupan B (2015) Gene prioritization by compressive data fusion and chaining, *PLoS Computational Biology* 11(10):e1004552.

Staric A, Demsar J, Zupan B (2015) Concurrent software architectures for exploratory data analysis. *WIREs Data Mining and Knowledge Discovery* 5(4):165-180.

Zitnik M, Zupan B (2015) Data fusion by matrix factorization. *IEEE Transactions on Pattern Analysis and Machine Intelligence* 37(1):41-53.

Celotna bibliografija je dostopna na SICRISu:

http://sicris.izum.si/search/rsr.aspx?lang=slv&id=7764.

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Zaznavanje v kognitivnih sistemih
Course title:	Perception in cognitive systems

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Magistrski študijski program druge stopnje Računalništvo in informatika Interdisciplinarni magistrski študijski program 2. stopnje Računalništvo in matematika Interdisciplinarni magistrski študijski program druge stopnje Pedagoško računalništvo in informatika	ni smeri	1, 2	zimski
Master study program Computer and Information Science, level 2 Interdisciplinary Master study program Computer Science and Mathematics, level 2 Interdisciplinary Master study program Computer Science Education, level 2	none	1, 2	fall

Vrsta predmeta / Course type	**strokovni izbirni predmet / specialist elective course** Umetna inteligenca / Artificial intelligence Medijske tehnologije / Media technologies
Univerzitetna koda predmeta / University course code:	63513

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje Laboratory work	Druge oblike študija Field work	Samost. delo Individ. work	ECTS
45	/	30	/	/	105	6

Nosilec predmeta / Lecturer: prof. dr. Aleš Leonardis

Jeziki / Languages:	
Predavanja / Lectures:	slovenščina in angleščina Slovene and English
Vaje / Tutorial:	slovenščina in angleščina Slovene and English

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:

Prerequisites:

Vsebina:

Predavanja:

- Računske teorije zaznavanja
- Kognitivne arhitekture zaznavanja
- Učenje, razpoznavanje, kategorizacija in abstrakcija vizualnih entitet
- Aktivni vid
- Računske teorije pozornostnih mehanizmov
- Vizualni kontekst
- Računske teorije zaznavanja prostora in prostorskih relacij

Vaje:

Študenti se na vajah spoznajo z dodatnimi vidiki računskih modelov zaznavanja in z njihovo

Content (Syllabus outline):

Lectures:

- Computational theories of perception
- Cognitive architectures of perception
- Learning, recognition, categorization and abstractions of visual entities
- Active vision
- Computational theories of attentional mechanisms
- Visual context
- Computational theories of spatial perception

Exercises:

Practical implementation of computational models related to perception and cognition. Under supervision, development of software and hardware

praktično implementacijo v okviru razvoja senzorskih ali robotskih sistemov. Pod vodstvom mentorja razvijejo programske in strojne rešitve s področja razpoznavanja in kategorizacije objektov, robotske lokalizacije in aktivnega vida.	solutions for object recognition and categorisation, robot localisation, and active vision.

Temeljni literatura in viri / Readings:

1. Object Categorization: Computer and Human Vision Perspectives, S. J. Dickinskon, A. Leonardis, B. Schiele, M. J. Tarr, (Eds.), Cambridge University Press, 2009, (ISBN-13: 9780521887380).

2. A. Pinz, Object Categorization, Foundations and Trends® in Computer Graphics and Vision, 1(4), pp. 255-353, 2006, (ISBN: 1-933019-13-1).

Dostopna tudi: http://www.emt.tugraz.at/system/files/CGV003-journal.pdf

3. S. Thrun, W. Burgard, D. Fox, Probabilistic Robotics: Intelligent Robotics and Autonomous Agents, (ISBN-10: 0262201623).

Cilji in kompetence:	**Objectives and competences:**
Cilj predmeta je študente računalništva in informatike naučiti osnov zaznavanja v kognitivnih sistemih, kar vključuje nekatere izbrane teorije računskega zaznavanja, računalniško modeliranje zaznavnih procesov ter uporabo teh modelov pri izgradnji aktivnih kognitivnih robotskih sistemov.	The objective of the course is to teach the students basic competences in the area of artificial perception in cognitive systems, including selected computational theories of perception, computational models of perceptual processes, and application of these models for designing active cognitive robotic systems.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Študent naj bi po uspešno opravljenem predmetu: - Poznal in razumel računske modele zaznavanja ter njihove implementacije v umetnih kognitivnih sistemih. - Znal snovati praktične rešitve s področja umetnega zaznavanja v kognitivnih sistemih. - Znal snovati in implementirati praktične rešitve s področja umetnega zaznavanja v kognitivnih sistemih, npr. v avtonomnih robotih, nadzornih	After successfully completing the course, the students will be able to: -understand computational models of perception and their implementation in artificial cognitive systems, - understand design principles for practical problems in the area of artificial perception in cognitive systems, - design and implement practical solutions in the area of machine perception in cognitive systems,

sistemih, inteligentnih okoljih ali mobilnem računalništvu. - Poznal širše raziskovalno področje umetnega in naravnega zaznavanja ter kognitivnih sistemov. - Bil sposoben samostojnega in multidisciplinarnega raziskovanja na osnovi strokovne literature in eksperimentalnega dela. Sposobnost programiranja senzorskih ali robotskih sistemov.	e.g., in autonomous robots, control systems, intelligent environments or mobile computing, - understand wider research area of artificial and natural perception and cognitive systems, - perform research based on professional literature and experimental work and program sensorial and robot systems.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja s podporo avdio-vizualne opreme. Laboratorijske vaje v primerno opremljenem laboratorijskem prostoru. Delo posamezno in v skupinah. Praktično delo in vrednotenje produktov.	Lectures with slides. Exercises in appropriately equipped laboratories. Individual work and work in small groups.

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

Reference nosilca / Lecturer's references:

Pet najpomembnejših del:

1. A. Leonardis, A. Gupta, and R. Bajcsy, »Segmentation of range images as the search for geometric parametric models«, *International Journal of Computer Vision*, **14**, pages 253-277, 1995.

2. A. Leonardis, A. Jaklic, and F. Solina, »Superquadrics for segmentation and modelling range data«, *IEEE Transactions on Pattern Analysis and Machine Intelligence*, **19**, pages 1289-1295, 1997.

3. A. Leonardis and H. Bischof, »Robust recognition using eigenimages«, *Computer Vision and Image Understanding*, **78**, no. 1, pages 99-118, 2000.

4. M. Jogan, E. Žagar, A. Leonardis. »Karhunen-Loéve expansion of a set of rotated templates«. *IEEE trans. image process.*, July 2003, vol. 12, no. 7, str. 817-825.

5. S. Fidler, D. Skočaj, A. Leonardis. »Combining reconstructive and discriminative subspace methods for robust classification and regression by subsampling«. *IEEE trans. pattern anal. mach. intell.*. Mar. 2006, vol. 28, no. 3, str. 337-350.

Celotna bibliografija je dostopna na SICRISu: http://sicris.izum.si/search/rsr.aspx?lang=slv&id=5591.

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Uvod v bioinformatiko
Course title:	Introduction to bioinformatics

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Magistrski študijski program druge stopnje Računalništvo in informatika	ni smeri	1, 2	zimski
Master study program Computer and Information Science, level 2	none	1, 2	fall

Vrsta predmeta / Course type	**strokovni izbirni predmet / specialist elective course** Umetna inteligenca / Artificial intelligence Računske metode / Computational methods
Univerzitetna koda predmeta / University course code:	63520

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

Nosilec predmeta / Lecturer:	prof. dr. Blaž Zupan

Jeziki / Languages:	**Predavanja / Lectures:**	slovenščina in angleščina Slovene and English
	Vaje / Tutorial:	slovenščina in angleščina Slovene and English

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites:**

Vsebina:

Kako podobna so si med seboj živa bitja? Smo ljudje res potomci neandertalcev? Kako so se živalske vrste lahko prilagodile na življenjska

okolja? Kateri geni so odgovorni za pojav različnih bolezni? Zakaj vsako leto potrebujemo drugo cepivo proti gripi?

Današnja biologija je polna zanimivih vprašanj in nikoli prej nismo bili tako blizu odgovorom. Nedavno razvite eksperimentalne biotehnologije omogočajo pridobivanje velikih količine eksperimentalnih podatkov: o genomih različnih vrst in osebkov, o genskih izrazih, koncentracij proteinov, vplivih učinkovin na delovanje celice, ipd. Tovrstni podatki so danes dostopni v javnih spletnih podatkovnih bazah in jih je potrebno statistično in matematično obdelati, v njih poiskati skrite vzorce in jih primeren način prikazati. Temu so namenjena orodja bioinformatike, področja, brez katerega danes ne bi mogli več odgovoriti niti na eno od zgoraj zapisanih vprašanj.

Gre za interdisciplinarno področje, ki združuje metode iz statistike, matematike, vizualizacije podatkov, strojnega učenja in umetne inteligence.

Pri predmetu si bomo v teoriji in na praktičnih primerih ogledali osnovne bioinformatične metode ter se spoznali s sledečimi vsebinami:

1. Osnove celične biologije
2. Statistične lastnosti nukleotidnih zaporedij
3. Računske tehnike za iskanje genov v nukleotidnih zaporedjih
4. Tehnike poravnave zaporedij, algoritem BLAST
5. Verjetnostni modeli zaporedij, markovske verige

Content (Syllabus outline):

How similar are living organisms? Have human indeed descended from Neanderthals? How did various species adapt to living environments? Which genes are responsible for susceptibility to various diseases? Why we need a different flu vaccine each year?

Modern biology poses many interesting questions, and never before have we been so close to answering them. Recently developed experimental biotechnologies allow us to gather vast amounts of experimental data. From genomes of various species, including that of *H. sapiens*, to gene expression, protein concentrations, effects of various chemicals to cell processes, and similar. Vast number of experimental data sets is today available in open, public repositories, and requires further statistical and mathematical analysis to discover useful and applicable patterns. The methods and techniques for such analysis is developed within the field of bioinformatics, which combines techniques from statistics, computer science, mathematics, data mining and visualization, machine learning and artificial intelligence. During the course, the students will in theory and practice get familiar with the following topics:

11. Basics of molecular biology
12. Statistical properties of nucleotide sequences
13. Computational approaches to gene finding and annotation
14. Sequence alignment (BLAST)
15. Probabilistic models for nucleotide sequences, Markov chain models
16. Computational techniques for assessment of genetic distances between species and individuals within the same species

6. Računske tehnike ocenjevanja genskih razlik med predstavniki osebkov iste vrste in osebkov različnih vrst
7. Filogenetska analiza, računski pristopi k odkrivanju evolucijskih dreves
8. Računske primerjave genomov
9. Analiza podatkov o genskih izrazih, uporaba tehnik uvrščanja in razvrščanja v skupine, genski izrazi v medicinski diagnostiki in prognostiki, analiza obogatenosti genskih skupin, vizualizacijske tehnike, genske mreže
10. Integrativna bioinformatika: uporaba različnih baz podatkov in baz znanj v namene odkrivanja smiselnih vzorcev v biomedicinskih podatkih

Teoretično predstavitev računskih pristopov in tehnik bo spremljal pregled javno dostopnih baz podatkov s področja, prikaz delovanja ustrezne odprtokodne programske opreme in prikaz uporabe tehnik in orodij pri reševanju praktičnih problemov s področja biomedicine in sistemske biologije. Pri analizi podatkov bomo uporabljali moderna skriptna okolja (npr. Python) in že razvite bioinformatične knjižnice (npr. Biopython in Orange). Uvod v uporabo bioinformatične programske opreme bo podan na predavanjih, praktično pa bomo ta orodja spoznali na vajah in pri projektnem delu.

17. Phylogenetic analysis, computational techniques for construction of evolution trees
18. Computational comparison of genomes
19. Analysis of transcriptome, utility of data mining and visualization techniques, gene set enrichment analysis, gene networks, applications in biomedicine
20. Integrative bioinformatics: how to combine various data sources and various modelling techniques to discover patterns in biomedical data sets

Theoretical study of the above concepts will be accompanied with familiarization with public data repositories and open-source tools to assess the data and perform subsequent analysis. We will use scripting tools (e.g. Python) and already developed bioinformatics libraries (e.g., Biopython and Orange).

Temeljni literatura in viri / Readings:

1. Christianinni N, Hahn MW (2007) Introduction to Computational Genomics: A Case Study Approach. Cambridge University Press, Cambrige.
2. Durbin *et al*. (1998) Biological sequence analysis, Cambridge University Press
3. James D. Watson, Andrew Berry (2004) DNA: The Secret of Life, Arrow Books, UK. (also in Slovene: DNK, skrivnost življenja, Modrijan, Ljubljana, 2007).

Cilji in kompetence:

Cilj predmeta je študente seznaniti z osnovnimi računskimi tehnikami, orodji in prosto dostopnimi bazami podatkov s področja bioinformatike. V okviru predmeta bodo predstavljene osnove biologije in genomike, ki bodo študentom računalništva omogočale razumevanje problemske domene tako, da lahko nato s pomočjo matematičnih, statističnih in računskih pristopov, ki

Objectives and competences:

This is an introductory course to bioinformatics. During the course the students will become familiar with computational methods and tools that can be used in bioinformatics, and with publically available data bases in molecular biology. The course will start with introduction to molecular biology and genomics, which will allow students of computer science to apply mathematical, statistical and computational techniques

jih bo študent spoznal pri predmetu, poišče odgovore na sicer kompleksna vprašanja s področij evolucije in razvoja živih bitij, povezav med geni in biološkimi procesi, vpliv genskih predispozicij na razvoj bolezni, in podobnih.	to problems from evolution of living organisms, interactions of genes and biological processes, interactions between genome and phenotypes and diseases, and similar.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Po uspešnem zaključku predmeta bo študent: - razumel osnovne pojme iz molekularne biologije in evolucije, - vedel, do kakšnih podatkov lahko dostopamo na področju molekularne biologije in kje na spletu je moč te podatke dobiti, - poznal osnovno matematične pristope in računske tehnike za modeliranje zaporedij, - poznal tehnke za filogenetsko analizo, analizo genskih izrazov in primerjavo genomov, - znal analizirati podatke s področja molekularne biologije z snovanjem in uporabe knjižnic v programskem jeziku Python, - lahko prepoznal priložnosti, ki jih uporaba računskih postopkov nudi na področju znanosti o življenju.	After successfull completion of the course, the students should be able to: - understand essential koncepts from molecular biology and evolution, - know how and where to access the molecular biology data, - understand computational techniques for sequence analysis, - understand techniques for phylogeny analysis, analysis of gene expression data, and comparison of genomes, - know how to access and analyze molecular biology data by scripting in Python and using Python libraries for bioinformatics, - recognize advantages that computational methods and algorithms may provide in the area of life sciences.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja s podporo avdio-vizualne opreme, sprotni razvoj programskih rešitev, laboratorijske vaje v računalniški učilnici z ustrezno programsko opremo. Delo posamezno in v skupinah. Velik poudarek na praktičnem delu (npr. razvoj skript za pregledovanje in analizo podatkov) in reševanju praktičnih problemov.	Combined lecturing with simultaneous use of the blackboard and computer projection (coding, visualization of models, results). Lab work in computer-equipped lecture rooms. Individual and work in team. Emphasis on practical problem solving.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Način (pisni izpit, ustno izpraševanje, naloge, projekt):	**50%**	Type (examination, oral, coursework, project):

Sprotno preverjanje (domače naloge, kolokviji in projektno delo) **Končno preverjanje** (pisni in ustni izpit) Ocene: 6-10 pozitivno, 5 negativno (v skladu s Statutom UL).	**50%**	**Continuing** (homework, midterm exams, project work) **Final** (written and oral exam) Grading: 6-10 pass, 5 fail (according to the rules of University of Ljubljana).

Reference nosilca / Lecturer's references:

Pet najpomembnejših del:

Stajdohar M, Rosengarten RD, Kokosar J, Jeran L, Blenkus D, Shaulsky G, Zupan B (2017) dictyExpress: a web-based platform for sequence data management and analytics in Dictyostelium and beyond, BMC Bioinformatics. 2017 Jun 2;18(1):291.

Zitnik M, Zupan B (2016) Jumping across biomedical contexts using compressive data fusion, *Bioinformatics* 15;32(12):i90-i100.

Zitnik M, Nam EA, Dinh C, Kuspa A, Shaulsky G, Zupan B (2015) Gene prioritization by compressive data fusion and chaining, *PLoS Computational Biology* 11(10):e1004552.

Staric A, Demsar J, Zupan B (2015) Concurrent software architectures for exploratory data analysis. *WIREs Data Mining and Knowledge Discovery* 5(4):165-180.

Zitnik M, Zupan B (2015) Data fusion by matrix factorization. *IEEE Transactions on Pattern Analysis and Machine Intelligence* 37(1):41-53.

Celotna bibliografija je dostopna na SICRISu:

http://sicris.izum.si/search/rsr.aspx?lang=slv&id=7764.

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Slikovna biometrija
Course title:	Image based biometry

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Magistrski študijski program druge stopnje Računalništvo in informatika Interdisciplinarni magistrski študijski program 2. stopnje Multimedija	ni smeri	1, 2	zimski
Master study program Computer and Information Science, level 2 Interdisciplinary Master study program Multimedia, level 2	none	1, 2	fall

Vrsta predmeta / Course type	**strokovni izbirni predmet / specialist elective course** Tematski sklopi / Thematic set: Umetna inteligenca / Artificial intelligence Medijske tehnologije / Media technologies Računske metode / Computational Methods FRI B/FRI B FRI C/FRI C
Univerzitetna koda predmeta / University course code:	63554

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

Nosilec predmeta / Lecturer:	izr. prof. dr. Peter Peer
Jeziki / Predavanja / Lectures:	slovenščina, angleščina

Languages:	Slovene, English
Vaje / Tutorial:	slovenščina, angleščina Slovene, English

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites:**

Vsebina:	**Content (Syllabus outline):**
Predmet temelji predvsem na postopkih računalniškega vida, ki predstavljajo izhodišče večine biometričnih sistemov. Ciljna skupina so študentje, ki jih zanimata visoko-tehnološki razvoj in raziskave, saj je veliko pristopov še v raziskovalni fazi. Glavna vsebina, ki se bo zaradi razvoja področja spreminjala: 1. Osnove biometrije 2. Biometrične modalnosti 3. Zgradba tipičnega biometričnega sistema 4. Razpoznava/verifikacija/identifikacija 5. Metrike 6. Pogoji za korektno primerjanje sistemov (baze, ogrodja) 7. Uspešnost in uporabnost sistemov 8. Računalniški vid kot temelj biometričnih sistemov --- 9. Prstni odtis a. Zajem b. Ocena kvalitete slike in izboljšanje kvalitete c. Procesiranje d. Singularne točke, minucije, grebeni e. Ujemanje --- 10. Šarenica a. Zajem b. Izboljšanje kvalitete c. Procesiranje (segmentacija, normalizacija, kodiranje)	The course relies mostly on computer vision, as most biometrics technologies are based on it. Students interested in cutting edge technology, much of which is still in a research stage, are the intended target for the course. The main content (will evolve due to developments in the field): 1. Biometry basics 2. Biometrical modalities 3. Structure of a typical biometric system 4. Recognition/verification/identification 5. Metrics 6. Conditions for correct comparisons of the systems (databases, frameworks) 7. Performance and usefulness of the systems 8. Computer vision as the foundation of the biometric systems --- 9. Fingerprint a. Acquisition b. Quality assessment and quality improvement c. Processing d. Singular points, minutiae, ridges e. Matching --- 10. Iris a. Acquisition b. Quality improvement c. Processing (segmentation, normalization, coding) d. Feature points

d. Značilke e. Ujemanje --- 11. Obraz a. Zajem b. Podmodalnosti c. Procesiranje d. Značilke (pristop na osnovi izgleda, modela in/ali tekstur) e. Ujemanje --- 12. Gibanje a. Zajem b. Vpliv dinamike c. Procesiranje (pristop na osnovi izgleda in/ali modela) d. Dinamične značilke e. Ujemanje --- 13. Uhelj a. Zajem b. Procesiranje c. Značilke d. Ujemanje --- 14. Večbiometrični sistemi / večmodalnost / fuzije 15. Ključni problemi modalnosti/sistemov (raziskovalni izzivi) Predavanja predstavijo pristope in razložijo njihovo delovanje. Na laboratorijskih vajah to znanje uporabimo za apliciranje na praktične probleme v Matlabu in odprtokodnih orodjih.	e. Matching --- 11. Face a. Acquisition b. Sub-modalities c. Processing d. Feature points (appearance/ model/texture-based approach) e. Matching --- 12. Gait a. Acquisition b. Influence of dynamics c. Processing (appearance/ model-based approach) d. Dynamic feature points e. Matching --- 13. Ear a. Acquisition b. Processing c. Feature points d. Matching --- 14. Multi-biometric systems / multi-modality / fusions 15. Key problems of modalities/systems (research challenges) The lectures introduce the approaches and explain their operation. At tutorial the knowledge is applied to practical problems in Matlab and open source tools.

Temeljna literatura in viri / Readings:

1. Anil K. Jain, Arun A. Ross, Karthik Nandakumar, *Introduction to Biometrics*, Springer, 2011 (glavna, izhodiščna literatura / primary literature)
2. Ruud M. Bolle, Jonathan Connell, Sharath Pankanti, Nalini K. Ratha, Andrew W. Senior, *Guide to Biometrics*, 2003

Vsebine bodo podprte tudi s članki iz pomembnih konferenc in revij. /

Content will be backed also with articles from important conferences and journals.

Cilji in kompetence:	**Objectives and competences:**

Cilji predmeta:

- Študent dobi dober pregled nad področjem biometrije in tistimi področji računalniškega vida, ki tvorijo temelje biometričnih sistemov.
- Študent je seznanjen s potekom raziskovalnega dela.
- Študent pridobi dobro osnovo za doktorski študij.

Pridobljene kompetence študenta:

- Pozna terminologijo in principe analize identitete.
- Pozna obseg biometričnih tehnologij in njihove prednosti in slabosti.
- Pozna delovanje biometričnega sistema od zajema do odločitve.
- Razume potek procesiranja za vsako biometrično modalnost.
- Pozna nekatere omejitve delovanja biometričnih sistemov.
- Kritično razmišlja o starejših in novejših modalnostih, kako se modalnosti lahko dopolnjujejo.
- Pozna nekatere odprte probleme/izzive v biometriji.

Objectives of the course:

- Student gains good overview over the biometry and with it related computer vision methods that set foundations of biometric systems.
- Student gets acquainted with the flow of the research work.
- Student gets good foundation for doctoral study.

Gained student competences:

- Knows the terminology and principles of identity analysis.
- Knows the scope of the biometric technologies and their (dis)advantages.
- Knows how the system works from the acquisition to decision.
- Understands the processing flow for each biometric modality.
- Knows some limitations of biometric systems.
- Is able to critically consider older and newer modalities and how they can work together.
- Is familiar with some open problems/challenges in biometry.

Predvideni študijski rezultati:

Po uspešno opravljenem predmetu bodo študenti zmožni:

- pojasniti razvojni cikel biometričnega sistema
- razlikovati med specifikami različnih modalnosti
- izbrati algoritme računalniškega vida za biometrični cevovod
- implementirati biometrični cevovod
- ovrednotiti kvaliteto vsakega koraka v cevovodu
- zgraditi večbiometrični sistem
- argumentirati izbiro metrik, baz, protokolov
- identificirati odprta raziskovalna vprašanja
- spisati tehnično poročilo.

Intended learning outcomes:

After successful completion of the course, students will be able to:

- explain the design cycle of the biometric system
- differentiate between specifics of different modalities
- choose computer vision algorithms for biometric pipeline
- implement biometric pipeline
- evaluate the quality of each step in the pipeline
- build multi-biometric system
- argument the choice of metrics, databases, protocols
- identify open research questions
- write a technical report.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja in laboratorijske vaje, individualno delo na domačih nalogah/projektu, predstavitve izdelkov.	Lectures and tutorial, individual work on assignments/project, presentations of outcomes.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Način (pisni izpit, ustno izpraševanje, naloge, projekt): **Sprotno preverjanje** (domače naloge/projekt, predstavitve) **Končno preverjanje** (pisni ali ustni izpit) Ocene: 6-10 pozitivno, 5 negativno (v skladu s Statutom UL).	**67%** **33%**	Type (examination, oral, coursework, project): **Continuing** (assignments/project, presentations) **Final**: (written or oral exam) Grading: 6-10 pass, 5 fail (according to the rules of University of Ljubljana).

Reference nosilca / Lecturer's references:

Pet relevantnih del:

1. EMERŠIČ, Žiga, ŠTRUC, Vitomir, PEER, Peter. Ear recognition : more than a survey. *Neurocomputing*, ISSN 0925-2312. [Print ed.], Sep. 2017, vol. 255, str. 26-39. [COBISS.SI-ID 1537395395], [JCR]
2. MEDEN, Blaž, MALLI, Refik Can, FABIJAN, Sebastjan, EKENEL, Hazim Kemal, ŠTRUC, Vitomir, PEER, Peter. Face deidentification with generative deep neural networks. *IET signal processing*, ISSN 1751-9675. [Print ed.], May 2017, vol. , no. , str. 1-17. [COBISS.SI-ID 1537419459], [JCR]
3. PEER, Peter, EMERŠIČ, Žiga, BULE, Jernej, ŽGANEC GROS, Jerneja, ŠTRUC, Vitomir. Strategies for exploiting independent cloud implementations of biometric experts in multibiometric scenarios. *Mathematical problems in engineering*, ISSN 1024-123X. [Print ed.], Mar. 2014, vol. 2014, str. 1-15. [COBISS.SI-ID 10478420], [JCR]
4. KOVAČ, Jure, PEER, Peter. Human skeleton model based dynamic features for walking speed invariant gait recognition. *Mathematical problems in engineering*, ISSN 1024-123X. [Print ed.], Jan. 2014, vol. 2014, str. 1-15. [COBISS.SI-ID 10477140], [JCR]
5. KOVAČ, Jure, PEER, Peter. Transformation based walking speed normalization for gait recognition. *Transactions on internet and information systems*, ISSN 1976-7277, Nov. 2013, vol. 7, no. 11, str. 2690-2701. http://www.itiis.org/. [COBISS.SI-ID 10308948], [JCR]
6.

(Nosilec ima sicer reference iz vseh modalnosti iz vsebine.)

Celotna bibliografija je dostopna na:

http://splet02.izum.si/cobiss/bibliography?code=19226&sciif=on.

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Obdelava naravnega jezika
Course title:	Natural language processing

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Magistrski študijski program druge stopnje Računalništvo in informatika	ni smeri	1, 2	zimski
Master study program Computer and Information Science, level 2	none	1, 2	fall

Vrsta predmeta / Course type	**strokovni izbirni predmet / specialist elective course** Tematski sklopi / Thematic set: Umetna inteligenca / Artificial Intelligence Medijske tehnologije / Media technologies Informacijski sistemi in sistemi za upravljanje / Information and Management Systems
Univerzitetna koda predmeta / University course code:	63555

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

Nosilec predmeta / Lecturer:	izr. prof. dr. Marko Robnik Šikonja

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

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites:**

Priporočamo solidno predznanje verjetnosti in statistike, programiranja, strojnega učenja in algoritmov.	Knowledge of probability and statistics, programming, machine learning, and algorithms is recommended.

Vsebina:	**Content (Syllabus outline):**
Vsebina predmeta temelji na izboru sodobnih statističnih tehnik obdelave naravnega jezika podkrepljenih s praktično rabo. V predavanjih predstavimo glavne pristope in pojasnimo delovanje posameznih metod in njihovo teoretično ozadje. V okviru laboratorijskih vaj znanje povežemo s praktično rabo in ga utrdimo z uporabo odprtokodnih sistemov za obdelavo naravnega jezika. Študenti rešujejo naloge, ki temeljijo na realnih raziskovalnih in praktičnih problemih, pretežno v slovenskem in angleškem jeziku. 16. Uvod: motivacija, razumevanje jezika, Turingov test, tradicionalni in statističen pristop. 17. Jezikovni viri: korpusi, slovarji, tezavri, omrežja in semantične baze, pregled orodij. 18. Lingvistika: fonologija in morfologija, sintaktična analiza, formalne gramatike. 19. Uporaba avtomatov in gramatik: avtomati in algoritmi za iskanje nizov, prepoznavanje sintakse, gramatično razčlenjevanje. 20. Oblikoslovno označevanje besedil: vrste oznak, lematizacija, ngrami, skriti markovski model, označevanje s pravili. 21. Računska in leksikalna semantika: predstavitve pomena, metode s pravili, leksikalna semantika. 22. Razvrščanje besedil in mere podobnosti: kosinusna razdalja, jezikovna omrežja in grafi, WordNet, vektorska predstavitev, uteževanje vektorjev, semantična korelacija. 23. Tekstovno rudarjenje: prilagojene klasifikacijske metode, metoda podpornih vektorjev na dokumentih, izbira atributov. 24. Globoka omrežja in besedila: predstavitev besedil za uporabo v globokih nevronskih	The syllabus is based on a selection of modern statistical natural learning techniques and their practical use. The lectures introduce the main tasks and techniques, explain their operation and theoretical background. During practical sessions and seminars the gained knowledge is applied to language practical task using open source tools. Student investigate and solve assignments, based on real-world research and commercial problems form English and Slovene languages. 1. Introduction to natural language processing: motivation, language understanding, Turing test, traditional and statistical approaches. 2. Language resources: corpuses, dictionaries, thesauruses, networks and semantic data bases, overview of tools. 3. Linguistics: phonology and morphology, syntactical analysis, formal grammars. 4. Using automata and grammars: automata and algorithms for searching strings, syntax parsing, dependency parsing. 5. Part-of-speech tagging: types of tags, lemmatization, ngrams, Hidden Markov model, rule-based tagging. 6. Computational and lexical semantics: semantic representations, rule-to-rule approaches, semantic role labelling. 7. Clustering words and text similarity measures: cosine distance, language networks and graphs, WordNet, vector representation, vector weighting, sematic correlation. 8. Text mining: adaptation of classification methods to the specifics of text, support vector machines for language, feature selection.

mrežah, avtoenkoderji, rekurzivne nevronske mreže. 25. Povzemanje: predstavitve besedil, matrična faktorizacija, ekstrakcijske metode, povpraševane metode. 26. Strojno prevajanje: jezikovni model, prevajalni model, poravnava jezikov, parametri modelov, izzivi v prevajanju. 27. Dopolnjevanje besedil z drugimi viri informacij: heterogena omrežja, predstavitev word2vec, heterogeni ansambli klasifikatorjev, analiza povezav. 28. Metodologija in evalvacija pri obdelavi naravnega jezika.	9. Deep networks for text: document representations for deep neural networks, autoencoders, recurrent neural networks. 10. Text summarization: text representations, matrix factorization, multi-document summarization, extractive methods, query based methods. 11. Machine translation: language model, translation model, alignment model, challenges in machine translation. 12. Augmenting text with other data sources: heterogeneous networks, word2vec representation, heterogeneous ensembles of classifiers, link analysis. 13. Methodology and evaluation in NLP.

Temeljni literatura in viri / Readings:

3. Jurafsky, David and Martin, James H. *Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics and Speech Recognition*, 2nd and 3rd draft. Upper Saddle River, NJ: Prentice-Hall, 2009 and 2017.
4. Aggarwal, Charu C., and Zhai, ChengXiang. *Mining text data*. Springer Science & Business Media, 2012.
5. Bird, Steven, Ewan Klein, and Edward Loper. *Natural language processing with Python*. O'Reilly Media, Inc., 2009.

Cilji in kompetence:	**Objectives and competences:**
Študenti se bodo naučili teorije in rabe osnovnih algoritmov in pristopov na področju obdelave naravnega jezika. Študenti bodo: • razumeli pristope k analizi sintakse in semantike na področju obdelave naravnega jezika; • razumeli pristope k povzemanju dokumentov; • razumeli delovanje statističnih pristopov k strojnemu prevajanju, • razumeli uporabo metod strojnega učenja v obdelavi naravnega jezika: skritega Markovskega modela, verjetnostnih kontekstno neodvisnih gramatik in algoritma EM, • znali uporabiti orodja za obdelavo naravnega jezika.	Upon completion of the course, students shall be able to explain and apply fundamental algorithms and techniques in the area of natural language processing. In particular, students will: • understand approaches to syntax and semantics in NLP, • understand approaches to summarization • understand statistical approaches to machine translation, • understand machine learning techniques used in NLP, including hidden Markov models, probabilistic context-free grammars, and the EM algorithm as applied within NLP, • know how to apply standard natural language processing tools.
Predvideni študijski rezultati:	**Intended learning outcomes:**

Ob zaključku predmeta bodo študenti:	Upon completion of the course, students will:
• razumeli pristope k analizi sintakse in semantike na področju obdelave naravnega jezika; • znali ovrednotiti pristope k povzemanju dokumentov; • razlikovali med različnimi statističnimi pristopi k strojnemu prevajanju, • uporabljali in prilagajali metode strojnega učenja za obdelavo naravnega jezika • uporabljali in kritično vrednotili orodja za obdelavo naravnega jezika • poznali obstoječe in znali zasnovati nove jezikovne vire • uporabljali vektorske vložitve besedil in jih prilagajali novi okoliščinam	• understand approaches to syntax and semantics in NLP, • evaluate approaches to summarization • differentiate between statistical approaches to machine translation, • use and adapt machine learning techniques for NLP • apply and critically evaluate natural language processing tools • know the existing language resources and be able to design new ones • use vector embeddings of text and adapt them to new contexts

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja, laboratorijske vaje, delo v majhnih skupinah, javne predstavitve projektov	Lectures, lab work, work in small groups, public presentations of projects.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Način (pisni izpit, ustno izpraševanje, naloge, projekt): **Sprotno preverjanje** (domače naloge, projektno delo, javne predstavitve) **Končno preverjanje** (pisni in ustni izpit) Pri obeh delih mora študent doseči vsaj polovico možnih točk. Ocene: 6-10 pozitivno, 5 negativno (v skladu s Statutom UL).	**50%** **50%**	Type (examination, oral, coursework, project): **Continuing** (homework, project work, public presentations) **Final**: (written and oral exam) In both parts students must get at least half of available points. Grading: 6-10 pass, 5 fail (according to the rules of University of Ljubljana).

Reference nosilca / Lecturer's references:

Pet najpomembnejših del:/Five most important works:

1. ROBNIK ŠIKONJA, Marko, KONONENKO, Igor. Theoretical and empirical analysis of ReliefF and RReliefF. *Mach. learning*, 2003, vol. 53, pp. 23-69.
2. ROBNIK ŠIKONJA, Marko. Data generators for learning systems based on RBF networks. IEEE transactions on neural networks and learning systems, May 2016, vol. 27, no. 5, pp. 926-938.

3. ROBNIK ŠIKONJA, Marko, VANHOOF, Koen. Evaluation of ordinal attributes at value level. *Data mining and knowledge discovery*, 2007, vol. 14, no. 2, pp. 225-243.
4. ROBNIK ŠIKONJA, Marko, KONONENKO, Igor. Explaining classifications for individual instances. *IEEE trans. knowl. data eng.* May 2008, vol. 20, no. 5, pp. 589-600.
5. KRANJC, Janez, ORAČ, Roman, PODPEČAN, Vid, LAVRAČ, Nada, ROBNIK ŠIKONJA, Marko. ClowdFlows: online workflows for distributed big data mining. FGCS, 2017, vol. 68, pp. 38-58

Celotna bibliografija je dostopna na SICRISu: / Complete bibliography is available in SICRIS:

http://sicris.izum.si/search/rsr.aspx?lang=slv&id=8741.

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Interaktivnost in oblikovanje informacij
Course title:	Interaction and Information Design

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Magistrski študijski program druge stopnje Računalništvo in informatika Interdisciplinarni magistrski študijski program 2. stopnje Računalništvo in matematika Interdisciplinarni magistrski študijski program druge stopnje Pedagoško računalništvo in informatika	ni smeri	1, 2	poletni/ zimski
Interdisciplinarni magistrski študijski program druge stopnje Multimedija		1	zimski
Master study program Computer and Information Science, level 2 Interdisciplinary Master study program Computer Science and Mathematics, level 2 Interdisciplinary Master study program Computer Science Education, level 2 Interdisciplinary Master study program Multimedia, level 2	none	1, 2	spring/fall
		1	fall

Vrsta predmeta / Course type	**strokovni izbirni predmet / specialist elective course** Tematski sklopi / Thematic set: Medijske tehnologije / Media technologies **obvezni predmet / compulsory course**
Univerzitetna koda predmeta / University course code:	63527

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

Nosilec predmeta / Lecturer:	prof. dr. Franc Solina

Jeziki / Languages:	**Predavanja / Lectures:**	slovenščina in angleščina Slovene and English
	Vaje / Tutorial:	slovenščina in angleščina Slovene and English

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites:**

Vsebina:	**Content (Syllabus outline):**

Pri predmetu Interaktivnost in oblikovanj informacij bodo obravnavani celostni pristopi k oblikovanju informacij in oblikovanju interaktivnosti. Poudarek bo na računskih pristopih k vidnemu sporočanju ter na razvoju interaktivnih rešitev, produktov in vmesnikov v hipermedijskih okoljih. Oblikovanje informacij in oblikovanje
interaktivnosti sta kontekstualizirani kot bistveni komponenti uporabniške izkušnje, ki v velikem delu determinira uporabnost informacijske storitve ali produkta.

Vsebina predmeta:
Oblikovanje informacij:
- Modeli vidnega zaznavanja
- Oblikovanje vidnih sporočil
- Predstavitev informacije
- Prikaz informacije
- Prikazne tehnologije
- Navigacija in interaktivnost

Interaktivno oblikovanje:
- Uporabniška izkušnja
- Konceptualni modeli interaktivnosti
- Kognitivni vidik interaktivnosti
- Kognitivni model uporabnika
- Kolaborativni in socialni vidiki
- Interaktivne tehnologije
- Razvojni proces interaktivnih rešitev
- Vrednotenje uporabnosti

Vaje:
Poudarek bo na razvoju in vrednotenju interaktivnih hipermedijskih rešitev. Študentje bodo v ustrezno opremljenem laboratoriju zasnovali in razvili več prototipov z uporabo programskih orodij za grafično procesiranje in obdelavo podatkov, ki so primerni za podporo prototipno osnovanemu razvojnemu ciklu. Poleg programskih orodij bodo pri delu uporabljani tudi senzorji, interaktivni vmesniki ter elektronske komponente. Predvideno je tudi sodelovanje podiplomskih študentov Akademije za likovno umetnost in oblikovanje.

The course is dedicated to a holistic perspective on information and interaction design. Emphasis will be given to computational aspects of visual messaging and development of interactive solutions, products and interfaces in hypermedia environments. Information and interaction design are considered as principal components of user experience that determines the usability of information services and products.

Syllabus outline:

Information design:
- Models of visual perception
- Design of visual messages
- Presentation of information
- Display of information
- Display technologies
- Navigation and interactivity

Interaction design:
- User experience
- Conceptual models of interactivity
- Cognitive perspective on interactivity
- Cognitive models of users
- Collaborative and social aspects
- Interaction technologies
- Development process of interactive solutions
- Usability assessment

Laboratory work centeres around the development and evaluation of hypermedia solutions. Students will design and develop a series of prototypes using various software tools for fast development. Beside software tools, sensors, interactive interfaces and electronic devices are used. Collaboration with students of new media at the Academy of Fine Arts at University of Ljubljana is organized.

Temeljni literatura in viri / Readings:

- Christian Tominski, Interaction for Visualization, Morgan & Claypool, 2015.
- Robert Spence, Information visualization: Design for Interaction, 2007.
- Ben Fry, Visualizing Data, O.'Reilly, 2008.

Cilji in kompetence:	**Objectives and competences:**
Cilj predmeta je študente naučiti oblikovanja in podajanja informacij ter oblikovanja interaktivnosti s poudarkom na razvoju uporabniško in podatkovno osredotočenih multimedijskih programskih rešitev.	To teach the design and presentation of information with emphasis on interactivity based on user and data centered multimedia software solutions.

Predvideni študijski rezultati:	**Intended learning outcomes:**

Znanje in razumevanje:
Poznavanje in razumevanje teoretičnih osnov:

- vidnega zaznavanja,
- vizualizacije informacij,
- interaktivnosti,
- obogatene resničnosti.

Uporaba:
Snovanje in implementiranje praktičnih rešitev s področja interaktivnosti in oblikovanja informacij v inteligentnih sistemih, npr. za

- učenje,
- analizo slikovnih informacij,
- video nadzor,
- kreiranje in vzdrževanje novomedijske umetnosti.

Refleksija:
Spoznavanje in razumevanje vloge sodobne informacijske tehnologije
v družbi nasploh, še posebej pa v umetnosti, ki nudi širok spekter možnosti za eksperimentiranje s to tehnologijo. Premislek tudi o zasvojenosti s to tehnologijo.

Prenosljive spretnosti - niso vezane le na en predmet:
Sposobnost poglobljenega samostojnega in multidisciplinarnega raziskovanja na osnovi strokovne literature in eksperimentalnega dela. Implementacija ciljno usmerjenih praktičnih rešitev.

Knowledge and understanding: Comprehension of basic principles of:

- visual perception
- information visualization
- interactivity
- augmented reality.

Application:
Development of practical solutions of interactivity and information design for intelligent systems, for example for:

- learning,
- analysis of images
- video surveyance,
- creation and preservation of new media art.

Reflection: Wholesome comprehension of the role of modern information technology in society in general and in particular in fine arts which offers a broad spectrum of possibilities for experimentation with these technologies. Reflection about the addiction with new information technology.

Transferable skills:
Capability to tackle independently multidisciplinary research projects with the help of literature research and experimental work. Implementation of goal directed practical solutions.

Metode poučevanja in učenja:

Predavanja s podporo avdio-vizualne opreme. Laboratorijske vaje v učilnici z ustrezno strojno in programsko opremo. Delo posamezno in v skupinah. Praktično delo in vrednotenje produktov.

Learning and teaching methods:

Lectures using audio visual equipment. Laboratory work with special hardware and software tools. Individual and team assignments.
Practical work and evaluation of products.

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

Reference nosilca / Lecturer's references:

Sedem del, vezanih na vsebino predmeta:

1. F. Solina, B. Meden. Light fountain - a virtually enhanced stone sculpture. Digital Creativity 28 (2): 89-102, 2017.
2. A. Jaklič, F. Solina, L. Šajn. User interface for a better eye contact in videoconferencing. Displays 46: 25–36, 2017.
3. B. Batagelj, F. Solina. Preservation of an interactive computer-based art installation—a case study. International journal of arts & technology 10 (3): 206-230, 2017.
4. A. Jaklič, M. Erič, I. Mihajlović, Ž. Stopinšek, F Solina. Volumetric models from 3D point clouds: The case study of sarcophagi cargo from a 2nd/3rd century AD Roman shipwreck near Sutivan on island Brač, Croatia. Journal of Archaeological Science 62 (October 2015: 143–152, 2015.
5. E. Pavlin, Ž. Elsner, T. Jagodnik, B. Batagelj, F. Solina. From illustrations to an interactive art installation. Journal of Information, Communication and Ethics in Society 13 (2): 130-145, 2015.
6. B. Batagelj, F. Solina. Image-Based Biometrics in Forensic Science. Revija za kriminalistiko in kriminologijo 66 (3): 259-266, 2015.
7. F. Solina. 15 seconds of fame. Leonardo 37 (2): 105-110, 2004.

Celotna bibliografija je dostopna na SICRISu:
http://sicris.izum.si/search/rsr.aspx?lang=slv&id=6749.

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Računalniška zvočna produkcija
Course title:	Computer based sound production

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Magistrski študijski program druge stopnje Računalništvo in informatika Interdisciplinarni magistrski študijski program 2. stopnje Računalništvo in matematika Interdisciplinarni magistrski študijski program druge stopnje Pedagoško računalništvo in informatika Interdisciplinarni magistrski študijski program druge stopnje Multimedija	ni smeri	1, 2 2	zimski
Master study program Computer and Information Science, level 2 Interdisciplinary Master study program Computer Science and Mathematics, level 2 Interdisciplinary Master study program Computer Science Education, level 2 Interdisciplinary Master study program Multimedia, level 2	none	1, 2	fall

		2	

Vrsta predmeta / Course type	**strokovni izbirni predmet / specialist elective course** Tematski sklopi / Thematic set: Medijske tehnologije / Media technologies Strojna oprema / Hardware FRI C / FRI C
Univerzitetna koda predmeta / University course code:	63523

Predavanja **Lectures**	**Seminar** **Seminar**	**Vaje** **Tutorial**	**Klinične vaje** **Laboratory work**	**Druge oblike študija** **Field work**	**Samost. delo** **Individ. work**	**ECTS**
45	/	30	/	/	105	6

Nosilec predmeta / Lecturer:	prof. dr. Denis Trček

Jeziki / Languages:	**Predavanja / Lectures:**	slovenščina in angleščina Slovene and English
	Vaje / Tutorial:	slovenščina in angleščina Slovene and English

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites:**

Vsebina:	**Content (Syllabus outline):**

5. Uvod in zgodovinski pregled področja.
6. Temelji zvoka in računalniške zvočne produkcije:
   7. fizikalni (zvok in amplituda, frekvenca, hitrost, jakost, faza, interferenca, absorbcija);
   8. matematični (Fourierova teorija, teorem o vzorčenju, konvolucija, korelacija, Gaborjev zvočni kvant, itd.);
   9. fiziološki - psihoakustika (slušna percepcija in frekvenčni razpon, posredna percepcija prek drugih anatomskih struktur, pomen harmonskih komponent zvoka, lokalizacija, maskiranje, kritični pasovi, učinki okolja, rezultati zadnjih raziskav nevro-znanosti na tem področju).
10. Elektronski in omrežni vidiki procesiranja: analogni in digitalni signal, (kvantizacijski) šum, pasovna širina medija in naprave, ojačitev in slabenje, analogno digitalna in digitalno analogna pretvorba, popačenja, filtriranje, mikrofoni.
11. Generatorji zvoka: sintetizatorji, vzorčevalniki.
12. Računalniško snemanje: zajem kodiranega zvoka (sekvencerji), zajem vzorčenega zvoka (direct-to-disc recording).
13. Standardne studijske komponente: mešalniki, limiterji, kompresorji, reverberatorji, odstranjevalci šuma, korektorji višine, ekvilizatorji.
14. Protokoli v zvočni produkciji: MIDI, IEC-60958 (AES / EBU), S/PDIF, AC-3, E-AC-3.
15. Sinhronizacijski mehanizmi: MTC, SMPTE, integracija z video produkcijo in filmom.
16. Programski standardi: vmesniki (VST / Steinberg, DirectX / MS), formati zapisov (Wav, MP3, Ogg).
17. Sodobna zvočna reprodukcija (omrežni tokovniki, protokoli RTP, RTCP in RTSP).
18. Profesionalna orodja (Steinberg, Roland, odprtokodne rešitve).
19. Zaščita intelektualne lastnine.
20. Zaključki.
21. Addendum: Mini vložki s praktičnim delom, ki pokrivajo najnovejše trende ali specifične vidike, ki niso pokriti na vajah.

- Introduction and overview of the field.
- Basics of sound and computer based production:
  - physics (sound and amplitude, frequency, speed, power, phase, interference, absorption);
  - mathematics (Fourier theory, sampling theory, convolution, corre-lation, Gabor's acoustic quant, etc.);
  - physiology - psychoacoustics (aural perception and frequency range, indirect perception by various anatomical structures, the role of harmonics, localization, masking, critical bands, environmental effects, some latest neuroscience research results in this domain).
- Electronic and network principles of sound processing: analog and digital signal, (quantization) noise, medium / device bandwidth, amplification and attenuation, analog to digital, and digital to analog conversion, distortion, filtering, microphones and capturing signals.
- Sound generators: synthesizers, samplers.
- Computer based recording: capturing of coded sound (sequencers), capturing of sampled sound (direct-to-disc recording).
- Standard studio components: mixers, limiters, compressors, reverbs, noise reducers, pitch correction tools, equalizers.
- Protocols and algorithms in computer based production: MIDI, IEC-60958 (AES / EBU), S/PDIF, AC-3, E-AC-3.
- Synchronization mechanisms: MTC, SMPTE, video and movie integration.
- Programming standards: interfaces (VST / Steinberg, DirectX / MS), formats (wav, MP3, Ogg).
- Contemporary sound reproduction (network streaming, protocols RTP, RTCP, RTSP).
- Professional tools (Steinberg, Roland, open source solutions).
- Intelectual property protection.
- Comclusions.
- Addendum: Mini practical tasks covering the latest technological issues or specific issues not covered at laboratory works.

Temeljni literatura in viri / Readings:

- D. Trček: Računalniška zvočna produkcija, kopije prosojnic, FRI UL, 2017 / 2018.
- Loy G., Musimathics, The MIT Press, MIT, Cambridge, 2006.

Cilji in kompetence:

Cilj predmeta je, da študentje tehničnih in umetniških profilov pridobijo in osvojijo znanja na področju računalniške zvočne produkcije tako za čisto tehnično, kot tudi kreativno aplikacijo v produkcijskih okoljih.

Splošne kompetence:

- Sposobnost definiranja, razumevanja in reševanja kreativnih profesionalnih izzivov na področju računalništva in informatike.
- Sposobnost profesionalnega komuniciranja v materinem in tujem jeziku.
- Sposobnost razumevanja in uporabe znanja računalništva in informatike na drugih relevantnih področjih (ekonomija, organizacija, umetnost, itd.).

Predmetno specifične kompetence:

- Praktična znanja in sposobnosti na področju strojne in programske opreme ter informacijske tehnologije za uspešno profesionalno delo.

Objectives and competences:

The goal of the course is to educate students (with technological and fine-arts background) for using computers in sound production be it for purely technical, or creative application scenarios and production environments.

General competences:

- The ability to define, understand and solve creative professional challenges in computer and information science.
- The ability of professional communication in the native language as well as a foreign language.
- The ability to understand and apply computer and information science knowledge to other technical and relevant fields (economics, organisational science, fine arts, etc).

Subject specific competences:

- Practical knowledge and skills of computer hardware, software and information technology necessary for successful professional work in computer and information science.

Predvideni študijski rezultati:

Po zaključku predmeta bo študent:

Intended learning outcomes:

After completition of the course a student will:

-poznal inženirske principe računalniške zvočne produkcije; -poznal in razumel fiziološke zakonitosti percepcije zvoka; -znal uporabljati omenjene principe v produkcijskem okolju; -sposoben razvoja enostavnejših tehnoloških rešitev na tem področju; -uporabe pridobljenih znanj tudi na področjih kreativnega ustvarjanja (umetnost); -poznal problematiko zaščite in varovanja intelektualne lastine.	-be familiar with the engineering principles of computer sound production; -know and understand physiological laws of sound perception; -be able to implement these principles in production environments; -be able to develop basic technological solutions in this area; -know how to use the acquired knowledge in creative ways (fine arts); -be familiar with intellectual property protection.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja, vaje s projektnim delom (praktične prototipne implementacije), lastne predstavitve. Udeležba na vajah je obvezna (zahtevan procent udeležbe se določi ob začetku študijskega leta). Nosilec predmeta lahko določi obvezno udeležbo tudi na predavanjih.	Lectures, laboratory work (with practical prototype implementations), students' presentations. Attendance of laboratory work is mandatory (the exact percentage is announced at the beginning of a study year). The lecturer may impose mandatory attendance of lectures.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
50 % ocene predstavlja sprotno delo študenta v obliki preverjanj na vajah (domače naloge, kvizi, praktičen projekt), 50 % ocene pa predstavlja izpit, ki je načeloma v pisni obliki, lahko pa tudi v pisni in ustni obliki (pri čemer lahko nosilec namesto ustnega izpita uvede seminar). Za uspešno opravljene obveznosti pri predmetu morata biti pozitivni obe delni oceni. Pristop k pisnemu izpitu je možen le po uspešno opravljenih obveznostih pri vajah (in v primeru dodatnih zahtev, ki se	**50%** **50%**	50% of the final grade is obtained on the basis of on-going laboratory work (home-works, quizzes, practical project implementations and presentations). The other 50% is obtained on the basis of a written exam, or written and oral exam (the lecturer may decide that a coursework replaces the oral exam). To be eligible for the written exam, a candidate must have successfully completed laboratory work, and fulfilled other obligations related to lecturing that the lecturer may have imposed. For successful

nanašajo na predavanja, po izpolnitvi le-teh). Ocene: 6-10 pozitivno, 5 negativno (v skladu s Statutom UL).		completition of the course both grades have to be positive. Grading: 6-10 pass, 5 fail (according to the rules of University of Ljubljana).

Reference nosilca / Lecturer's references:

Pet najpomembnejših del:

1. Trček D., An integrative architecture for a sensor-supported trust management system. Sensors, vol. 12, no. 8, str. 1-14, 2012.

2. Trček D. et al., Computationally supported musical composition using Petri Nets, Proc. of the ACACOS '13, str. 149--152, Kuala Lumpur, 2013.

3. Jelenc D., Trček D., Qualitative trust model with a configurable method to aggregate ordinal data, Autonomous agents and multi-agent systems, vol. 28, iss. 5, pp. 805-835, Springer, 2014.

4. Trček D., STRATOSpheric SMOOTH, CD and MP3 web edition, Amazon / CreateSpace, Seattle, 2012.

5. Tamara T. Pečak et al., Gabrijel Stupica pod drobnogledom - tehnologija nastajanja in reševanja umetnin, DVD, Moderna galerija, UL ALUO, Zavod za varstvo kulturne dediščine, Ljubljana, 2013 (glasbena oprema, soavtor D. Trček).

Celotna bibliografija je dostopna na SICRISu:

The whole bibliography can be obtained at the below URL:

http://sicris.izum.si/search/rsr.aspx?lang=slv&id=7226.

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Napredna računalniška grafika
Course title:	Advanced Computer Graphics

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Magistrski študijski program druge stopnje Računalništvo in informatika Interdisciplinarni magistrski študijski program 2. stopnje Multimedija	**ni smeri**	**1, 2**	**zimski**
Master study program Computer and Information Science, level 2 Interdisciplinary Master study program Multimedia, level 2	**none**	**1, 2**	**fall**

Vrsta predmeta / Course type	**strokovni izbirni predmet / specialist elective course** Tematski sklopi / Thematic set: Medijske tehnologije / Media technologies Računske metode / Computational Methods FRI C/FRI C
Univerzitetna koda predmeta / University course code:	63553

Predavanja **Lectures**	**Seminar** **Seminar**	**Vaje** **Tutorial**	**Klinične vaje** **Laboratory work**	**Druge oblike študija** **Field work**	**Samost. delo** **Individ. work**	**ECTS**
45	**/**	**30**	**/**	**/**	**105**	**6**

Nosilec predmeta / Lecturer:	doc. dr. Matija Marolt
Jeziki / Predavanja / Lectures:	slovenščina, angleščina

Languages:	Slovene, English
Vaje / Tutorial:	slovenščina, angleščina Slovene, English

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:

Prerequisites:

Vsebina:

Predavanja:

3D predstavitve

1. polna telesa, CSG, B-Reps
2. voksli, posredno upodabljanje, volumetrično upodabljanje
3. točkovne predstavitve, pretvorba v ploskovne

Upodabljanje

1. osnove fotometrije in radiometrije, osvetljevanje, odsevanje
2. napredni modeli osvetljevanja in odsevanja, BRDF, podpovršinsko razprševanje
3. globalna osvetlitev: enačba upodabljanja, modeli za reševanje
4. Monte Carlo sledenje poti, Metropolis light transport, mapiranje fotonov

Animacija

1. interpolacija, kinematika
2. zajem gibanja, urejanje gibanja, predelava gibanja
3. dinamika: sistemi delcev in vzmeti, animacija tekočin, toga telesa, mehka telesa

Content (Syllabus outline):

Lectures:

3D representations

1. solid bodies, CSG, B-Reps
2. voxels, indirect rendering, volumetric rendering
3. point based representations, mesh reconstruction

Rendering

1. foundations of radio- and photometry, lighting, reflection
2. advanced lighting models, BRDF, subsurface scattering
3. global illumination: rendering equation, models for solutions
4. Monte Carlo path tracing, Metropolis light transport, photon mapping

Animation

1. interpolation, kinematics
2. motion capture, editing and retargeting
3. dynamics: particle and mass-spring systems, animation of fluids, rigid bodies, deformable models
4. crowd simulation

4. simulacija množic
5. obrazna animacija

Vaje:

Laboratorijski projekti, na katerih študenti implementirajo lastne rešitve za vizualizacijo in animacijo 3D predmetov.

5. facial animation

Laboratory:

Laboratory projects, where students implement their own solutions for visualization and animation of 3D models.

Temeljni literatura in viri / Readings:

1. Matt Phar and Greg Humphreys: *Physically Based Rendering: From Theory To Implementation.* Morgan Kaufmann, Second Edition, 2010
2. Rick Parent: *Computer Animation: Algorithms and Techniques*. Morgan Kaufmann, 3. edition 2012.
3. John Hughes , Andries van Dam, Morgan McGuire, David F. Sklar, James D. Foley, Steven K. Feiner, Kurt Akeley: *Computer Graphics: Principles and Practice.* Addison-Wesley Professional; 3. edition, 2013

Cilji in kompetence:

Cilj predmeta je, da študenti razumejo matematične in fizikalne aspekte in algoritme, ki so podlaga modernih pristopov v računalniški grafiki (teoretična podlaga), ter da jih znajo aplicirati v svoje programske rešitve (praksa).

Študenti bodo pridobili naslednje kompetence:

- Zmožnost kritičnega, analitičnega in sintetičnega razmišljanja
- Zmožnost definiranja, razumevanja in reševanja ustvarjalnih profesionalnih izzivov v računalništvu in informatiki
- Sposobnost profesionalnega komuniciranja v materinem in tujem jeziku
- Sposobnost uporabe pridobljenega znanja za reševanje tehničnih in znanstvenih problemov v računalništvu; sposobnost nadgrajevanja pridobljenega znanja.
- Kompetence na področju računalništva in informatike, ki omogočajo nadaljevanje študija na tretji stopnji.

Objectives and competences:

The objective of the course is that students gain understanding of mathematical, physical and algorithmic aspects that are the basis of modern approaches in computer graphics (theory) and that they can apply them to their own software solutions (practice).

When completing the course, students will gain the following competences:

- Developing skills in critical, analytical and synthetic thinking
- The ability to define, understand and solve creative professional challenges in computer and information science
- The ability of professional communication in the native language as well as a foreign language
- The ability to apply acquired knowledge in independent work for solving technical and scientific problems in computer and information science; the ability to upgrade acquired knowledge
- Competences in computer and information science granting access to further study at 3rd cycle doctoral programmes

Predvideni študijski rezultati:	**Intended learning outcomes:**
Po uspešnem zaključku tega predmeta bo študent: - razumel delovanj metod neposredne in posredne rekonstrukcije in upodabljanja 3D predmetov - poznal osnove radiometrije in fotometrije - razumel delovanje metod za fotorealistično upodabljanje - razumel in uporabljal verjetnostne metode za numerično integracijo - razumel in uporabljal metode za numerično reševanje navadnih diferencialnih enačb - razumel delovanje različnih vrst animacijskih algoritmov - sposoben analizirati in implementirati napredne metode računalniške grafike na podlagi znanstvene literature	After the completion of the course the student will be able to: - understand the methods for direct and indirect reconstruction and rendering of 3D objects - know the basics of radiometry and photometry - understand the methods for photorealistic rendering - understand and use probabilistic methods for numerical integration - understand and use methods for numeric solving of ordinary differential equations - understand the different methods for animation - analyze and implement advanced computer graphics methods based on study of scientific literature

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja s praktičnimi demonstracijami, izvajanje laboratorijskega projekta pod mentorstvom asistenta.	Lectures with practical demostrations, laboratory work under the supervision of assistants.

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

Reference nosilca / Lecturer's references:

Pet najpomembnejših del:

1. LESAR, Žiga, BOHAK, Ciril, MAROLT, Matija. Evaluation of angiogram visualization methods for fast and reliable aneurysm diagnosis. Medical imaging 2015 : image perception, observer performance, and technology assessment : 25-26 February 2015, Orlando, Florida, United States.

2. BOHAK, Ciril, SODJA, Anže, MAROLT, Matija, MITROVIĆ, Uroš, PERNUŠ, Franjo. Fast segmentation, conversion and rendering of volumetric data using GPU. IWSSIP 2014 : proceedings, (International Conference on Systems, Signals, and Image Processing (Print), ISSN 2157-8672), 2014, str. 239-242.

3. MAROLT, Matija. A connectionist approach to automatic transcription of polyphonic piano music. IEEE trans. multimedia. [Print ed.], str. 439-449, ilustr. [COBISS.SI-ID 4203860]

4. MAROLT, Matija. A mid-level representation for melody-based retrieval in audio collections. IEEE trans. multimedia. [Print ed.], Dec. 2008, vol. 10, no. 8, str. 1617-1625, ilustr. [COBISS.SI-ID 6908756]

5. PESEK, Matevž, LEONARDIS, Aleš, MAROLT, Matija. Robust real-time music transcription with a compositional hierarchical model. PloS one, ISSN 1932-6203, Jan. 2017, vol. 12, no. 1, str. 1-21 [COBISS.SI-ID 1537322179]

Celotna bibliografija je dostopna na SICRISu:

http://sicris.izum.si/search/rsr.aspx?lang=slv&id=8948

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Brezžična senzorska omrežja
Course title:	Wireless sensors networks

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Magistrski študijski program druge stopnje Računalništvo in informatika Interdisciplinarni magistrski študijski program druge stopnje Multimedija	ni smeri	1, 2	poletni
Master study program Computer and Information Science, level 2 Interdisciplinary Master study program Multimedia, level 2	none	1, 2	spring

Vrsta predmeta / Course type	**strokovni izbirni predmet / specialist elective course** Tematski sklopi / Thematic set: Strojna oprema / Hardware Omrežja in varnost / Computer networks and security FRI D / FRI D
Univerzitetna koda predmeta / University course code:	63511

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

Nosilec predmeta / Lecturer:	prof. dr. Nikolaj Zimic

Jeziki / Languages:	**Predavanja / Lectures:**	slovenščina in angleščina Slovene and English
	Vaje / Tutorial:	slovenščina in angleščina Slovene and English

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites:**

Vsebina:

Poglavja predavanj:

1. Zgradba omrežnega priključka (senzorja)
2. Arhitektura senzorskega omrežja
3. Fizični nivo
4. Poimenovanje in naslavljanje
5. Časovna sinhronizacija
6. Določanje pozicije v prostoru
7. Topologija omrežja
8. Usmerjevalni protokoli
9. Podatkovno in vsebinsko usmerjena omrežja
10. Transportni protokoli

Content (Syllabus outline):

Basic topics:

1. Single – node architecture
2. Network architecture
3. Physical layer
4. Naming and addressing
5. Time synchronization
6. Localization and positioning
7. Network topology
8. Routing protocols
9. Data centric and content – based networks
10. Transport layer

Temeljni literatura in viri / Readings:

1. Holger Karl, Andreas Willig, “Protocols and Architectures for Wireless Sensor Networks ”, Wiley, 2007, ISBN: 0470519231
2. Waltenegus Dargie, Christian Poellabauer , Fundamentals of Wireless Sensor Networks: Theory and Practice, Wiley , 2010, ISBN: 978-0-470-99765-9

Dodatna literatura:

1. Ibrahiem M. M. El Emary, S. Ramakrishnan, "Wireless Sensor Networks: From Theory to Applications", CRC Press, 2013, ISBN-10: 1466518103

Cilji in kompetence:

Cilj predmeta je študentom računalništva in informatike predstaviti senzorska omrežja. Poudarek je na posebnostih senzorskih omrežij, ki se od običajnih razlikujejo po omejeni moči procesorja ter omejeni energiji za napajanje.

Objectives and competences:

The goal of this course is to gain the main knowledge about wireless sensor networks with their special properties (different processing and power capabilities).

Predvideni študijski rezultati:

Intended learning outcomes:

Znanje in razumevanje:	**Knowledge and understanding:**
Po uspešno opravljenem modulu na bi bili študenti zmožni: - izkazati znanje in razumevanje osnovnih principov senzorskih omrežij - uporabiti postopke časovne sinhronizacije, - določiti pozicijo senzorja v prostoru, - zasnovati enostavno topologijo senzorskega omrežja, - uporabiti ustrezen usmerjevalni protokol, - izbrati ustrezen transportni protokol, razlikovati med podatkovno in vsebinsko usmerjenimi omrežji. **Uporaba:** Uporaba senzorskih omrežij pri raznih pogojih uporabe (v industriji, pri zajemanju podatkov na širokem področju, v domu, ...). **Refleksija:** Spoznavanje in razumevanje uglašenosti med teorijo in njeno aplikacijo na konkretnih primerih s področja senzorskih omrežij. **Prenosljive spretnosti - niso vezane le na en predmet:** Reševanje drugih konceptualno sorodnih problemov s področja komunikacije in zajemanja podatkov.	After successful completion of the course, students should be able to: - understand the principles of sensor networks, - use time synchronization techniques, - determine the position of the sensor in the space, - design a simple topology of the sensor network, - use an appropriate routing protocol, - select the appropriate transport protocol, - distinguish between data and content-oriented networks. **Application:** Use of sensor networks in various scenarios (industry, general data acquisition, intelligent home,…). **Reflection:** Learning and understanding the correlation between theory and its application to specific scenarios of sensor network use. **Transferable skills:** Solving other conceptually related problems from the fields of communication and data acquisition.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja, računske vaje z ustnimi nastopi. Poseben poudarek je na sprotnem študiju in na laboratorijskem delu pri vajah.	Lectures, numerical exercises and oral presentations. Special attention is given to active study and laboratory work.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Način (pisni izpit, ustno izpraševanje, naloge, projekt):		Type (examination, oral, coursework, project):
Sprotno preverjanje (domače naloge, kolokviji, projektno in seminarsko delo)	**50%**	**Continuing** (homework, midterm exams, project work or seminar paper)
Končno preverjanje (pisni izpit)	**50%**	**Final** (written exam)
Ocene: 6-10 pozitivno, 5 negativno (v skladu s Statutom UL).		Grading: 6-10 pass, 5 fail (according to the rules of University of Ljubljana).

Reference nosilca / Lecturer's references:

Pet najpomembnejših del:
VASYLCHENKOVA, Anastasiia, MRAZ, Miha, ZIMIC, Nikolaj, MOŠKON, Miha. Classical mechanics approach applied to analysis of genetic oscillators. IEEE/ACM transactions on computational biology and bioinformatics, ISSN 1545-5963. [Print ed.], May/Jun. 2017, vol. 14, no. 3, str. 721-727,

BORDON, Jure, MOŠKON, Miha, ZIMIC, Nikolaj, MRAZ, Miha. Fuzzy logic as a computational tool for quantitative modelling of biological systems with uncertain kinetic data. IEEE/ACM transactions on computational biology and bioinformatics, ISSN 1545-5963. [Print ed.], 2015, vol. 12, no. 5, str. 1199-120

PETRONI, Mattia, ZIMIC, Nikolaj, MRAZ, Miha, MOŠKON, Miha. Stochastic simulation algorithm for gene regulatory networks with multiple binding sites. Journal of computational biology, ISSN 1066-5277. [Print ed.], Mar. 2015, vol. 22, no. 3, str. 218-226,

ŠOBERL, Domen, ZIMIC, Nikolaj, LEONARDIS, Aleš, KRIVIC, Jaka, MOŠKON, Miha. Hardware implementation of FAST algorithm for mobile applications. Journal of signal processing systems for signal, image, and video technology, ISSN 1939-8018. [Print ed.], 2015, vol. 79, no. 3, str. 247-256,

PEČAR, Primož, MRAZ, Miha, ZIMIC, Nikolaj, JANEŽ, Miha, LEBAR BAJEC, Iztok. Solving the ternary quantum-dot cellular automata logic gate problem by means of adiabatic switching. *Japanese journal of applied physics*, ISSN 0021-4922, 2008, vol. 47, no. 6, str. 5000-5006

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Nekonvencionalne platforme in metode procesiranja
Course title:	Unconventional computing

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Magistrski študijski program druge stopnje Računalništvo in informatika	**ni smeri**	**1, 2**	**zimski**
Master study program Computer and Information Science, level 2	**none**	**1, 2**	**fall**

Vrsta predmeta / Course type	**strokovni izbirni predmet / specialist elective course** Strojna oprema / Hardware Računske metode / Computational methods
Univerzitetna koda predmeta / University course code:	63512

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

Nosilec predmeta / Lecturer:	prof. dr. Miha Mraz

Jeziki / Languages:	**Predavanja / Lectures:**	slovenščina in angleščina Slovene and English
	Vaje / Tutorial:	slovenščina in angleščina Slovene and English

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites:**

Vsebina:

Predavanja:

I. Platformno pogojene metode procesiranja:

a.) Kvantni celularni avtomati (angl. quantum dot cellular automata)

b.) Kvantno računalništvo (angl. quantum processing, q.computer)

c.) MEMS in NEMS naprave (angl. micro/nano electro mechanical systems)

d.) Optično računalništvo (angl. optical computing)

e.) DNK procesiranje (angl. DNA computing)

f.) Nanocevi (angl. nanotubes)

II. Platformno neodvisne metode procesiranja:

a.) Amorfno procesiranje (angl. amorphous computing)

b.) Reverzibilno procesiranje (angl. reversible computing)

c.) Večstanjsko in analogno procesiranje (angl. multistate and analogous computing)

d.) Naravno inspirirano procesiranje (angl. bio inspired computing)

Content (Syllabus outline):

Basic topics:

I. Unconventional processing platforms:

- quantum dot cellular automata,
- quantum computing,
- MEMS/NEMS devices,
- Optical computing
- DNA processing,
- nanotubes, etc.

II. Unconventional processing approaches:

- amorphous computing,
- reversible computing,
- multistate and analogous computing,
- bio inspired computing, etc.

Temeljni literatura in viri / Readings:

1. M.Mraz: Iskanje procesne platforme prihodnosti. https://ucilnica.fri.uni-lj.si/course/view.php?id=91. (e-book, 2017)

2. F.Lombardi, J.Huang: Design and test of digital circuits by quantum-dot cellular automata**,** Artech House Inc., 2008

3. U.Alon: An introduction to systems biology : design principles of biological circuits, Chapman & Hall / CRC, 2007

Cilji in kompetence:

Cilj predmeta je študentom predstaviti nekatere najbolj aktualne metode in platforme procesiranja z vidika bazičnih sestavnih struktur, ki se danes uveljavljajo kot možne alternative klasičnim električno tranzistorskim dvovrednostnim logičnim strukturam. Razvoj slednjih bo drastično upočasnjen zaradi problemov tendenc miniaturizacije, saj jim bo tehnologija s svojimi rešitvami vse težje sledila. Ostale kompetence:

- Zmožnost definiranja, razumevanja in reševanja profesionalnih izzivov
- Zmožnost iskanja novih virov znanj in njihova kritična evaluacija

Objectives and competences:

The main goal of the course is to present recent unconventional methods and platforms for computer processing needs. The motivation for the course comes from the restrictions in the field of minimization of classical computer structures. Other competences:

- The ability to define, understand and solve creative professional challenges in computer and information science;
- The ability to search knowledge sources and to search for resources and critically evaluate information.

Predvideni študijski rezultati:

Po uspešnem zaključku tega predmeta bo študent:

- sposoben kritične analitične obravnave načina delovanja obstoječih platform in metod procesiranja,
- razumel koncept reverzibilnosti logičnih funkcij,
- poznal in znal uporabljati koncepte porazdeljenih sistemov celularnih avtomatov in kvantnih celularnih avtomatov,
- razumel in znal uporabljati koncepte večvrednostnih logik in procesiranja,
- razumel koncepte biološkega procesiranja,
- razumel koncepte kvantnega procesiranja,
- sposoben obravnave in reševanja problema na osnovi alternativnih metod procesiranja.

Intended learning outcomes:

After the completion of the course a student:

- will be able to objectively analyse the existing processing platforms and methods,

- will be able to understand the concept of logic functions reversibility,

- will be familiar with the concepts of distributed systems, such as cellular automata and quantum-dot cellular automata,

- will understand and will be able to apply the concepts of a many-valued logic and processing in practice,

- will understand the concepts of biological computing,

- will understand the concepts of quantum computing,

- will be able to solve problems on the basis of alternative processing methods.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja, praktične vaje s seminarji vsebinsko vezane na izvajanje eksperimentov, postavitve modelov, itd.	Lectures, practical lessons with seminar works, etc.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Način (pisni izpit, ustno izpraševanje, naloge, projekt): **Sprotno preverjanje** (domače naloge, kolokviji, projektno in seminarsko delo) **Končno preverjanje** (pisni izpit) Ocene: 6-10 pozitivno, 5 negativno (v skladu s Statutom UL).	**50%** **50%**	Type (examination, oral, coursework, project): **Continuing** (homework, midterm exams, project work or seminar paper) **Final** (written exam) Grading: 6-10 pass, 5 fail (according to the rules of University of Ljubljana).

Reference nosilca / Lecturer's references:

Pet najpomembnejših del:

1. LEBAR BAJEC, Iztok, ZIMIC, Nikolaj, MRAZ, Miha. Towards the bottom-up concept: extended quantum-dot cellular automata. *Microelectron. eng.*. [Print ed.], 2006, vol. 83, no. 4/9, str. 1826-1829, ilustr. [COBISS.SI-ID 5212244], [WoS, št. citatov do 7.8.09: 4, brez avtocitatov: 2, normirano št. citatov: 2] JCR IF: 1.398, SE (48/206), engineering, electrical & electronic, x: 0.942, SE (18/32), nanoscience & nanotechnology, x: 2.04, SE (20/55), optics, x: 1.239, SE (34/84), physics, applied, x: 1.846
2. LEBAR BAJEC, Iztok, ZIMIC, Nikolaj, MRAZ, Miha. The ternary quantum-dot cell and ternary logic. *Nanotechnology (Bristol)*, 2006, vol. 17, no. 8, str. 1937-1942, ilustr. [COBISS.SI-ID 5201748], [WoS, št. citatov do 7.5.09: 5, brez avtocitatov: 3, normirano št. citatov: 4] JCR IF: 3.037, SE (2/66), engineering, multidisciplinary, x: 0.746, SE (5/32), nanoscience & nanotechnology, x: 2.04, SE (22/175), materials science, multidisciplinary, x: 1.659, SE (9/84), physics, applied, x: 1.846
3. MOŠKON, Miha, MRAZ, Miha. Systematic approach to computational design of gene regulatory networks with information processing capabilities. *IEEE/ACM transactions on computational biology and bioinformatics*, ISSN 1545-5963. [Print ed.], 2014, vol. 11, no. 2
4. PETRONI, Mattia, ZIMIC, Nikolaj, MRAZ, Miha, MOŠKON, Miha. Stochastic simulation algorithm for gene regulatory networks with multiple binding sites. *Journal of computational biology*, ISSN 1557-8666. [Online ed.], 2014, vol. 21
5. STRAŽAR, Martin, MRAZ, Miha, ZIMIC, Nikolaj, MOŠKON, Miha. An adaptive genetic algorithm for parameter estimation of biological oscillator models to achieve target quantitative system response. *Natural computing*, ISSN 1567-7818, Mar. 2014, vol. 13, no. 1, str. 119-127.

Celotna bibliografija je dostopna na SICRISu:

http://sicris.izum.si/search/rsr.aspx?lang=slv&id=8066.

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Računalniško vodenje procesov
Course title:	Computer-based process control

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Magistrski študijski program druge stopnje Računalništvo in informatika	**ni smeri**	**1, 2**	**zimski / poletni**
Master study program Computer Science and Informaticss, level 2	**none**	**1, 2**	**fall / spring**

Vrsta predmeta / Course type	**strokovni izbirni predmet / specialist elective course** Strojna oprema / Hardware
Univerzitetna koda predmeta / University course code:	63543

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

Nosilec predmeta / Lecturer:	izr. prof. dr. Uroš Lotrič

Jeziki / Languages:	**Predavanja / Lectures:**	slovenščina in angleščina Slovene and English
	Vaje / Tutorial:	slovenščina in angleščina Slovene and English

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites:**

Uspešno opravljene domače naloge in seminarsko-projektne naloge so pogoj za opravljanje izpita.	Student duties as specified in rules of the Faculty and University. Successful completion of homework and projects is required for students to approach to a final exam.

Vsebina:	**Content (Syllabus outline):**
• Sistemi in sistemska teorija • Principi vodenja in teorija vodenja • Hierarhija sistemov vodenja • Industrijski merilni sistemi • Izvršni sistemi v vodenju procesov • Vmesniki in signalne povezave • Industrijski komunikacijski protokoli • Programirljivi logični krmilniki • Standardni programski jeziki za programiranje logičnih krmilnikov • Regulacija procesov: osnove, regulator PID • Moderni pristopi k regulaciji: mehka logika, učeči sistemi • Naprave za komunikacijo s človekom • Standard OPC • Namen in funkcije nadzornih sistemov MES • Varnost • Dokumentacija	• Systems and the system theory • Principles of control and the control theory • Hierarchy of the control systems • Industrial sensors • Actuators • Interfaces and signal connections • Industrial communication protocols • Programmable logic controllers • Programming languages for programmable logic controllers • Process control: basics, PID controller • Modern process control: fuzzy logic, intelligent control • Human machine interfaces • The OPC standard • The purpose and functions of the Management Execution Systems (MES) • Safety • Documentation

Temeljni literatura in viri / Readings:

- Zupančič, B.: Avtomatsko vodenje sistemov, Založba FE in FRI, 2011
- Dorf, R.C, Bishop, R.H.: Modern Control Systems, 11 izdaja, Prentice Hall, 2008
- Hackworth, J.R., Hackworth, F.D.: Programmable Logic Controllers: Programming Methods and Applications, Pearson, 2004.
- Dobnikar, A., Šter, B.: Mehko računanje za modeliranje, razpoznavanje in regresijo, Založba FE in FRI, 2008
- Nguyen, H.T., Prasad, N.R., Walker, C.L., Walker, E.A.:A First Course in Fuzzy and Neural Control, CRC, 2003

Cilji in kompetence:	**Objectives and competences:**

Študentje naj bi v okviru tega predmeta pridobili znanja, ki so potrebna za zasnovo in izvedbo celovite računalniške podpore vodenja procesov.	During the course students should gain the knowledge needed to design and implement computer aided control of industrial processes.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Po uspešnem zaključku tega predmeta bo študent: - poznal arhitekturo modernih sistemov vodenja - znal programirati industrijske krmilnike v vsaj enem standarnem jeziku - znal pripraviti in v sistem integrirati vmesnik človek-stroj - obladal osnovne principe vodenja procesov - sposoben izkazati znanje osnovnih principov regulacij (večtočkovni regulator, regulator PID) - poznal principe moderne kontrole vodenja (mehki regulatorji, regulatorji na osnovi nevronskih mrež)	After the completion of the course the student will be able to: - understand the architecture of modern control systems - know how to program in one of the standard programming languages - prepare human-machine interface and integrate it to control system - understand the basic principles of control systems - understand closed-loop control and use it in practice (two-point controller, PID controller) - know the principles of modern control (fuzzy controllers, neural-network based controllers)

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja s podporo avdio-vizualne opreme, demonstracije v živo. Predavanja vabljenih specialistov, obisk tovarn. Velik poudarek na praktičnih vajah na modelnih sistemih.	Lecturing with the help of audio-visual equipment and real-life demonstrations. Invited lectures from industry, visits of production companies. Important focus on practical exercises using models of real production lines and robots.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Način (pisni izpit, ustno izpraševanje, naloge, projekt): **Sprotno preverjanje** (domače naloge in projektno delo) **Končno preverjanje** (ustni izpit)	**50%** **50%**	Type (examination, oral, coursework, project): **Continuing** (homework, project work) **Final** (oral exam)

Ocene: 6-10 pozitivno, 5 negativno (v skladu s Statutom UL).		Grading: 6-10 pass, 5 fail (according to the rules of University of Ljubljana).

Reference nosilca / Lecturer's references:

Pet najpomembnejših del:

1. TREBAR, Mira, ŠUŠTERIČ, Zoran, LOTRIČ, Uroš. Predicting mechanical properties of elastomers with neural networks. Polymer (Guildf.). [Print ed.], 2007, 48, 5340-5347
2. BRATINA, Marko, ŠUŠTERIČ, Zoran, ŠTER, Branko, LOTRIČ, Uroš, DOBNIKAR, Andrej. Predictive control of rubber mixing process based on neural network models. Kautschuk-Gummi-Kunststoffe, 2009, vol. 62, 378-382
3. SILVA, Catarina, LOTRIČ, Uroš, RIBEIRO, Bernardete, DOBNIKAR, Andrej. Distributed text classification with an ensemble kernel-based learning approach. IEEE trans. syst. man cybern., Part C Appl. rev., May 2010, vol. 40, 287-297
4. LOTRIČ, Uroš, BULIĆ, Patricio. Applicability of approximate multipliers in hardware neural networks. Neurocomputing, 2012, vol. 96, str. 57-65
5. LOTRIČ, Uroš, BULIĆ, Patricio. Logarithmic arithmetic for low-power adaptive control systems. Circuits Systems and Signal Processing, 2016, 1-21

Celotna bibliografija je dostopna na SICRISu: http://sicris.izum.si/search/rsr.aspx?lang=slv&id=9241.

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Informacijska varnost in zasebnost
Course title:	Information Security and Privacy

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Magistrski študijski program druge stopnje Računalništvo in informatika Interdisciplinarni magistrski študijski program druge stopnje Računalništvo in matematika Interdisciplinarni magistrski študijski program druge stopnje Pedagoško računalništvo in informatika Interdisciplinarni magistrski študijski program druge stopnje Multimedija	ni smeri	1, 2 1	zimski
Master study program Computer and Information Science, level 2 Interdisciplinary Master study program Computer Science and Mathematics, level 2 Interdisciplinary Master study program Computer Science Education, level 2 Interdisciplinary Master study program Multimedia, level 2	none	1, 2	fall

		1	

Vrsta predmeta / Course type	**strokovni izbirni predmet / specialist elective course** Tematski sklopi / Thematic set: Programska oprema / Software Informacijski sistemi in sistemi za upravljanje / Information and management systems Omrežja in varnost / Computer networks and security FRI 1 / FRI 1 FRI B / FRI B FRI D / FRI D
Univerzitetna koda predmeta / University course code:	63521

Predavanja **Lectures**	**Seminar** **Seminar**	**Vaje** **Tutorial**	**Klinične vaje** **Laboratory work**	**Druge oblike študija** **Field work**	**Samost. delo** **Individ. work**	**ECTS**
45	/	30	/	/	105	6

Nosilec predmeta / Lecturer:	prof. dr. Denis Trček

Jeziki / Languages:	**Predavanja / Lectures:**	slovenščina in angleščina Slovene and English
	Vaje / Tutorial:	slovenščina in angleščina Slovene and English

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites:**

Vsebina:

- Uvodni pregled področja.
- Ključne organizacije in standardi (ISO, ITU-T, IETF, W3C, OASIS, OMA).
- Varnostni mehanizmi in varnostne storitve (principi in praktične izvedbe overjanja, zaupnosti, celovitosti, nezatajljivosti, nadzora dostopa, beleženja in alarmiranja), infrastruktura javnih ključev (časovna normala, upravljanje imenskega prostora, operativni protokoli), osnove kvantnega procesiranja (kvantna izmenjava ključev).
- Infrastruktura za overjanje, avtorizacijo in nadzor (principi, primeri standardiziranih rešitev – RADIUS in Diameter).
- Varovanje na fizičnem in linijskem sloju (protokoli WEP, WPA1 in WPA2).
- Varovanje na mrežnem, transportnem in aplikacijskem sloju, vključno z internetom stvari in računalništvom v oblaku (protokoli IPSec, TLS, S/MIME, SET, XMLSec, SAML, XACML, WS-*).
- Formalne metode (taksonomija formalnih metod in primeri kot so metoda R. Rueppla, logika BAN).
- Obvladovanje zasebnosti (senzorske mreže, rešitve RFID) in obvladovanje zaupanja ter ugleda v storitvenih arhitekturah.
- Varnostno usmerjeno programsko inženirstva (prverjanje modelov).
- Obvladovanje tveganj pri varovanju informacijskih sistemov, organizacijski pristopi ter obvladovanje človeškega dejavnika (varnostne politike, modeliranje človeškega dejavnika in simulacije).
- Akreditacijski in nadzorno-revizijski postopki varnosti informacijskih sistemov (ISO 2700X, CISSP) ter evalvacijski postopki za zagotavljanje varnosti strojno-programskih komponent (Common Criteria).
- Temeljna zakonodaja (direktive EU in nacionalne implementacije).
- Zaključki.
- Addendum: Mini vložki s praktičnim delom, ki pokrivajo najnovejše trende.

Content (Syllabus outline):

- Introduction.
- Key standards and organizations (ISO, ITU-T, IETF, W3C, OASIS, OMA).
- Security mechanisms, security services (principles and practical implementations of authentication, confidentiality, integrity, non-repudiation, access control, logging and alarming), public key infrastructure (time base, name space management, operational protocols), quantum computing basics (quantum key exchange).
- Authentication, authorization and accounting infrastructure (principles, examples of standardized solutions like RADIUS and Diameter).
- Security of physical and data layers (example protocols are WEP, WPA1 and WPA2).
- Security of network, transport and application layers, including internet of things and clouds (example protocols are IPSec, TLS, S/MIME, SET, XMLSec, SAML, XACML, WS-*).
- Formal methods (taxonomy of formal methods, examples like R. Rueppl's method, logic BAN).
- Privacy management and privacy by design (sensor networks, RFID systems) with trust management and reputation management basics in services oriented architectures.
- Secure programming (model checking).
- Risk management in IS, organizational views and human factor views (security policies, human factor modelling and simulations).
- Accreditation and auditing of IS related to security (ISO 2700X, CISSP), and standards for technical implementations of hardware and software components (Common Criteria).
- Basic legislation in the area of IS security and privacy (EU directives, national implementations).
- Comclusions.
- Addendum: Mini practical tasks covering the latest selected technological issues.

Temeljni literatura in viri / Readings:

- D. Trček: Information Systems Security and Privacy, Springer, New York, Heidelberg, 2006.
- D. Trček, Informacijska varnost in zasebnost, kopije prosojnic, FRI UL 2017/2018.

Cilji in kompetence:

Cilj predmeta je, da študentje aktivno osvojijo znanja varovanja omrežij in zasebnosti v sodobnih informacijskih sistemih in sicer za namen skrbništva (administracije), kot tudi namen razvoja novih rešitev.

Kategorizirane kompetence:

-Razvijanje sposobnosti kritičnega, analitičnega in sintetičnega razmišljanja.

-Sposobnost definiranja, razumevanja in reševanja kreativnih profesionalnih izzivov na področju računalništva in informatike.

-Sposobnost profesionalnega komuniciranja v materinem in tujem jeziku.

-Sposobnost biti skladen z varnostnimi, funkcionalnimi in okoljskimi zahtevami.

-Sposobnost razumevanja in uporabe znanja računalništva in informatike na drugih relevantnih področjih (ekonomija, organizacija, umetnost, itd.).

-Praktična znanja in sposobnosti na področju strojne in programske opreme ter informacijske tehnologije za uspešno profesionalno delo.

Objectives and competences:

The goal of the course is to educate students to be able to actively provide security and privacy in contemporary information systems, be it as systems administrators, or developers of new solutions.

Categorized competences:

- Developing skills in critical, analytical and synthetic thinking.

- The ability to define, understand and solve creative professional challenges in computer and information science.

- The ability of professional communication in the native language as well as a foreign language.

- Compliance with security, functional, economic and environmental principles.

- The ability to understand and apply computer and information science knowledge to other technical and relevant fields (economics, organisational science, fine arts, etc).

-Practical knowledge and skills of computer hardware, software and information technology necessary for successful professional work in computer and information science.

Predvideni študijski rezultati:

Po zaključku predmeta bo študent:

-poznal in razumel principe varovanja informacijskih sistemov ter zagotavljanja zasebnosti;

-poznal in razumel standardne rešitve na tem področju;

Intended learning outcomes:

After completing this course a student will:

-know and be familiar with principles for providing security and privacy in information systems;

-know and understand standard solutions in this area;

-be able to administer security and privacy of information systems;

-sposoben operativno upravljati informacijske sisteme s stališča zagotavljanja varnosti in zasebnosti; -znal razvijati enostavnejše varnostne rešitve; -sposoben interne revizije informacijskih sistemov s stališča varnosti; -znal specificirati varnostno politiko.	-be able to develop simpler solutions in this domain; -be qualified for internal security and privacy auditing; -be able to define security policy.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja, vaje s projektnim delom (praktične prototipne implementacije), lastne predstavitve. Udeležba na vajah je obvezna (zahtevan procent udeležbe se določi ob začetku študijskega leta). Nosilec predmeta lahko določi obvezno udeležbo tudi na predavanjih.	Lectures, laboratory work (with practical prototype implementations), students' presentations. Attendance of laboratory work is mandatory (the exact percentage is announced at the beginning of a study year). The lecturer may impose mandatory attendance of lectures.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
50 % ocene predstavlja sprotno delo študenta v obliki preverjanj na vajah (domače naloge, kvizi, praktičen projekt), 50 % ocene pa predstavlja izpit, ki je načeloma v pisni obliki, lahko pa tudi v pisni in ustni obliki (pri čemer lahko nosilec namesto ustnega izpita uvede zagovor seminarja). Za uspešno opravljene obveznosti pri predmetu morata biti pozitivni obe delni oceni. Pristop k pisnemu izpitu je možen le po uspešno opravljenih obveznostih pri vajah (in v primeru dodatnih zahtev, ki se nanašajo na predavanja, po izpolnitvi le-teh). Ocene: 6-10 pozitivno, 5 negativno (v skladu s Statutom UL).	**50%** **50%**	50% of the final grade is obtained on the basis of on-going laboratory work (home-works, quizzes, practical project implementations and presentations). The other 50% is obtained on the basis of a written exam, or written and oral exam (the lecturer may decide that a coursework replaces the oral exam). To be eligible for the written exam, a candidate must have successfully completed laboratory work, and fulfilled other obligations related to lecturing that the lecturer may have imposed. For successful completition of the course both grades have to be positive. Grading: 6-10 pass, 5 fail (according to the rules of University of Ljubljana).

Reference nosilca / Lecturer's references:

Nekaj najpomembnejših del:

1. Trček D, Wireless sensors grouping proofs for medical care and ambient assisted-living deployment, Sensors, vol. 16, no. 1, str. 1-12, 2016.

2. Trček D., Likar B., Driving information systems security through innovations : first indications, Cybernetics and systems, ISSN 0196-9722, 2014.

3. Trček D., Qualitative assessment dynamics : complementing trust methods for decision making, International journal of information technology & decision making. vol. 13, no. 1, str. 155-173, 2014.

4. Trček D., Lightweight protocols and privacy for all-in-silicon objects, Ad hoc networks, ISSN 1570-8705, July 2013, vol. 11, no. 5, str. 1619-1628.
5. Trček D., Brodnik A., Hard and soft security provisioning for computationally weak pervasive computing systems in e-health, IEEE wireless communications, vol. 20, no. 4, 8 str., 2013.

Celotna bibliografija je dostopna na SICRISu:

The whole bibliography can be obtained at the below URL:

http://sicris.izum.si/search/rsr.aspx?lang=slv&id=7226.

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Sodobne metode razvoja programske opreme
Course title:	Modern software development methods

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Magistrski študijski program druge stopnje Računalništvo in informatika Interdisciplinarni magistrski študijski program 2. stopnje Računalništvo in matematika Interdisciplinarni magistrski študijski program druge stopnje Pedagoško računalništvo in informatika Interdisciplinarni magistrski študijski program druge stopnje Multimedija	ni smeri	1, 2 1	poletni
Master study program Computer and Information Science, level 2 Interdisciplinary Master study program Computer Science and Mathematics, level 2 Interdisciplinary Master study program Computer Science Education, level 2 Interdisciplinary Master study program Multimedia, level 2	none	1, 2	spring

		1	

Vrsta predmeta / Course type	**strokovni izbirni predmet / specialist elective course** Tematski sklopi / Thematic set: Programska oprema / Software **obvezni predmet / compulsory course**
Univerzitetna koda predmeta / University course code:	63515

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

Nosilec predmeta / Lecturer:	prof. dr. Viljan Mahnič

Jeziki / Languages:	**Predavanja / Lectures:**	slovenščina in angleščina Slovene and English
	Vaje / Tutorial:	slovenščina in angleščina Slovene and English

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites:**

Vsebina:	**Content (Syllabus outline):**

Predavanja:

Vsebina predmeta se prilagaja trenutno aktualnim trendom na področju razvoja programske opreme. Trenutno je prilagojena obravnavi agilnih metod in empiričnemu ovrednotenju njihove učinkovitosti:

1. Pregled značilnosti agilnih metod za razvoj programske opreme

2. Vodenje agilnih projektov razvoja programske opreme

- iterativen in inkrementalen razvoj
- metoda Scrum

3. Tipične prakse ekstremnega programiranja

- Programiranje v parih
- Testno voden razvoj programske opreme
- Sprotno preoblikovanje kode (refactoring)
- Orodja za podporo testno vodenemu razvoju in preoblikovanju kode

4. Pomanjkljivosti ekstremnega programiranja

5. Kanban in vitek razvoj programske opreme

6. Metrike v programski opremi in merjenje učinkovitosti razvojnega procesa

7. Študija primera: empirično ovrednotenje posameznih praks iz točk 2 in 3

8. Primerjava agilnega pristopa z modeli za discipliniran razvoj programske opreme (Personal Software Process, Team Software Process, Capabilty Maturity Model)

Vaje:

Namen vaj je dvojen:

1. seznanjanje s sodobnimi orodji za razvoj programske opreme;

2. empirično ovrednotenje posameznih pristopov k razvoju programske opreme na podlagi praktičnega dela na projektih, ki so čim bolj podobni realnim.

Delo izven kontaktnih ur:

Študenti razvijajo programe, ki so sestavni del projekta, ki služi kot osnova za študijo primera.

Lectures:

The contents adapts to current trends in software development. At the moment the focus is on agile methods for software development and empirical evaluation of these methods:

1. Overview of agile methods for software development and their characteristics

2. Agile software project management

- Iterative and incremental development
- Scrum

3. Typical Extreme Programming practices

- Pair programming
- Test driven development (TDD)
- Refactoring
- Software tools that support TDD and refactoring

4. Weaknesses of Extreme Programming

5. Kanban and lean software development

6. Metrics in Software Engineering and measuring the effectiveness of the software development process

7. Case study: Empirical evaluation of the aforementioned practices

8. Comparison of agile approach to traditional disciplined software development processes (Personal Software Process, Team Software Process, Capability Maturity Model)

Lab practice:

The purpose of lab practice is twofold:

1. to acquaint students with modern software development tools;

2. to empirically evaluate different approaches to software development through practical work on (almost) real software projects.

Individual work outside of contact hours:

Students develop programs that are part of the project that serves as a case study.

Temeljni literatura in viri / Readings:

1. K. Schwaber: Agile Project Management with Scrum, Microsoft Press, 2004.

2. K. Beck: Extreme Programming Explained, Addison-Wesley, več izdaj.

3. D. Anderson, Kanban – Successful Evolutionary Change for Your Technology Business, Sequim, WA: Blue Hole Press, 2010.

4. K. Beck: Test-Driven Development: By Example, Addison-Wesley, 2003.

5. M. Cohn: User stories applied, Addison-Wesley, 2004.

Dodatna literatura:

1. B. Boehm, R. Turner: Balancing Agility and Discipline – A Guide for the Perplexed, Pearson Education, 2004.

2. CMMI for Development (CMMI-DEV), Version 1.2. CMU/SEI-2006-TR-008, Software Engineering Institute, Carnegie Mellon University, 2006.

Cilji in kompetence:

Cilj predmeta je poglobljena obravnava sodobnih (trenutno aktualnih) metod razvoja programske opreme v primerjavi z že uveljavljenimi pristopi. Študenti delajo na obsežnejšem projektu, ki služi kot študija primera za ovrednotenje novih pristopov, da bi ugotovili njihove prednosti in pomanjkljivosti.

Predvidene kompetence:

- sposobnost opredelitve, razumevanja in reševanja kreativnih strokovnih izzivov na področju računalništva in informatike;
- sposobnost uporabe pridobljenega znanja pri samostojnem delu za reševanje tehničnih in znanstvenih problemov na področju računalništva in informatike; sposobnost nadgradnje pridobljenega znanja,
- sposobnost skupinskega dela v profesionalnem delovnem okolju; vodenje manjše strokovne skupine;
- sposobnost administrativnega vodenja procesov, povezanih z raziskovanjem, industrijo, izobraževanjem in drugimi področji;
- sposobnost razumevanja in uporabe znanja računalništva in informatike na drugih tehničnih in relevantnih področjih (ekonomija, organizacijske vede ipd.);

Objectives and competences:

In depth treatment and empirical evaluation of modern software development methods in comparison to traditional approach. Students work on a project that serves as a case study for evaluation of modern approaches in order to find their strengths and weaknesses.

The competences students gain are:

- the ability to define, understand and solve creative professional challenges in computer and information science;
- the ability to apply acquired knowledge in independent work for solving technical and scientific problems in computer and information science; the ability to upgrade acquired knowledge.
- the ability of teamwork within the professional environment; management of a small professional team;
- the ability for administrative management of processes related to research, industry, education and other fields;
- the ability to understand and apply computer and information science knowledge to other technical and relevant fields (economics, organisational science, etc);
- practical knowledge and skills of computer hardware, software and information technology

• praktično znanje in spretnosti, potrebne za uspešno strokovno delo na področju računalništva in informatike; • samostojno reševanje zahtevnih razvojnih, inženirskih in organizacijskih nalog kot tudi povprečno zahtevnih raziskovalnih nalog na področju računalništva in informatike.	necessary for successful professional work in computer and information science; • independently tackle demanding developmental, engineering, and organisational tasks as well as moderately demanding research tasks in their fields of study.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Po uspešnem zaključku tega predmeta bo študent zmožen: • poznati in razumeti sodobne pristope k razvoju programske opreme • razumeti ključne prednosti sodobnih metod razvoja programske opreme (v primerjavi z že uveljavljenim tradicionalnim pristopom) • uporabljati orodja, ki podpirajo sodobne metode razvoja programske opreme • uporabiti sodobne metode razvoja programske opreme pri razvoju dejanskih softverskih projektov • empirično ovrednotiti rezultate novih metod • bolje razumeti različne faktorje in okoliščine, ki vplivajo na uspešnost softverskih projektov • izboljšati sposobnosti za skupinsko delo, vodenje, načrtovanje in organizacijo, medsebojno komuniciranje, pisno in ustno poročanje.	After the completion of the course a student will be able to: • know and understand modern approaches to software development • understand key benefits of modern software development methods (in comparison to traditional software development) • use tools that support modern software development methods • apply modern software development methods in the context of a real software development project • empirically evaluate the outcomes of new methods • increase understanding of different factors and circumstances that affect the success of a software development project • increase professional skills like team-work, management, planning and organization, written and oral communication

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja z aktivno udeležbo študentov (razlaga, diskusija, primeri, reševanje problemov). Laboratorijske vaje s praktičnim delom na večjem projektu, ki služi kot študija primera za ovrednotenje posameznih pristopov k razvoju programske opreme.	Lectures with active participation on the part of students (discussion, examples, problem solving). Lab practice requires practical work on an almost real project that serves as a case study for evaluation of different approaches to software development.

Delež (v %) /

Načini ocenjevanja:	Weight (in %)	**Assessment:**
Način (pisni izpit, ustno izpraševanje, naloge, projekt): **Sprotno preverjanje** (domače naloge, kolokviji in projektno delo) **Končno preverjanje** (pisni in ustni izpit) Ocene: 6-10 pozitivno, 5 negativno (v skladu s Statutom UL).	**50%** **50%**	Type (examination, oral, coursework, project): **Continuing** (homework, midterm exams, project work) **Final** (written and oral exam) Grading: 6-10 pass, 5 fail (according to the rules of University of Ljubljana).

Reference nosilca / Lecturer's references:

Pet najpomembnejših del:

1. MAHNIČ, Viljan. A capstone course on agile software development using Scrum. *IEEE trans. ed.*, Feb. 2012, vol. 55, no. 1, str. 99-106.
2. MAHNIČ, Viljan, HOVELJA, Tomaž. On using planning poker for estimating user stories. *J. syst. softw.*. Sep. 2012, vol. 85, no. 9, str. 2086-2095.
3. MAHNIČ, Viljan, ŽABKAR, Nataša. Measuring progress of Scrum-based software projects. *Electronics and Electrical Engineering*. 2012, vol. 18, no. 8, str. 73-76.
4. MAHNIČ Viljan. Teaching Scrum through team-project work : students' perceptions and teacher's observations. *International journal of engineering education*, 2010, vol. 26, no. 1, str. 96-110.
5. MAHNIČ, , Viljan, HOVELJA, Tomaž. Teaching user stories within the scope of a software engineering capstone course: analysis of students' opinions. *International journal of engineering education*, 2014, vol. 30, no. 4, str. 901–915.

Celotna bibliografija je dostopna na SICRISu:

http://sicris.izum.si/search/rsr.aspx?lang=slv&id=4767.

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Aproksimacijski in naključnostni algoritmi
Course title:	Approximation and randomized algorithms

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Magistrski študijski program druge stopnje Računalništvo in informatika Interdisciplinarni magistrski študijski program druge stopnje Računalništvo in matematika Interdisciplinarni magistrski študijski program druge stopnje Pedagoško računalništvo in informatika	ni smeri	1,2	zimski
Master study program Computer and Information Science, level 2 Interdisciplinary Master study program Computer Scinece and Mathematics, level 2 Interdisciplinary Master study program Computer Science Education, level 2	none	1,2	fall

Vrsta predmeta / Course type	**strokovni izbirni predmet / specialist elective course** Algoritmika / Algorithmics Računske metode / Computational methods

Univerzitetna koda predmeta / University course code:	63557

Predavanja **Lectures**	**Seminar** **Seminar**	**Vaje** **Tutorial**	**Klinične vaje** **work**	**Druge oblike študija**	**Samost. delo** **Individ. work**	**ECTS**
45	/	30	/	/	105	6

Nosilec predmeta / Lecturer:	prof. dr. Borut Robič

Jeziki / **Languages:**	**Predavanja / Lectures:**	slovenščina Slovene
	Vaje / Tutorial:	slovenščina Slovene

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisits:**

Vsebina:	**Content (Syllabus outline):**
Predmet bo vseboval naslednje vsebine: • Uvod ▪ Računska zahtevnost odločitvenih in optimizacijskih problemov ▪ NP-polni in NP-težki problemi ▪ Hevristični algoritmi, kakovost suboptimalnih rešitev, (ne)obstoj zagotovila za kakovost • Približno reševanje NP-težkih probl. ▪ Aproksimacijski algoritmi ▪ Kakovost približnih rešitev ▪ Razred APX ▪ Tehnika z vrzeljo ▪ Aproksimacijske sheme	The course will offer the following themes: • Introduction ▪ Computational complexity of decision and optimization problems ▪ NP-complete and NP-hard problems ▪ Heuristic algorithms, quality of suboptimal solutions, (non)existence of a guarantee of quality • Approximate solving of NP-hard problems ▪ Approximation algorithms ▪ Quality of approximate solutions ▪ The class APX ▪ Gap technique ▪ Approximation schemes

▪ Razreda PTAS in FPTAS ▪ Meje približnega reševanja • Razvoj aproksimacijskih algoritmov ▪ Požrešna metoda ▪ Osredotočanje na podporobleme ▪ Zaporedno razdeljevanje ▪ Dinamično programiranje • Naključnostno reševanje NP-težkih probl. ▪ Las Vegas in Monte Carlo algoritmi ▪ Razredi RP, co-RP, ZPP, PP, BPP • Razvoj naključnostnih algoritmov ▪ Naključno vzorčenje ▪ Zagotavljanje obilice prič ▪ Naključno preurejanje vhoda ▪ Zgoščanje ▪ Enakomerno porazdeljevanje bremen	▪ The classes PTAS and FPTAS ▪ Limits of approximate solving • The design of approximation algorithms ▪ Greedy method ▪ Focusing on subproblems ▪ Iterative partitioning ▪ Dynamic programming • Randomized solving of NP-hard problems ▪ Las Vegas and Monte Carlo algorithms ▪ The classes RP, co-RP, ZPP, PP, BPP • The design of randomized algorithm ▪ Random sampling ▪ Establishing abundance of witnesses ▪ Random reordering ▪ Hashing ▪ Load balancing

Temeljni literatura in viri / Readings:

B. Robič, *Aproksimacijski algoritmi,* Založba FE in FRI, 2.izd., 2009.

D.P. Williamson, D.B. Shmoys, *The Design of Approximation Algorithms*, Cambridge University Press, 2011.

V. V. Vazirani, *Approximation Algorithms,* Springer, 2004.

D. Hochbaum, *Approximation Algorithms for NP-hard Problems,* Course Technology, 1996.

R. Motwani, P.Raghavan, *Randomized Algorithms,* Cambridge University Press, 1995.

M. Mitzenmacher, E. Upfal, *Probability and Computing: Randomized algorithms and Probabilistic Analysis,* Cambridge University Press, 2005.

Cilji in kompetence:	**Objectives and competences:**
Slušatelji bodo na teoretičnem nivoju in prek praktičnih primerov osvojili znanja za približno in naključnostno reševanje praktičnih problemov, ki so v razumnem času drugače neobvladljivi.	Students will learn, both theoretically and through practical examples, how to use approximation and randomization techniques to solve practical yet intractable computational problems.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Znanje in razumevanje: Študent bo po opravljenem predmetu: -- razumel razloge za aproksimacijski in/ali naključnostni pristop k reševanju nekaterih, predvsem NP-težkih računskih problemov;	Knowledge and understanding: After completing the course the student will: -- understand the reasons for approximative or randomized approach to solving of (mainly NP-hard) computational problems;

-- razumel razliko (in povezave) med odločitvenimi in optimizacijskimi problemi; -- razumel praktične razloge za aproks. ali naklj. računanje suboptimalnih rešitev problemov; -- razumel osnovne pojme o aproks. in naklj. algoritmih; -- razumel razne pristope za določanje kakovosti suboptimalnih rešitev ter omejitve teh pristopov; -- razumel razrede zahtevnosti odločitvenih in optimizacijskih problemov glede na njihovo odzivnost na aproks. ali naklj. reševanje, in relacije med temi razredi; -- poznal aproks. In naklj. algoritme za izbrane pomembne NP-težke probleme; -- usposobljen uporabljati razne metode za razvoj in analizo aproks. in naklj. algoritmov -- usposobljen za samostojno iskanje in razumevanje novih raziskovalnih rezultatov s področij aproksimacijsega in naključnostnega reševanja računskih problemov.	-- understand the differences (and connections) between decision and optimization problems; -- understand the practical reasons for approx. or rand. computing of suboptimal solutions; -- understand the basic notions about approx. and rand. algorithms; -- understand different approaches to estimation of the quality of suboptimal solutions, and their limitations; -- undertand the complexity classes of decision and optimizations problems according to their amenability to approx. or rand. solving, and the relations between the classes; -- know approx. or rand. algorithms for selected importand NP-hard problems; -- be able to use different methods of the design and analysis of approx. and rand. algorithms; -- be able to follow and understand the new research results in the area of approximation and randomized algorithms

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja, domače naloge, seminarski način dela pri vajah.	Lectures, homeworks, and exercise groups.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Način (pisni izpit, naloge, projekt) **Sprotno preverjanje** (domače naloge, praktično delo) **Končno preverjanje** (pisni izpit)	 **50%** **50%**	Type (examination, coursework, project): **Continuing** (homework, practical work) **Final** (written exam)

Ocene: 6-10 pozitivno, 5 negativno (skladno s Statutom UL).		**Grading**: 6-10 pass, 5 fail (in accordance with the rules of the University of Ljubljana).

Reference nosilca / Lecturer's references:

1. B.Robič, *The Foundations of Computability Theory*, Spinger, 2015. (ISBN 978-3662448076)
2. M.Bezenšek, B.Robič, A survey of parallel and distributed algorithms for the Steiner tree problem. *Int. J. Par. Program.,* 42:287-319, 2013.
3. J.Mihelič, A.Mahjoub, C.Rapine, B.Robič, Two-stage flexible-choice problems under uncertainty. *Eur. J. Oper. Res.* 201(2):399-403, 2010.
4. J.Mihelič, B.Robič, Flexible-attribute problems. *Comput. Optim. Appl.* 47(3):553-566, 2010.
5. R.Trobec, M.Šterk, B.Robič, Computational complexity and parallelization of the meshless local Petrov-Galerkin methods. *Comput. Struct.* 87(1):81-90,2009.

Celotna bibliografija je dostopna na SICRIS: http://sicris.izum.si/search/rsr.aspx?lang=slv&id=5520

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Topološka analiza podatkov
Course title:	Topological data analysis

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Magistrski študijski program druge stopnje Računalništvo in informatika Interdisciplinarni magistrski študijski program druge stopnje Računalništvo in matematika	ni smeri	1, 2	poletni
Master study program Computer Science and Informaticss, level 2 Interdisciplinary Master study program Computer Science and Mathematics, level 2	none	1, 2	spring

Vrsta predmeta / Course type	**strokovni izbirni predmet /elective course** Algoritmika / Algorithmics Računske metode / Computational methods
Univerzitetna koda predmeta / University course code:	63542

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

Nosilec predmeta / Lecturer:	prof. dr. Nežka Mramor Kosta
Jeziki / **Predavanja / Lectures:**	slovenščina in angleščina Slovene and English

Languages:	**Vaje / Tutorial:**	slovenščina in angleščina Slovene and English

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisits:**
Uspešno opravljene domače naloge in seminarsko-projektne naloge so pogoj za opravljanje izpita.	Successful completion of homework and projects is required for students to approach to a final exam.

Vsebina:	**Content (Syllabus outline):**
Topologija je področje matematike, ki se ukvarja z analizo oblik in več dimenzionalnih objektov. Topološka analiza podatkov pa je področje med topologijo in računalništvom, ki obravnava in analizira lastnosti oblik zajetih iz podatkov, slik in več dimenzionalnih podatkovnih množic. Ob množici podatkov, ki se neprestano zajemajo, na eni strani in pa vse bolj zmogljivimi računalnškimi sistemi na drugi se razvija tudi vrsta novih algoritmov za analizo in predstavitev, ki uporabljajo čedalje več topoloških pojmov in modelov. Za predstavitev podatkov se uporabljajo grafi in ploskve, triangulacije, simplicialni in celični kompleksi ter mnogoterosti. Za analizo podatkov pa se uporabljajo topološke invariante teh objektov kot so število komponent, fundamentalna grupa, homološke grupe in kohomološki kolobar, Morsova teorija, filtracije in vztrajnost. Takšne invariante se tipično lepo izračunajo in dajejo odgovore na vprašanja kot so, ali je objekt sestavljen iz enega li več kosov, ali ima kakšne luknje in tunele, kakšne značilnosti ima pri različnih resolucijah, kako so posamezni kosi zlepljeni skupaj v celoto... Na drugi strani je na voljo tudi čedalje več hitrih in učinkovitih algoritmov za njihovo računanje. Pri predmetu bodo predstavljeni osnovni topološki pojmi in modeli, ki se uporabljajo za predstavitev večdimenzionalnih objektov in prostorov, nekaj njihovih osnovnih številskih in algebraičnih invariant. Poudarek pa bo na uporabi teh modelov	Topology is the mathematical field dealing with shapes and with modeling and understanding higher dimensional objects. Topologial data analysis is a field between topology and computer science dealing with shapes arising from data, images, and higher dimensional data sets. In view of massive quantities of experimental data on one hand, and available computing power on the other hand, numerous new algorithms and models for qualitative analysis and representation of such data sets using topological models and methods have been developed. Graphs, surfaces, triangulations, simplicial and cell complexes and manifolds are used for data representation and object reconstruction. Topological invariants like the number of components, the fundamental group, hopology groups and the cohomology ring, Morse theory, filtrations and persistence are used for analyzing these models. These invariants are typically computable and give answers to questions like, is the object composed from one or more components, does it have holes and tunnels, which features appear at different resolutions, how do the separate pieces connect into the whole, … On the other hand new algorithms for efficient computation of these invariants are appearing. In the course, fundamental topological concepts and methods, which are used in modeling and analyzing higher dimensional objects and spaces, will be introduced. Further, basic numerical and algebraic invariants of the topological models will be explained.

in invariant pri analizi in rekonstrukciji objektov iz zajetih podatkov, konfiguracijskih prostorov robotov in mehaničnih sistemov, pri analizi omrežij in v drugih povsem uporabnih domenah. Posamezna teme, ki jih bomo obravnavali, so 1. Osnovni pojmi topoloških in metričnih prostorov 2. Grafi in ploskve 3. Triangulacije, simplicialni in celični kompleksi 4. Homološke grupe in Bettijeva števila, njihova interpretacija in osnovni algoritmi za njihovo računanje 5. Diskretne Morsove funkcije in njihova uporaba pri analizi podatkov 6. Filtracije in vztrajnost za analizo podatkov pri različnih resolucijah Pri predmetu bo poudarek predvsem na uporabi opisanih topoloških pojmov in algoritmov pri analizi konkretnih podatkovnih množic, problemov in modelov.	Special attention will be given to applications of these methods to analysis of data sets and reconstruction of the underlying objects, configuration spaces of robots and mechanical systems, analysis of networks and other practical problems and domains. We will introduce the following topological concepts and models: 1. Fundamentals of topological and metric spaces 2. Graphs and surfaces 3. Triangulations, simplicial and cell complexes 4. Homology groups and Betti numbers, , their interpretation, and basic algorithms for their computation 5. Discrete Morse functions and their application to data analysis and object reconstruction 6. Filtrations and persistence for dealing with changing resolutions The main part of the course will be devoted to applications of the topological concepts and algorithms in analyzing specific data sets, problems and models.

Temeljni literatura in viri / Readings:

1. Herbert Edelsbrunner, John Harer: Computational Topology, American Mathematical Society, 2010
2. Afra J. Zomorodian: Topology for Computing, Cambridge University Press, 2005
3. Hjelle**, Øyvind,** Dæhlen**, Morten: Triangulations and applications, Springer, 2006**
4. **Kevin Knudson: Morse theory, smooth and discrete, World Scientific, 2015**

Cilji in kompetence:	**Objectives and competences:**
Cilj predmeta je študentom na razumljiv način predstaviti osnovne pojme algebraične topologije, ki se uporabljajo v računalniških algoritmih pri analizi velikih množic večdimenzionalnih podatkov, pri rekonstrukciji objektov in konfiguracijskih prostorov robotov in mehaničnih sistemov in pri drugih realnih problmemih. Matematični pojmi bodo predstavljni predvsem z uporabnega zornega kota, poudarek bo na konkretnih primerih in računalniških algoritmih.	The aim of this course is to introduce in an informal and intuitive way the basic concepts of algebraic topology which are used in algorithms for analysis of big, possibly higher dimensional data sets, for reconstruction of obects and configuration soaces of robots and mechanical systems and in other practical applications. Mathematical concept will be presented from the point of view of applications, special attention will be given to specific examples and algorithms.
Predvideni študijski rezultati:	**Intended learning outcomes:**

Po uspešno opravljenem predmetu bo študen	After completing the course students will
• razumel pojem topološke invariante in njenega pomena pri analizi oblike in drugih lastnosti podatkov • razumel pojem simplicialnega kompleksa in poznal osnovne algoritme za konstrukcijo simplicialnih kompleksov na danih podatkih • poznal osnovne računske prijeme in algoritme za računanje topoloških Eulerjeve karakteristike, homoloških grup in Bettijevih števil • razumel pojem filtracije in vztrajnosti • znal pridobljeno znanje uporabiti za konstrukcijo preprostih topoloških algoritmov za analizo podatkovnih množic in rezultate interpretirati	• understand the concept of a topological invariant and its role in analyzing shape and other properties of data • understand the concept of a simplcial complex and the basic algorithms for constructing simplicial complexes on data sets • understand the basic computational approches and algorithms for computing Euler characteristic, homology groups and Betti numbers • understand the concepts of filtrations and persistence • be able to use the concepts intruduced to construct simple topological algorithms for analysizing data sets and interpret the results

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja s podporo avdio-vizualne opreme, predstavitev teoretičnih pojmov in prikaz pomena na konkretnih primerih, laboratorijske vaje v računalniški učilnici z ustrezno programsko opremo. Delo posamezno in v skupinah. Velik poudarek na praktičnem delu in na skupinskem reševanju praktičnih problemov.	Combined lecturing with simultaneous use of the blackboard and computer projection explaining the theoretical concepts and specific meaning in specific cases. Lab work in computer-equipped lecture rooms. Individual and work in team. Emphasis on practical problem solving and group work.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Način (pisni izpit, ustno izpraševanje, naloge, projekt):		Type (examination, oral, coursework, project):
Sprotno preverjanje (domače naloge, kolokviji in projektno delo)	**60%**	**Continuing** (homework, midterm exams, project work)
Končno preverjanje (pisni in ustni izpit)	**40%**	**Final** (written and oral exam)
Ocene: 6-10 pozitivno, 5 negativno (v skladu s Statutom UL).		Grading: 6-10 pass, 5 fail (according to the rules of University of Ljubljana).

Reference nosilca / Lecturer's references:

Pet najpomembnejših del:

1. JURČIČ-ZLOBEC, Borut, MRAMOR KOSTA, Neža. Geometric constructions on cycles. Rocky Mt. j. math., 2004, vol. 34, no. 4, str. 1565-1585. [COBISS.SI-ID 13268057]

2. KING, Henry C., KNUDSON, Kevin, MRAMOR KOSTA, Neža. Generating discrete Morse functions from point data. Exp. math., 2005, vol. 14, no. 4, str. 435-444. http://www.expmath.org/. [COBISS.SI-ID 13872985]

3. JAWOROWSKI, Jan, MRAMOR KOSTA, Neža. The degree of maps of free G-manifolds. J. fixed point theory appl. (Print), 2007, vol. 2, no. 2, str. 209-213. http://dx.doi.org/10.1007/s11784-007-0047-0. [COBISS.SI-ID 14569305]

4. JERŠE, Gregor, MRAMOR KOSTA, Neža. Ascending and descending regions of a discrete Morse function. Comput. geom.. [Print ed.], 2009, vol. 42, iss. 6-7, str. 639-651. http://dx.doi.org/10.1016/j.comgeo.2008.11.001, doi: 10.1016/j.comgeo.2008.11.001. [COBISS.SI-ID 14994265]

5. AYALA, Rafael, VILCHES, Jose Antonio, JERŠE, Gregor, MRAMOR KOSTA, Neža. Discrete gradient fields on infinite complexes. Discrete contin. dyn. syst., 2011, vol. 30, no. 3, str. 623-639. http://dx.doi.org/10.3934/dcds.2011.30.623. [COBISS.SI-ID 15865945]

Celotna bibliografija je dostopna na SICRISu:

http://izumbib.izum.si/bibliografije/Y20120229234622-08947.html

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Numerična matematika
Course title:	Numerical mathematics

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Magistrski študijski program druge stopnje Računalništvo in informatika Interdisciplinarni magistrski študijski program druge stopnje Pedagoško računalništvo in informatika Interdisciplinarni magistrski študijski program druge stopnje Multimedija	ni smeri	1, 2	poletni / zimski
Master study program Computer and Information Science, level 2 Interdisciplinary Master study program Computer Science Education, level 2 Interdisciplinary Master study program Multimedia, level 2	none	1, 2	spring / zimski

Vrsta predmeta / Course type	**strokovni izbirni predmet / specialist elective course** Tematski sklopi / Thematic set: Algoritmika / Algorithmics Računske metode / Computational methods FRI 2 / FRI 2 FRI A / FRI A

Univerzitetna koda predmeta / University course code:	63522

Predavanja **Lectures**	**Seminar** **Seminar**	**Vaje** **Tutorial**	**Klinične vaje** **Laboratory work**	**Druge oblike študija** **Field work**	**Samost. delo** **Individ. work**	**ECTS**
45	/	30	/	/	105	6

Nosilec predmeta / Lecturer:	prof. dr. Bojan Orel

Jeziki / Languages:	**Predavanja / Lectures:**	slovenščina in angleščina Slovene and English
	Vaje / Tutorial:	slovenščina in angleščina Slovene and English

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites:**

Vsebina:	**Content (Syllabus outline):**
Predavanja: a) Uvod v numerično računanje (osnove numeričnih napak in stabilnost numeričnih algoritmov); b) Linearna algebra: sistemi linearnih enačb (direktne in iterativne metode), lastne vrednosti matrik (inverzna in QR iteracija); c) Interpolacija in aproksimacija (Lagrangeuva in Newtonova interpolacija, metoda najmanjših kvadratov, trigonometrična aproksimacija); d) Numerično integriranje (Newton-Cotesove formule, Rombergova metoda, Gaussove integracijske formule, ocenjevanje napake	**Lectures:** 1. Introduction to numerical computing (numerical errors and stability of numerical algorithms); 2. Linear algebra: systems of linear equations (direct and iterative methods). Matrix eigenvalues (inverse and QR iteration); 3. Interpolation and approximation (Lagrange and Newton interpolation formulas, least squares method, trigonometric approximation); 4. Numerical integration (Newton-Cotes formulas, Romberg integration, Gauss integration formulas, error estimation and

in izbira koraka, numerično računanje odvodov); e) Reševanje diferencialnih enačb (osnovne eno- in več-stopenjske metode, stabilnost, enačbe višjih redov, sistemi diferencialnih enačb, robni problemi), parcialne diferencialne enačbe (metode končnih diferenc, končnih elementov in spektralne metode). **Vaje:** Pri vajah bodo študentje s pomočjo numeričnih metod reševali različne (uporabne) probleme. **Domače naloge:** Z domačimi nalogami bodo študentje preverjali in s samostojnim delom utrdili doseženo znanje.	step-size selection, numerical differentiation); 5. Ordinary differential equations (basic one- and multistep formulas, stability, higher order equations, systems of differential equations, boundary value problems), partial differential equations (finite difference, finite element and spectral methods). **Tutorials:** Tutorials will illustrate and/or expand concepts presented in lectures by working through (real life) example problems. **Homeworks:** Homeworks are essential part of the course. With homeworks the students will test and upgrade their knowledge.

Temeljni literatura in viri / Readings:

Obvezna literatura: Bojan Orel: Osnove numerične matematike

Dodatna literatura:

- K. Atkinson: Elementary Numerical Analysis
- S. D. Cont & C. de Boor: Elementary Numerical Analysis
- B. N. Datta: Numerical Linear Algebra and Applications

Cilji in kompetence:	**Objectives and competences:**
Cilj predmeta je študentom računalništva in informatike predstaviti osnovne metode numerične matematike in jih usposobiti za samostojno reševanje numeričnih problemov, ki jih bodo lahko srečali pri svojem strokovnem delu.	This course explores the basic methods of numerical mathematics. Successful students be able to solve numerical problems they will encounter in their work.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Študent naj bi po uspešno opravljenem predmetu: -poznal in razumel osnovne numerične metode, -poznal prednosti in slabosti različnih numeričnih metod,	After successfully completing the course, the students will be able to: - understand and use basic numerical methods,

-znal uporabljati ustrezne numerične metode pri reševanju problemov iz strokovnega dela, -spoznal, da so računalniške simulacije nujna sestavina raziskovalnega dela (poleg eksperimentov in teorije), -imel sposobnost prenosa numeričnega pristopa k analizi problema na druga področja.	- know and understand their advantages and weaknesses, - use appropriate numerical methods for problem solving, - discover that computer simulations are a necessary ingredient of research work (besides experiments and theory), - transfer systematic approach to numerical problem solving to other problems.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja, laboratorijske vaje in domače naloge. Poudarek na samostojnem reševanju problemov.	Lectures, (hands-on) tutorials and homeworks.

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

Reference nosilca / Lecturer's references:

Pet najpomembnejših del:

1. B. Orel: Real pole approximations to the exponential function. BIT 31, 1991, 144--159.
2. B. Orel: Parallel Runge--Kutta methods with real eigenvalues. Applied Numerical Mathematics 11, 1993, 241--250.
3. D. Janežič, B. Orel: Implicit Runge-Kutta Method for molecular dynamics integration. J. of Chem. Inf. Comput. Sci. 33, 1993.
4. E. Celledoni, A. Iserles, S. P. Norsett, B. Bojan. Complexity theory for Lie-group solvers. Journal of complexity 18, 2001, 242-286.

5. OREL, Bojan. Accumulation of global error in Lie group methods for linear ordinary differential equations. Electronic Transactions on Numerical analysis 37, 2010, 252-262.

Celotna bibliografija je dostopna na SICRISu: http://sicris.izum.si/search/rsr.aspx?lang=slv&id=6758.

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Raziskovalni seminar
Course title:	Research seminar

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Magistrski študijski program Računalništva in informatike, 2. stopnja	ni smeri	2	zimski
Master study programme Computer and Information Science, 2nd cycle	none	2	fall

Vrsta predmeta / Course type	**strokovni izbirni predmet / specialist elective course**
Univerzitetna koda predmeta / University course code:	63544

Predavanja **Lectures**	**Seminar** **Seminar**	**Vaje** **Tutorial**	**Klinične vaje** **Laboratory work**	**Druge oblike študija** **Field work**	**Samost. delo** **Individ. work**	**ECTS**
15	45	/	/	/	300	12

Nosilec predmeta / Lecturer:	prodekan za pedagoško dejavnost FRI/vice dean for education	
Jeziki / Languages:	**Predavanja / Lectures:**	slovenščina in angleščina Slovene and English
	Vaje / Tutorial:	slovenščina in angleščina Slovene and English

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites:**

Vsebina:	**Content (Syllabus outline):**
Cilj predmeta je študente uvesti v raziskovalno delo. Na predavanjih bodo predstavljene osnovne veščine, ki jih bodo potrebovali pri svojem raziskovalnem delu, kot so načrtovanje in priprava raziskovalne naloge, principi pisnega sporočanja v znanosti in citiranje ter principi ustnega sporočanja. Pridobljeno znanje bodo uporabili v praksi pri izdelavi projektne raziskovalne naloge, ki jo bodo opravljali pod nadzorstvom mentorja. Poudarek bo na individualnem delu in na seminarski obliki dela. Študentje bodo izbrali raziskovalni problem, ga analizirali, zasnovali in implementirali rešitev ter jo pisno dokumentirali in predstavili po pravilih znanstvenega sporočanja.	The goal of the course is to introduce students to the research work. During the lectures the basic skills necessary for efficient research work will be presented, such as planning research tasks and the principles of the written and the oral communication. The acquired knowledge will be utilized in practice during the project work the students will have to complete under the guidance of a supervisor. The main emphasis will be on the individual work and seminars. The students will chose a research problem, they will analyze it, design and implement a solution, and write a report as well as present their work following the rules of scientific communication.

Temeljni literatura in viri / Readings:

1. Justin Zobel, Writing for Computer Science, second edition, Springer, 2004
2. B. Ballenger, The Curious Researcher, A Guide to writing research papers. Longman, 4th edition, 2003.
3. Bourne PE, Ten simple rules for getting published, PLoS Computational Biology 1(5): e57, 2005
4. Bourne PE, Ten simple rules for making good oral presentations, PLoS Computational Biology 3(4): e77, 2007
5. Erren TC, Bourne PE, Ten simple rules for a good poster presentation, PLoS Computational Biology 3(5): e102, 2007

Cilji in kompetence:	**Objectives and competences:**
Cilj predmeta je seznaniti se z osnovnimi principi znanstveno raziskovalnega dela in sporočanja ter na tej osnovi pristopiti k reševanju projektne naloge: spoznati širše področje in relevantno literaturo s področja teme projektne naloge, razumeti zastavljene probleme,	The main goal of the course is to acquaint students with the basic principles of the research work and communication and based on this to address and complete a research project; the students should be able to study the related work, to understand the

zasnovati in implementirati ustrezno rešitev ter to rešitev ustrezno dokumentirati in predstaviti. Splošne kompetence: - Sposobnost kritičnega razmišljanja - Razvijanje sposobnosti kritičnega, analitičnega in sintetičnega razmišljanja - Sposobnost prenosa znanja in sposobnost pisanja v domačem in tujem jeziku - Sposobnost iskanja virov znanja in kritičnega ocenjevanja informacij - Poznavanje raziskovalnih metod na področju računalništva in informatike - Razvijanje strokovne odgovornosti in etike Predmetno specifične kompetence: - Samostojno reševanje zahtevnih razvojnih, inženirskih in organizacijskih nalog pa tudi zmerno zahtevnih raziskovalnih nalog na svojem področju - Kompetence na področju računalništva in informatike, ki omogočajo dostop do nadaljnega študija na 3. stopnji	problem, to design and implement a suitable solution and to document and present this solution. General Competences: - Ability of critical thinking - Developing skills in critical, analytical and synthetic thinking. - The ability of knowledge transfer and writing skills in the native language as well as a foreign language. - The ability to search knowledge sources and to search for resources and critically evaluate information. - Proficiency in research methods in the field of computer science - Development of professional responsibility and ethics Subject specific competences: - Independently tackle demanding developmental, engineering, and organizational tasks as well as moderately demanding research tasks in their fields of study. - Competences in computer and information science granting access to further study at 3rd cycle doctoral programmes

Predvideni študijski rezultati:	**Intended learning outcomes:**
Študenti spoznavajo samostojno znanstveno-raziskovalno delo, znajo analizirati problem, poiskati ustrezno rešitev ter jo ustrezno predstaviti. Analizirajo in rešujejo kompleksne probleme, razvijajo kompleksne sistemov, in se naučijo predstaviti rešitve tako v obliki pisnega izdelka kot tudi ustno.	Students are acquainted with the individual research work, they know how to analyse the problem, how to search for an adequate solution and how to present the solution. They analyse and solve of complex problems, design and develop complex systems, learn to present problems and their solutions in the form of a written and oral presentation.

Metode poučevanja in učenja:	**Learning and teaching methods:**

Delo v skupini na seminarjih in samostojno delo pod vodstvom mentorja.	Seminar work in groups and individual work under the supervisor's guidance.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Način (pisni izpit, ustno izpraševanje, naloge, projekt): **Sprotno preverjanje** (vmesna pisna in ustna poročila in predstavitve) **Končno preverjanje** (ocena zaključnega poročila o raziskovalni nalogi in zagovora) Ocene: 6-10 pozitivno, 5 negativno (v skladu s Statutom UL).	**30%** **70%**	Type (examination, oral, coursework, project): **Continuing** (intermediate written and oral reports) **Final** (written final report and the presentation) Grading: 6-10 pass, 5 fail (according to the rules of University of Ljubljana).

Reference nosilca / Lecturer's references:

1. FIJAVŽ, Gašper, WOOD, David Richard. Graph minors and minimum degree. The Electronic journal of combinatorics, ISSN 1077-8926. [Online ed.], 2010, vol. 17, no. 1, r151 (30 str.).

2. DUJMOVIĆ, Vida, FIJAVŽ, Gašper, JORET, Gwenaël, SULANKE, Thom, WOOD, David Richard. On the maximum number of cliques in a graph embedded in a surface. European journal of combinatorics, ISSN 0195-6698, 2011, vol. 32, no. 8, str. 1244-1252.

3. ALAM, Muhammad Jawaherul, CHAPLICK, Steven, FIJAVŽ, Gašper, KAUFMANN, Michael, KOBOUROV, Stephen G., PUPYREV, Sergey. Threshold-coloring and unit-cube contact representation of graphs. V: BRANDSTÄDT, Andreas (ur.), JANSEN, Klaus (ur.), REISCHUK, Rüdiger (ur.). Graph-theoretic concepts in computer science : 39th International Workshop, WG 2013, Lübeck, Germany, June 19-21, 2013 : revised papers, WG 2013, 39th International Workshop on Graph-Theoretic Concepts in Computer Science, June 19 - 21, 2013, Lübeck, Germany, (Lecture notes in computer science, ISSN 0302-9743, 8165). Heidelberg [etc.]: Springer. cop. 2013, str. 26-37.

4. FIJAVŽ, Gašper, PISANSKI, Tomaž, RUS, Jernej. Strong traces model of self-assembly polypeptide structures. MATCH Communications in Mathematical and in Computer Chemistry, ISSN 0340-6253, 2014, vol. 71, no. 1, str. 199-212.

5. FIJAVŽ, Gašper, NAKAMOTO, Atsuhiro. Odd complete minors in even embeddings on surfaces. Discrete Mathematics, ISSN 0012-365X. [Print ed.], 2016, vol. 339, iss. 1, str. 165-178.

Celotna bibliografija je dostopna na SICRISu:

http://www.sicris.si/search/rsr.aspx?lang=slv&id=9390.

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Aktualno raziskovalno področje I
Course title:	Topical research themes I

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Magistrski študijski program druge stopnje Računalništvo in informatika Interdisciplinarni magistrski študijski program druge stopnje Računalništvo in matematika	ni smeri	1, 2	zimski
Master study program Computer and Information Science, level 2 Interdisciplinary Master study program Computer Science and Mathematics, level 2	none	1, 2	fall

Vrsta predmeta / Course type	**strokovni izbirni predmet / specialist elective course**
Univerzitetna koda predmeta / University course code:	63545

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

Nosilec predmeta / Lecturer:	skrbnik programa / programme coordinator izvajalec je vsako leto drug učitelj s primernimi novostmi iz praktičnega raziskovalnega dela / each year the lecturer is a professor with an appropriate cutting edge practically oriented research topic
Jeziki / Languages: **Predavanja / Lectures:**	slovenščina, angleščina Slovene, English

Vaje / Tutorial:	slovenščina, angleščina Slovene, English

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites:**

Vsebina:	**Content (Syllabus outline):**
Predmet izvajajo (mlajši) učitelji, ki bodo pokrivali novosti iz praktično usmerjenega raziskovalnega dela. Predstavili bodo tehnološke preboje ali uporabne rešitve s področja praktičnega računalništva in informatike, ki še niso vključene v vsebine obstoječih predmetov. Podrobna vsebina in predavatelj se določi vsako leto posebej glede na predloge, potrebe programa in zadnje raziskovalne smernice v svetu.	The course is lectured by (younger) professors who present novelties from practically oriented research work. Currently uncovered topics interesting due to recent technological breakthroughs or their applicative value are presented. The lecturer and specific contents of the course are determined annually according to the propositions, programme needs, and latest research trends.

Temeljni literatura in viri / Readings:

1. T. Hastie, R. Tibshirani, J. Friedman: *The elements of statistical learning, 2nd edition*. Springer, 2009.
2. J. L. Hennessy, D. A. Patterson, *Computer Architecture, 5th edition: A Quantitative Approach.* Morgan Kaufmann, 2011.

Dodatna literatura se predpiše vsako leto posebej glede na vsebino in predloge izbranega predavatelja.

Additional literature is given annually, with respect to the current topic of the course.

Cilji in kompetence:	**Objectives and competences:**
Cilj predmeta je prenesti raziskovalne novosti v učni program in študentom omogočiti, da spoznajo zadnje tehnološke dosežke in praktične implementacije novih metod in tehnologij na področju računalništva in informatike.	The goal of the course is a transfer of recent research results into the curriculum. Students will be introduced to novel technological breakthroughs as well as practical implementations of new methods and technologies in the field of computer and information science.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Po zaključku predmeta bo študent: - Poznal nove praktične raziskovalne prijeme, ki v obstoječem predmetniku še niso zajeta. - Znal uporabiti najnovejše pristope in tehnike z izbranega področja računalništva in informatike v praksi. - Razumel primernosti izbranih pristopov s področja računalništva in informatike za reševanje praktičnih primerov v poslovnih okoljih. - Znal reševati kompleksne probleme in razvijati kompleksne sisteme.	After completing this course a student will: - Be familiar with the field of study from the practical point of view, and recent new methods and concepts. - Know current practically oriented approaches and techniques from the specific field of computer and information science in. - Understand the advantages of the chosen approaches in computer and information science in solving specific practical tasks. - Know how to solve complex problems, and design complex systems.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja, laboratorijske vaje.	Lectures, lab work.

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

Reference nosilca / Lecturer's references:

Pet najpomembnejših del:

1. ČEHOVIN, Luka, KRISTAN, Matej, LEONARDIS, Aleš. Robust visual tracking using an adaptive coupled-layer visual model. *IEEE transactions on pattern analysis and machine intelligence*, ISSN 0162-8828. [Print ed.], Apr. 2012, vol. 35, no. 4, str. 941-953, [COBISS.SI-ID 9431124]
2. SULIĆ KENK, Vildana, MANDELJC, Rok, KOVAČIČ, Stanislav, KRISTAN, Matej, HAJDINJAK, Melita, PERŠ, Janez. Visual re-identification across large, distributed camera networks. *Image and vision computing*, ISSN 0262-8856. [Print ed.], Feb. 2015, vol. 34, str. 11-26, [COBISS.SI-ID 10896980]
3. KRISTAN, Matej, LEONARDIS, Aleš, SKOČAJ, Danijel. Multivariate online kernel density estimation with Gaussian kernels. *Pattern recognition*, ISSN 0031-3203. [Print ed.], 2011, vol. 44, no. 10/11, str. 2630-2642. [COBISS.SI-ID 8289876]
4. KRISTAN, Matej, KOVAČIČ, Stanislav, LEONARDIS, Aleš, PERŠ, Janez. A two-stage dynamic model for visual tracking. *IEEE transactions on systems, man, and cybernetics. Part B, Cybernetics*, ISSN 1083-4419. [Print ed.], Dec. 2010, vol. 40, no. 6, str. 1505-1520, [COBISS.SI-ID 7709524]
5. KRISTAN, Matej, PERŠ, Janez, PERŠE, Matej, KOVAČIČ, Stanislav. Closed-world tracking of multiple interacting targets for indoor-sports applications. *Computer vision and image understanding*, ISSN 1077-3142. [Print ed.], May 2009, vol. 113, no. 5, str. 598-611, [COBISS.SI-ID 6401620].

Celotna bibliografija je dostopna na SICRISu: http://www.sicris.si/public/jqm/search_basic.aspx?lang=slv&opdescr=search&opt=2&subopt=1&code1=cmn&code2=auto&search_term=30155.

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Aktualno raziskovalno področje II
Course title:	Topical research themes II

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Magistrski študijski program druge stopnje Računalništvo in informatika Interdisciplinarni magistrski študijski program druge stopnje Računalništvo in matematika	**ni smeri**	**1, 2**	**poletni**
Master study program Computer and Information Science, level 2 Interdisciplinary Master study program Computer Science and Mathematics, level 2	**none**	**1, 2**	**spring**

Vrsta predmeta / Course type	**strokovni izbirni predmet / specialist elective course**
Univerzitetna koda predmeta / University course code:	63546

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

Nosilec predmeta / Lecturer:	skrbnik programa/programme coordinator izvajalec je vsako leto drug učitelj s primernimi novostmi iz teoretičnega raziskovalnega dela. / Each year the lecturer is a professor with an appropriate cutting edge theoretically oriented research topic.
Jeziki / Languages: **Predavanja / Lectures:**	slovenščina, angleščina Slovene, English

Vaje / Tutorial:	slovenščina, angleščina Slovene, English

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites:**

Vsebina:	**Content (Syllabus outline):**
Predmet izvajajo (mlajši) učitelji, ki bodo pokrivali novosti iz teoretično usmerjenega raziskovalnega dela. Predstavili bodo nove ideje, metodološke preboje ali nove usmeritve na področju teoretičnega računalništva in informatike, ki še niso vključene v vsebine obstoječih predmetov. Podrobna vsebina in predavatelj se določi vsako leto posebej glede na predloge, potrebe programa in zadnje raziskovalne smernice v svetu.	The course is lectured by (younger) professors who present novelties from theoretically oriented research work. Currently uncovered topics interesting due to recent theoretical findings or methodological breakthroughs are presented. The lecturer and specific contents of the course are determined annually according to the propositions, programme needs, and latest research trends.

Temeljni literatura in viri / Readings:

3. M. Li, P. Vitányi, *An Introduction to Kolmogorov Complexity and Its Applications, 3rd edition.* Springer, 2008
4. J. E. Hopcroft, R. Motwani, J. D. Ullman , *Introduction to Automata Theory, Languages, and Computation, 3rd edition.* Prentice Hall, 2006.

Dodatna literatura se predpiše vsako leto posebej glede na vsebino in predloge izbranega predavatelja.

Additional literature is given annually, with respect to the current topic of the course.

Cilji in kompetence:	**Objectives and competences:**
Cilj predmeta je prenesti raziskovalne novosti v učni program in študentom omogočiti, da spoznajo njihove teoretične osnove, metodološke novosti in posledice za razvoj novih metod in tehnologij na področju računalništva in informatike.	The goal of the course is a transfer of recent research results into the curriculum. Students will be introduced to novel theoretical ideas as well as their possible impact for development of new methods and technologies in the field of computer and information science.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Po zaključku predmeta bo študent: - Poznal nove praktične raziskovalne prijeme, ki v obstoječem predmetniku še niso zajeta. - Znal uporabiti najnovejše pristope in tehnike z izbranega področja računalništva in informatike v praksi. - Razumel primernosti izbranih pristopov s področja računalništva in informatike za reševanje praktičnih primerov v poslovnih okoljih. - Znal reševati kompleksne probleme in razvijati kompleksne sisteme.	After completing this course a student will: - Be familiar with the field of study from the practical point of view, and recent new methods and concepts. - Know current practically oriented approaches and techniques from the specific field of computer and information science in. - Understand the advantages of the chosen approaches in computer and information science in solving specific practical tasks. - Know how to solve complex problems, and design complex systems.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja, laboratorijske vaje.	Lectures, lab work.

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

Reference nosilca / Lecturer's references:

Pet najpomembnejših del:

6. ČEHOVIN, Luka, KRISTAN, Matej, LEONARDIS, Aleš. Robust visual tracking using an adaptive coupled-layer visual model. *IEEE transactions on pattern analysis and machine intelligence*, ISSN 0162-8828. [Print ed.], Apr. 2012, vol. 35, no. 4, str. 941-953, [COBISS.SI-ID 9431124]
7. SULIĆ KENK, Vildana, MANDELJC, Rok, KOVAČIČ, Stanislav, KRISTAN, Matej, HAJDINJAK, Melita, PERŠ, Janez. Visual re-identification across large, distributed camera networks. *Image and vision computing*, ISSN 0262-8856. [Print ed.], Feb. 2015, vol. 34, str. 11-26, [COBISS.SI-ID 10896980]
8. KRISTAN, Matej, LEONARDIS, Aleš, SKOČAJ, Danijel. Multivariate online kernel density estimation with Gaussian kernels. *Pattern recognition*, ISSN 0031-3203. [Print ed.], 2011, vol. 44, no. 10/11, str. 2630-2642. [COBISS.SI-ID 8289876]
9. KRISTAN, Matej, KOVAČIČ, Stanislav, LEONARDIS, Aleš, PERŠ, Janez. A two-stage dynamic model for visual tracking. *IEEE transactions on systems, man, and cybernetics. Part B, Cybernetics*, ISSN 1083-4419. [Print ed.], Dec. 2010, vol. 40, no. 6, str. 1505-1520, [COBISS.SI-ID 7709524]
10. KRISTAN, Matej, PERŠ, Janez, PERŠE, Matej, KOVAČIČ, Stanislav. Closed-world tracking of multiple interacting targets for indoor-sports applications. *Computer vision and image understanding*, ISSN 1077-3142. [Print ed.], May 2009, vol. 113, no. 5, str. 598-611, [COBISS.SI-ID 6401620].

Celotna bibliografija je dostopna na SICRISu:
http://www.sicris.si/public/jqm/search_basic.aspx?lang=slv&opdescr=search&opt=2&subopt=1&code1=cmn&code2=auto&search_term=30155.

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Magistrsko delo
Course title:	Master thesis

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Magistrski študijski program druge stopnje Računalništvo in informatika	ni smeri	2	zimski, poletni
Master study program Computer and Information Science, level 2	none	2	fall, spring

Vrsta predmeta / Course type	**obvezni predmet / compulsory course**
Univerzitetna koda predmeta / University course code:	63548

Predavanja **Lectures**	**Seminar** **Seminar**	**Vaje** **Tutorial**	**Klinične vaje** **Laboratory work**	**Druge oblike študija** **Field work**	**Samost. delo** **Individ. work**	**ECTS**
/	60	/	/	/	660	24

Nosilec predmeta / Lecturer:	

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

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites:**

Vsebina:	**Content (Syllabus outline):**
Predmet je namenjen pripravi in izdelavi magistrskega dela.	The course is intended for preparing and completing the master thesis.

Temeljni literatura in viri / Readings:

1. Justin Zobel, Writing for Computer Science, second edition, Springer, 2004.
2. D. Evans and P. Gruba, How to Write a Better Thesis, Second edition, Melbourne University Press, Melbourne, 2002.
3. Herman T.: Ethics and Technology: Controversies, Questions, and Strategies for Ethical Computing, Wiley; 3 edition, 2010.

Cilji in kompetence:	**Objectives and competences:**
Cilj predmeta je spoznati širše področje in relevantno literaturo s področja teme magistrskega dela,razumeti zastavljene probleme in poiskati smiselne teoretične ter ustrezne programske rešitve, napisati magistrsko delo in izdelati programsko podporo. Splošne kompetence: - Sposobnost kritičnega, analitičnega in sintetičnega razmišljanja. - Sposobnost strokovne komunikacije v slovenskem in tujem jeziku.	The goal of the course is to obtain insight into and an overview of the wide field of the topic of the master thesis, to get acquainted with the relevant literature, understand the addressed problems and find suitable theoretical and programming solutions, and finally to write the thesis and produce the necessary computer support. General competences: - Ability of critical, analytical and synthetic thinking. - The ability of professional communication in the Slovenian language as well as a foreign language.

- Sposobnost aplikacije pridobljenega znanja pri reševanju problemov s področja računalništva in informatike; sposobnost nadgradnje znanja. - Obvladovanje raziskovalnih metod na področju računalništva in informatike. - Razvoj strokovne odgovornosti in etike.	- The ability to apply acquired knowledge for solving technical and scientific problems in computer and information science; the ability to upgrade acquired knowledge. - Proficiency in research methods in the field of computer science - Development of professional responsibility and ethics.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Po zaključku predmeta bo študent: - Spoznal samostojno raziskovalno delo, literaturo in obstoječe rešitve. - Spoznal bo postopek iskanja novih prijemov za reševanje zastavljenih problemov. - Znal bo pridobivati znanja in izkušenje pri iskanju lastnih rešitev teoretičnih in praktičnih problemov, pri pisanju strokovnih del in predstavitvi lastnih rezultatov. - Poznal bo primernosti izbranih pristopov s področja računalništva in informatike za reševanje praktičnih primerov v poslovnih okoljih. - Znal bo predstaviti rešitev v obliki zaključenega pisnega izdelka in ustne predstavitve.	After completing this course a student will: - Be familiar with the challenge of individual research work, are acquainted to the literature and the existing solutions. - Know how to find new approaches to the posed problems. - Know how to obtain knowledge and experience in individually solving theoretical and practical problems, writing technical texts and presenting obtained results and solutions. - Will know the advantages of the chosen approaches in computer and information science in solving specific practical tasks. - Will know how to present problems and their solutions in the form of a written and oral presentation.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Seminarsko in samostojno delo pod vodstvom mentorja.	Seminar work and individual work under the advisor's guidance.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Način (pisni izpit, ustno izpraševanje, naloge, projekt):		Type (examination, oral, coursework, project):

Sprotno preverjanje (vmesna pisna in ustna poročila in predstavitve) **Končno preverjanje** (ocena magistrskega dela in zagovora) Ocene: 6-10 pozitivno, 5 negativno (v skladu s Statutom UL).	**30%** **70%**	**Continuing** (intermediate written and oral reports) **Final** (grading the written thesis and the presentation) Grading: 6-10 pass, 5 fail (according to the rules of University of Ljubljana).

Reference nosilca / Lecturer's references:

Pet najpomembnejših del:

1. FIJAVŽ, Gašper, WOOD, David Richard. Graph minors and minimum degree. The Electronic journal of combinatorics, ISSN 1077-8926. [Online ed.], 2010, vol. 17, no. 1, r151 (30 str.).

2. DUJMOVIĆ, Vida, FIJAVŽ, Gašper, JORET, Gwenaël, SULANKE, Thom, WOOD, David Richard. On the maximum number of cliques in a graph embedded in a surface. European journal of combinatorics, ISSN 0195-6698, 2011, vol. 32, no. 8, str. 1244-1252.

3. ALAM, Muhammad Jawaherul, CHAPLICK, Steven, FIJAVŽ, Gašper, KAUFMANN, Michael, KOBOUROV, Stephen G., PUPYREV, Sergey. Threshold-coloring and unit-cube contact representation of graphs. V: BRANDSTÄDT, Andreas (ur.), JANSEN, Klaus (ur.), REISCHUK, Rüdiger (ur.). Graph-theoretic concepts in computer science : 39th International Workshop, WG 2013, Lübeck, Germany, June 19-21, 2013 : revised papers, WG 2013, 39th International Workshop on Graph-Theoretic Concepts in Computer Science, June 19 - 21, 2013, Lübeck, Germany, (Lecture notes in computer science, ISSN 0302-9743, 8165). Heidelberg [etc.]: Springer. cop. 2013, str. 26-37.

4. FIJAVŽ, Gašper, PISANSKI, Tomaž, RUS, Jernej. Strong traces model of self-assembly polypeptide structures. MATCH Communications in Mathematical and in Computer Chemistry, ISSN 0340-6253, 2014, vol. 71, no. 1, str. 199-212.

5. FIJAVŽ, Gašper, NAKAMOTO, Atsuhiro. Odd complete minors in even embeddings on surfaces. Discrete Mathematics, ISSN 0012-365X. [Print ed.], 2016, vol. 339, iss. 1, str. 165-178.

Celotna bibliografija je dostopna na SICRISu:

http://www.sicris.si/search/rsr.aspx?lang=slv&id=9390.

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Obštudijska strokovna dejavnost I
Course title:	Extracurricular professional activities I

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Magistrski študijski program druge stopnje Računalništvo in informatika Interdisciplinarni magistrski študijski program druge stopnje Multimedija	ni smeri	1, 2	zimski, poletni
Master study programme Computer and Information Science, 2nd cycle Interdisciplinary Master study program Multimedia, level 2	none	1, 2	fall, spring

Vrsta predmeta / Course type	**izbirni predmet / elective course**
Univerzitetna koda predmeta / University course code:	63534

Predavanja **Lectures**	**Seminar** **Seminar**	**Vaje** **Tutorial**	**Klinične vaje** **Laboratory work**	**Druge oblike študija** **Field work**	**Samost. delo** **Individ. work**	**ECTS**
5	/	/	/	40	45	3

Nosilec predmeta / Lecturer:	prodekan za pedagoško dejavnost FRI, FE/vice dean for education FRI, FE
Jeziki / Languages: **Predavanja / Lectures:**	Slovenščina in angleščina Slovene and English

Vaje / Tutorial:	Slovenščina in angleščina Slovene and English

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites:**

Vsebina:	**Content (Syllabus outline):**
Na uvodnih predavanjih študentom pojasnimo cilje predmeta in kako jih lahko dose□žejo. Med aktivnosti, ki jih lahko štejemo kot obveznosti pri predmetu sodijo vodenje računalniškega (ali po strokovni tematiki sorodnega) krožka na osnovni ali srednji šoli, vodenje študijske skupine na fakulteti, redno obiskovanje izven kurikularnih strokovnih predavanj na fakulteti ali na drugih članicah UL, ki so povezana s predmetom ipd.	After an introductiory lecture on the necessary background of the activities involved in the course, the students' activities include classes on topics in computer and information science and lab work with students of elementary and high schools, organizing study groups of students at the 1st degree level, attending extracurricular lectures at the University of Ljubljana on subjects associated to the topics of the course.

Temeljni literatura in viri / Readings:

1. **Keller** Gustav, **Binder** Annette, **Thiel** Rolf Dietmar (1999). Boljša motivacija uspešnejše učenje (translated from German); Trening učnih navad. Ljubljana: Center za psihodiagnostična sredstva.
2. **Bratanič**, Marija (1990), Mikropedagogija, interakcijsko-komunikacijski aspekt odgoja, Školska knjiga, Zagreb

Cilji in kompetence:	**Objectives and competences:**

Cilj predmeta je študentom je omogočiti in s kreditnimi točkami ovrednotiti njihovo izven kurikularno strokovno, nepridobitno delo, ki je za profesionalno profiliranje strokovnjaka na področju računalništva in informatike potrebno, pa ga učni načrt sicer ne pokriva. Splošne kompetence: • Sposobnost strokovnega sporazumevanja v domačem in v tujem jeziku • Sposobnost skupinskega dela v strokovnem okolju, vodenje manjše strokovne skupine • Sposobnost administrativnega vodenja procesov, povezanih z raziskovanjem, industrijo, izobraževanjem in drugimi področji • Sposobnost prenašanja znanja in pisanja v domačem in tujem jeziku Predmetno specifične kompetence: • Sposobnost celovite obdelave manjših projektov in reševanja problemov iz prakse s področja računalništva in informatike. • Naučiti se izbrati primerno orodje in tehnologijo za reševanje konkretnega problema • Razvijati sposobnosti za posredovanje znanja in popularizacijo računalniških znanj in veščin. • Sodelovanje pri skupinskem reševanju problemov, vodenja manjše skupine, pripravo gradiv, ki so za vodenje take skupine potrebna, organizacijo in pridobivanje znanj, ki so potrebni za delo skupine, pripravo terminskega in vsebinskega načrta za delo skupine itd.	The object of this course is to provide a framework for awarding study credits for extracurricular non-profit activities of students related to computer and information science, providing useful experience for experts in this field that are not included in the curriculum of the study program. General competences: • The ability of professional communication in the native language as well as a foreign language • The ability of teamwork within the professional environment; management of a small professional team • The ability for administrative management of processes related to research, industry, education and other fields • The ability of knowledge transfer and writing skills in the native language as well as a foreign language. Subject specific competences: • Completing smaller practical projects and solve problems in the fields for computer and information science • Obtaining the knowhow to choose the suitable tools and technologies for a specific problem • Developing teaching skills and means for popularizing computer and information science topics and issues. • Participating in group solutions, organizing and supervising the work of a smaller group including the preparation of the necessary materials, planning group work, etc.
Predvideni študijski rezultati:	**Intended learning outcomes:**
Spoznavanje osnovnih zakonitosti pri posredovanju znanja in popularizaciji računalniškega področja manjši skupini predvsem mlajših članov, organizaciji njenega dela in razumevanje pomena in uporabe takih znanj pri strokovnem delu strokovnjaka na področju računalništva in informatike.	Basic educational principles and teaching practice in the process of introducing computer science topics to smaller groups of younger students, organization of group work, understanding the role of such competencies in the work of an expert in the field of commuter and information science.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja, mentorski in seminarski način dela ter spremljanja dela študenta, z ustnim nastopom ob zaključku semestra. Poseben poudarek je na skupinskem delu pri seminarjih.	Lectures, individual work with students, seminars with oral presentations with special emphasis on group work.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Način (pisni izpit, ustno izpraševanje, naloge, projekt):		Type (examination, oral, coursework, project):
Način (pisni izpit, ustno izpraševanje, naloge, projekt):		Type (examination, oral, coursework, project):
Sprotno preverjanje (domače naloge, kolokviji in projektno delo)	**50%**	**Continuing** (homework, midterm exams, project work)
Končno preverjanje (pisni in ustni izpit)	**50%**	**Final** (written and oral exam)
Ocene: opravil z odliko, opravil ali ni opravil (v skladu s Statutom UL).		Grading: passed with excellence, passed or failed (according to the Statute of UL).

Reference nosilca / Lecturer's references:

1. FIJAVŽ, Gašper, WOOD, David Richard. Graph minors and minimum degree. The Electronic journal of combinatorics, ISSN 1077-8926. [Online ed.], 2010, vol. 17, no. 1, r151 (30 str.).

2. DUJMOVIĆ, Vida, FIJAVŽ, Gašper, JORET, Gwenaël, SULANKE, Thom, WOOD, David Richard. On the maximum number of cliques in a graph embedded in a surface. European journal of combinatorics, ISSN 0195-6698, 2011, vol. 32, no. 8, str. 1244-1252.

3. ALAM, Muhammad Jawaherul, CHAPLICK, Steven, FIJAVŽ, Gašper, KAUFMANN, Michael, KOBOUROV, Stephen G., PUPYREV, Sergey. Threshold-coloring and unit-cube contact representation of graphs. V: BRANDSTÄDT, Andreas (ur.), JANSEN, Klaus (ur.), REISCHUK, Rüdiger (ur.). Graph-theoretic concepts in computer science : 39th International Workshop, WG 2013, Lübeck, Germany, June 19-21, 2013 : revised papers, WG 2013, 39th International Workshop on Graph-Theoretic Concepts in Computer Science, June 19 - 21, 2013, Lübeck, Germany, (Lecture notes in computer science, ISSN 0302-9743, 8165). Heidelberg [etc.]: Springer. cop. 2013, str. 26-37.

4. FIJAVŽ, Gašper, PISANSKI, Tomaž, RUS, Jernej. Strong traces model of self-assembly polypeptide structures. MATCH Communications in Mathematical and in Computer Chemistry, ISSN 0340-6253, 2014, vol. 71, no. 1, str. 199-212.

5. FIJAVŽ, Gašper, NAKAMOTO, Atsuhiro. Odd complete minors in even embeddings on surfaces. Discrete Mathematics, ISSN 0012-365X. [Print ed.], 2016, vol. 339, iss. 1, str. 165-178.

Celotna bibliografija je dostopna na SICRISu:

http://www.sicris.si/search/rsr.aspx?lang=slv&id=9390.

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Obštudijska strokovna dejavnosti II
Course title:	Extracurricular professional activities II

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Magistrski študijski program druge stopnje Računalništvo in informatika Interdisciplinarni magistrski študijski program druge stopnje Multimedija	ni smeri	1, 2 2	zimski, poletni
Master study programme Computer and Information Science, 2nd cycle Interdisciplinary Master study program Multimedia, level 2	none	1, 2 2	fall, spring

Vrsta predmeta / Course type	**izbirni predmet /elective course**
Univerzitetna koda predmeta / University course code:	63535

Predavanja **Lectures**	**Seminar** **Seminar**	**Vaje** **Tutorial**	**Klinične vaje** **Laboratory work**	**Druge oblike študija** **Field work**	**Samost. delo** **Individ. work**	**ECTS**
5	/	/	/	40	45	3

Nosilec predmeta / Lecturer:	prodekan za pedagoško dejavnost FRI, FE/vice dean for education FRI, FE
Jeziki / **Predavanja / Lectures:**	Slovenščina in angleščina

Languages:	Slovene and English
Vaje / Tutorial:	Slovenščina in angleščina Slovene and English

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:

Prerequisites:

Vsebina:

Na uvodnih predavanjih študentom pojasnimo cilje predmeta in kako jih lahko dose□žejo. Med aktivnosti, ki jih lahko štejemo kot obveznosti pri predmetu sodijo vodenje ra␣unalniškega (ali po strokovni tematiki sorodnega) krožka na osnovni ali srednji šoli, vodenje študijske skupine na fakulteti, redno obiskovanje izven kurikularnih strokovnih predavanj na fakulteti ali na drugih članicah UL, ki so povezana s predmetom ipd.

Content (Syllabus outline):

After an introductiory lecture on the necessary background of the activities involved in the course, the students' activities include classes on topics in computer and information science and lab work with students of elementary and high schools, organizing study groups of students at the 1st degree level, attending extracurricular lectures at the University of Ljubljana on subjects associated to the topics of the course.

Temeljni literatura in viri / Readings:

1. **Keller** Gustav, **Binder** Annette, **Thiel** Rolf Dietmar (1999). Boljša motivacija uspešnejše učenje (translated from German); Trening učnih navad. Ljubljana: Center za psihodiagnostična sredstva.
2. **Bratanič**, Marija (1990), Mikropedagogija, interakcijsko-komunikacijski aspekt odgoja, Školska knjiga, Zagreb

Cilji in kompetence:

Objectives and competences:

Cilj predmeta je študentom je omogočiti in s kreditnimi točkami ovrednotiti njihovo izven kurikularno strokovno, nepridobitno delo, ki je za profesionalno profiliranje strokovnjaka na področju računalništva in informatike potrebno, pa ga učni načrt sicer ne pokriva. Splošne kompetence: • Sposobnost strokovnega sporazumevanja v domačem in v tujem jeziku • Sposobnost skupinskega dela v strokovnem okolju, vodenje manjše strokovne skupine • Sposobnost administrativnega vodenja procesov, povezanih z raziskovanjem, industrijo, izobraževanjem in drugimi področji • Sposobnost prenašanja znanja in pisanja v domačem in tujem jeziku Predmetno specifične kompetence: • Sposobnost celovite obdelave manjših projektov in reševanja problemov iz prakse s področja računalništva in informatike. • Naučiti se izbrati primerno orodje in tehnologijo za reševanje konkretnega problema • Razvijati sposobnosti za posredovanje znanja in popularizacijo računalniških znanj in veščin. • Sodelovanje pri skupinskem reševanju problemov, vodenja manjše skupine, pripravo gradiv, ki so za vodenje take skupine potrebna, organizacijo in pridobivanje znanj, ki so potrebni za delo skupine, pripravo terminskega in vsebinskega načrta za delo skupine itd.	The object of this course is to provide a framework for awarding study credits for extracurricular non-profit activities of students related to computer and information science, providing useful experience for experts in this field that are not included in the curriculum of the study program. General competences: • The ability of professional communication in the native language as well as a foreign language • The ability of teamwork within the professional environment; management of a small professional team • The ability for administrative management of processes related to research, industry, education and other fields • The ability of knowledge transfer and writing skills in the native language as well as a foreign language. Subject specific competences: • Completing smaller practical projects and solve problems in the fields for computer and information science • Obtaining the knowhow to choose the suitable tools and technologies for a specific problem • Developing teaching skills and means for popularizing computer and information science topics and issues. • Participating in group solutions, organizing and supervising the work of a smaller group including the preparation of the necessary materials, planning group work, etc.
Predvideni študijski rezultati:	**Intended learning outcomes:**
Spoznavanje osnovnih zakonitosti pri posredovanju znanja in popularizaciji računalniškega področja manjši skupini predvsem mlajših članov, organizaciji njenega dela in razumevanje pomena in uporabe takih znanj pri strokovnem delu strokovnjaka na področju računalništva in informatike.	Basic educational principles and teaching practice in the process of introducing computer science topics to smaller groups of younger students, organization of group work, understanding the role of such competencies in the work of an expert in the field of computer and information science.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja, mentorski in seminarski način dela ter spremljanja dela študenta, z ustnim nastopom ob zaključku semestra. Poseben poudarek je na skupinskem delu pri seminarjih.	Lectures, individual work with students, seminars with oral presentations with special emphasis on group work.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Način (pisni izpit, ustno izpraševanje, naloge, projekt):		Type (examination, oral, coursework, project):
Način (pisni izpit, ustno izpraševanje, naloge, projekt):		Type (examination, oral, coursework, project):
Sprotno preverjanje (domače naloge, kolokviji in projektno delo)	**50%**	**Continuing** (homework, midterm exams, project work)
Končno preverjanje (pisni in ustni izpit)	**50%**	**Final** (written and oral exam)
Ocene: opravil z odliko, opravil ali ni opravil (v skladu s Statutom UL).		Grading: passed with excellence, passed or failed (according to the Statute of UL).

Reference nosilca / Lecturer's references:

1. FIJAVŽ, Gašper, WOOD, David Richard. Graph minors and minimum degree. The Electronic journal of combinatorics, ISSN 1077-8926. [Online ed.], 2010, vol. 17, no. 1, r151 (30 str.).

2. DUJMOVIĆ, Vida, FIJAVŽ, Gašper, JORET, Gwenaël, SULANKE, Thom, WOOD, David Richard. On the maximum number of cliques in a graph embedded in a surface. European journal of combinatorics, ISSN 0195-6698, 2011, vol. 32, no. 8, str. 1244-1252.

3. ALAM, Muhammad Jawaherul, CHAPLICK, Steven, FIJAVŽ, Gašper, KAUFMANN, Michael, KOBOUROV, Stephen G., PUPYREV, Sergey. Threshold-coloring and unit-cube contact representation of graphs. V: BRANDSTÄDT, Andreas (ur.), JANSEN, Klaus (ur.), REISCHUK, Rüdiger (ur.). Graph-theoretic concepts in computer science : 39th International Workshop, WG 2013, Lübeck, Germany, June 19-21, 2013 : revised papers, WG 2013, 39th International Workshop on Graph-Theoretic Concepts in Computer Science, June

19 - 21, 2013, Lübeck, Germany, (Lecture notes in computer science, ISSN 0302-9743, 8165). Heidelberg [etc.]: Springer. cop. 2013, str. 26-37.

4. FIJAVŽ, Gašper, PISANSKI, Tomaž, RUS, Jernej. Strong traces model of self-assembly polypeptide structures. MATCH Communications in Mathematical and in Computer Chemistry, ISSN 0340-6253, 2014, vol. 71, no. 1, str. 199-212.

5. FIJAVŽ, Gašper, NAKAMOTO, Atsuhiro. Odd complete minors in even embeddings on surfaces. Discrete Mathematics, ISSN 0012-365X. [Print ed.], 2016, vol. 339, iss. 1, str. 165-178.

Celotna bibliografija je dostopna na SICRISu:

http://www.sicris.si/search/rsr.aspx?lang=slv&id=9390.

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	**Izbrana poglavja iz računalništva in informatike**
Course title:	**Topics in Computer and Information Science**

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Magistrski študijski program druge stopnje Računalništvo in informatika	ni smeri	1, 2	zimski
Master study program Computer and Information Science, level 2	none	1, 2	fall

Vrsta predmeta / Course type	**izbirni predmet / elective course**
Univerzitetna koda predmeta / University course code:	**63536**

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje Laboratory work	Druge oblike študija Field work	Samost. delo Individ. work	ECTS
45	/	30	/	/	105	6

Nosilec predmeta / Lecturer:	prodekan za pedagoško dejavnost izvajalec je vsako leto gostujoči profesor z drugih univerz/ each year the lecturer is a visiting professor from other universities

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

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisits:**

Opravljanje študijskih obveznosti je opredeljeno v Študijskih pravilih FRI.	As specified by internal acts of the University of Ljubljana and Faculty of Computer and Information Science.

Vsebina:	**Content (Syllabus outline):**
Predmet je namenjen uveljavljenim gostujočim predavateljem iz tujine ali iz prakse. Ti bodo študentom v okviru predmeta predstavili nove odmevne ideje, metodološke preboje ali uporabne rešitve s področja računalništva in informatike, ki kot take še niso vključene v vsebine obstoječih predmetov. Podrobna vsebina se določi vsako leto posebej glede na predloge in strokovno usmeritev izbranega predavatelja.	The course is intented for established visiting researchers and lecturers and for experts in computer and information science which will introduce students to topics that are interesting due to recent theoretical findings and mehodological breakthroughs or for their applicative value, and are as such not included into the existing curriculum. The specific contents of the course is determined yearly.

Temeljni literatura in viri / Readings:

1. Thomas H. Cormen, Charles E. Leiserson...: Introduction to Algorithms, 2nd edition, MIT Press, 2001.
2. Graham, Ronald L.; Knuth, Donald E.; Patashnik, Oren (1994). *Concrete Mathematics* (second ed.). Reading, MA: Addison-Wesley Publishing Company. pp. xiv+657. ISBN 0-201-55802-5. MR1397498
3. O'Regan, Gerard: A Brief History of Computing, Springer, 2008.

Dodatna literatura se predpiše vsako leto posebej glede na vsebino in predloge izbranega predavatelja.

Additional literature is given yearly, with respect to the current topic of the course.

Cilji in kompetence:	**Objectives and competences:**
Cilj predmeta je spoznati teoretične osnove in praktične implementacije novih metod in tehnologij na področju računalništva in informatike.	The goal of the course is to introduce basic theoretical ideas as well as practical implementations of new methods and technologies in the field of computer and information science

Predvideni študijski rezultati:	**Intended learning outcomes:**

Znanje in razumevanje: Študenti spoznavajo nova področja in prijeme, ki v obstoječem predmetniku še niso zajeta. **Uporaba:** Uporaba najnovejših pristopov in tehnik z izbranega področja računalništva in informatike. **Refleksija:** Razumevanje primernosti izbranih pristopov s področja računalništva in informatike za reševanje praktičnih primerov v poslovnih okoljih. **Prenosljive spretnosti - niso vezane le na en** **predmet:** Reševanje kompleksnih problemov, razvoj kompleksnih sistemov.	**Knowledge and understanding:** A broader overview and understanding of the field of study, and of up to date methods and concepts. **Application:** Applying current approaches and techniques from the specific field of computer and informations science. **Reflection:** Understanding the advantages of the chosen approaches in computer and information science in solving specific practical tasks. **Transferable skills:** Solving complex problems, designing complex systems.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja, laboratorijske vaje	Lectures, lab excersises

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Način (pisni izpit, ustno izpraševanje, naloge, projekt): **Sprotno preverjanje** (domače naloge, kolokviji in projektno delo) **Končno preverjanje** (pisni in ustni izpit) Ocene: 6-10 pozitivno, 1-5 negativno (v skladu s Statutom UL)	**50%** **50%**	Type (examination, oral, coursework, project): **Continuing** (homework, midterm exams, project work) **Final**: (written and oral exam) Grading: 6-10 pass, 1-5 fail.

Reference nosilca / Lecturer's references:

Pet najpomembnejših del:

FIJAVŽ, Gašper, MOHAR, Bojan. K [sub] 6 -minors in projective planar graphs. *Combinatorica (Bp. 1981)*, 2003, vol. 23, no. 3, str. 453-465. [COBISS.SI-ID 12801625]

2. FIJAVŽ, Gašper. Contractions of 6-connected toroidal graphs. *J. comb. theory, Ser. B*, 2007, vol. 97, no. 4, str. 553-570. [COBISS.SI-ID 14332761]

3. BOKAL, Drago, FIJAVŽ, Gašper, WOOD, David Richard. The minor crossing number of graphs with an excluded minor. *Electron. j. comb. (On line)*. [Online ed.], 2008, vol. 15, no. 1, r4 (13 str.). http://www.combinatorics.org/Volume_15/PDF/v15i1r4.pdf. [COBISS.SI-ID 14499417]

4. FIJAVŽ, Gašper, WOOD, David Richard. Graph minors and minimum degree. *Electron. j. comb. (On line)*. [Online ed.], 2010, vol. 17, no. 1, r151 (30 str.). http://www.combinatorics.org/Volume_17/PDF/v17i1r151.pdf. [COBISS.SI-ID 15813209]

5. DUJMOVIĆ, Vida, FIJAVŽ, Gašper, JORET, Gwenaël, SULANKE, Thom, WOOD, David Richard. On the maximum number of cliques in a graph embedded in a surface. *Eur. j. comb.*, 2011, vol. 32, no. 8, str. 1244-1252. http://dx.doi.org/10.1016/j.ejc.2011.04.001. [COBISS.SI-ID 16079449]

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