

**UČNI NAČRT PREDMETA / COURSE SYLLABUS**

**Predmet:** Izbrana poglavja iz arhitektur in algoritmov 1  
**Course title:** Selected Topics in Architectures and Algorithms 1

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Doktorski študijski program Računalništvo in informatika, 3. stopnja	ni smeri	1, 2	poletni
Doctoral Program in Computer and Information Science, level 3	none	1, 2	spring

**Vrsta predmeta / Course type** izbirni/elective from CS

**Univerzitetna koda predmeta / University course code:** 63824

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje Laboratory work	Druge oblike študija Field work	Samost. delo Individ. work	ECTS
15	20	15	/	75		5

**Nosilec predmeta / Lecturer:** prof. dr. Borut Robič (predstojnik Katedre za teoretično računalništvo / *Head of Theoretical Computer Science Chair*)  
izvajalec se izbere na internem razpisu/the lecturer is selected on the internal call

**Jeziki / Languages:**

<b>Predavanja / Lectures:</b>	slovenščina in angleščina Slovene and English
<b>Vaje / Tutorial:</b>	slovenščina in angleščina Slovene and English

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

Redni vpis na doktorski študij.

Enrollment in the Ph. D. program.

**Vsebina:**

Na kakšnih principih delujejo najhitrejši računalniki in kako so narejeni? Kako je sploh mogoče narediti računalnik, ki je več kot milijonkrat hitrejši od tipičnega stroja? Ali so uporabni za vse probleme? Ali obstajajo arhitekture, ki so prilagojene določenim vrstam problemov?. To so vprašanja na katere odgovarjamo pri predmetu "Izbrana poglavja iz arhitektur in algoritmov 1".

Predmet obsega naslednja poglavja:

- Omejitve zaporednega računanja
- Osnovne vrste vzporednosti in algoritmi za njihovo izkoriščanje
- Superskalarni računalniki
- Taksonomija vzporednosti: Flynnova klasifikacija
- Vektorski računalniki
- SIMD in MIMD računalniki
- GPU računanje
- Medprocesorska komunikacija in povezovalne mreže
- Programiranje vzporednih računalnikov
- Pregled najzmogljivejših vzporednih računalnikov (superračunalnikov)
- Problem energetske učinkovitosti
- Arhitekture, ki so prilagojene specifičnim algoritmom
- Porazdeljeno računanje
- Ne-Von Neumannovi računalniki

**Content (Syllabus outline):**

What are the principles on which the fastest computers work and how are they designed? How is it possible to build a computer that is more than a million times faster than a typical computer? Can they be used on all problems? Are there architectures which are tailored to the specific type of problems? These are the questions that are answered in the "Selected Topics in Architectures and Algorithms 1" course.

The following topics are included:

- Limitations of the serial computing
- Basic types of parallelism and algorithms for its exploitation
- Superscalar computers
- Taxonomy of parallelism: Flynn's classification
- Vector computers
- SIMD and MIMD computers
- GPU computing
- Interprocessor communication and interconnection networks
- Programming parallel computers
- Survey of the most powerful parallel computers (supercomputers)
- Energy efficiency problem
- Architectures that are tailored to specific algorithms
- Distributed computing
- Non-Von Neumann computers

**Temeljni literatura in viri / Readings:**

Hennessy JL., Patterson DA. (2012) Computer architecture: a quantitative approach, 5th edition, Elsevier.

Kodek D. (2008) Arhitektura in organizacija računalniških sistemov, Bi-Tim.

Bader DA. (2008) Petascale computing: algorithms and applications, Chapman and Hall/CRC.

Gramma A., Gupta A, Karypis G, Kumar V. (2003) Introduction to parallel computing, 2nd edition, Pearson.

Berman KA., Paul JL. (2004) Algorithms: Sequential, Parallel, and Distributed, Course Techn.

**Cilji in kompetence:**

Cilj predmeta je podati znanja s področja vzporednega računanja, ki na mnogih področjih postaja osnovno sredstvo za reševanje problemov. Ta znanja obsegajo arhitekture vzporednih računalnikov in osnovne algoritme za izkoriščanje vzporednosti. Predmet je zasnovan tako, da bodo študenti poleg teoretičnega znanja o delovanju vzporednih računalnikov razumeli tudi kdaj in kje jih je smiselno uporabiti v praksi. Najnovejši vzporedni računalniki bodo obdelani kot primeri.

**Objectives and competences:**

The purpose of this course is to introduce students to the field of parallel computing which is in many areas becoming a basic tool for problem solving. The topics include architectures of parallel computers and basic algorithms for exploitation of parallelism. The course is structured so that it will provide students with a theoretical knowledge of parallel computer systems and also with understanding when and where it makes sense to use them in practice. The latest parallel computers will be studied as examples.

**Predvideni študijski rezultati:**

Znanje in razumevanje:  
Znanje o arhitekturah vzporednih računalnikov, ki se uporabljajo za reševanje zahtevnih računskih problemov.

Uporaba:  
Uporaba znanja o arhitekturah za odločitve o uporabi vzporednih računalnikov pri praktičnem reševanju težkih računskih problemov na raznih področjih znanosti in tehnike.

**Intended learning outcomes:**

Knowledge and understanding:  
Knowledge of parallel computer architectures that are used to solve hard computational problems.

Application:  
Applying knowledge about architectures for making decisions about the practical use of parallel computers in solving the hard computational problems in different areas of science and technology.

**Metode poučevanja in učenja:**

Predavanja s podporo avdio-vizualne opreme, domače naloge in seminar. Delo bo potekalo po skupinah, pri domačih nalogah, seminarju in konzultacijah pa individualno.

**Learning and teaching methods:**

Lectures combining blackboard with computer projections. Working in groups and individually for homework, seminar and consultations.

**Načini ocenjevanja:**

Delež (v %) /

Weight (in %)

**Assessment:**

Način (pisni izpit, ustno izpraševanje, naloge)	Delež (v %) / Weight (in %)	Type (examination, oral, homework):
Pisni izpit (domače naloge in seminarska naloga se upoštevata pri oceni pisnem izpitu).	50%	Written exam (homeworks and seminar work are used for grading the written exam).
Ustni izpit.	50%	Oral exam.
Ocene: 6-10 pozitivno, 1-5 negativno (v skladu s Statutom UL).		Grades: 6-10 passing, 1-5 failing (according to the Statute of UL).

**Reference nosilca / Lecturer's references:**

Robič B. (2015) *The Foundations of Computability Theory*, Springer, ISBN 978-3-662-44807-6.

Šilc J., Robič B., Ungerer T. (1999) *Processor architecture : from dataflow to superscalar and beyond*. Springer, ISBN 3-540-64798-8.

Ungerer T., Robič B., Šilc J. (2003) A survey of processors with explicit multithreading. *ACM computing surveys*, 35:29-63.

Mihelič J., Mahjoub A., Rapine C., Robič B., (2010) Two-stage flexible-choice problems under uncertainty. *European journal of operational research*, 201(2):399-403.

Trobec R., Šterk M., Robič B. (2009) Computational complexity and parallelization of the meshless local Petrov-Galerkin methods. *Computers & Structures*, 87(1/2):81-90.

**UČNI NAČRT PREDMETA / COURSE SYLLABUS**

**Predmet:** Izbrana poglavja iz arhitektur in algoritmov 2  
**Course title:** Selected Topics in Architectures and Algorithms 2

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Doktorski študijski program Računalništvo in informatika, 3. stopnja	ni smeri	1, 2	poletni
Doctoral Program in Computer and Information Science, level 3	none	1, 2	spring

ß

izbirni/elective from CS

**Univerzitetna koda predmeta / University course code:** 63825

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje Laboratory work	Druge oblike študija Field work	Samost. delo Individ. work	ECTS
15	20	15	/	75		5

**Nosilec predmeta / Lecturer:**

prof. dr. Borut Robič (predstojnik Katedre za teoretično računalništvo / Head of Theoretical Computer Science Chair)  
izvajalec se izbere na internem razpisu/the lecturer is selected on the internal call

**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:**

Redni vpis na doktorski študij.

Enrollment in the Ph. D. program.

**Vsebina:**

Kakšni algoritmi so primerni za vzporedne računalnike? Kaj lahko z vzporednimi algoritmi sploh dosežemo? Kako vzporedne algoritme snujemo? Kako so odvisni od arhitekture vzporednega računalnika? Kako jih programiramo? V katerih programskih jezikih? Kje se uporabljajo? To so vprašanja na katere odgovarjamo pri predmetu 'Izbrana poglavja iz arhitektur in algoritmov 2'.

Predmet obsega naslednja poglavja:

- Formalni modeli in računska zahtevnost vzporednega računanja
- Snovanje in analiza vzporednih algoritmov
- Primeri vzporednih algoritmov (npr. algoritmi iskanja in urejanja, algoritmi nad grafi, geometrijski algoritmi, algoritmi iz aritmetike, algoritmi iz linearne algebre)
- Sinhronizacija procesov, dodeljevanje računskih virov, uskladitev ur, nadzor sočasnosti
- Principi paralelnega programiranja, podatkovno paralelno programiranje, podatkovno vodeno in funkcijsko programiranje
- Jeziki in prevajalniki za vzporedno računanje
- Uporabno vzporedno računanje (npr. problem n teles, valčki in Fourierove transformacije, problemi iz linearne algebre, optimizacijski problemi, uporaba v umetni inteligenci)

**Content (Syllabus outline):**

What algorithms are appropriate for parallel computers? What can be achieved by using parallel algorithms? How are such algorithms designed? How are they influenced by the underlying parallel computer architecture? How are they programmed? In what languages? Where are they applied? These are the questions that are answered in the 'Selected Topics in Architectures and Algorithms 2' course.

The following topics are included:

- Formal models and computational complexity of parallel computing
- Design and analysis of parallel algorithms
- Examples of parallel algorithms (e.g., search and sort algorithms, graph algorithms, geometry algorithms, arithmetic algorithms, computational algorithms)
- Process synchronization, allocation of computing resources, clock synchronization, concurrency management
- Principles of parallel programming, data parallel programming, dataflow and functional programming
- Languages and compilers for parallel computing
- Applications of parallel computers (e.g., n-body problem, wavelets and Fourier transformations, linear algebra problems, optimization problems, applications in AI)

**Temeljni literatura in viri / Readings:**

Bader D. A. (2015) Parallel Graph Algorithms, Chapman and Hall/CRC.  
Roosta S. H. (2013) Parallel Processing and Parallel Algorithms: Theory and Computation, Springer.  
Parhami B. (2013) Introduction to Parallel Processing: Algorithms and Architectures, Springer.  
Fokkink W. (2013) Distributed Algorithms: An Intuitive Approach, MIT Press.  
Gebali F. (2011) Algorithms and Parallel Computing, Wiley.  
Casanova H., Legrand A, Robert Y. (2008) Parallel Algorithms, Chapman and Hall/CRC.  
Bader D. A. (2008) Petascale Computing: Algorithms and Applications, Chapman and Hall/CRC.

#### **Cilji in kompetence:**

Cilj predmeta je opremiti študenta s tistimi znanji s področja vzporednega računanja, ki se nanašajo na razvoj vzporednih algoritmov in njihovo programiranje v končne programe, ki se bodo učinkovito izvajali na izbranem vzporednem računalniku. Predmet je zasnovan tako, da bodo študenti teoretična znanja znali uporabiti v praksi pri načrtovanju vzporednih algoritmov ter pri njihovi uporabi pri reševanju zahtevnih računskih problemov. Naučili uporabljati napredna orodja pri vzporednem reševanju konkretnega problema.

#### **Objectives and competences:**

The purpose of this course is to equip students with the knowledge from those fundamental areas of parallel computing which will enable the student to design parallel algorithms for various computational problems, and to program such algorithms so that they will execute efficiently on a given parallel computer. The structure of the course will allow students to use theoretical knowledge for practical design of parallel computer systems and parallel algorithms that can be used for complex problem solving. The advanced tools for solving a typical parallel problem will be given.

#### **Predvideni študijski rezultati:**

Znanje in razumevanje:  
Poznavanje vzporednih algoritmov in ustreznih programirnih tehnologij, ki se uporabljajo na vzporednih računalnikih za vzporedno reševanje računskih problemov.

Uporaba:  
Uporaba znanja iz vzporednih algoritmov na tipičnih problemih, dovzetnih za vzporedno reševanje, kot so napovedovanje vremena, simulacija kemijskih in fizikalnih procesov, astronomski izračuni in podobno.

#### **Intended learning outcomes:**

Knowledge and understanding:  
Knowledge of parallel algorithms and parallel programming technologies that are used to solve problems on parallel computers.

Application:  
Application of knowledge from parallel algorithms on typical parallel problems such as weather forecasting, chemical and physical processes simulation, computational astronomy and similar.

**Metode poučevanja in učenja:**

Predavanja s podporo avdio-vizualne opreme, domače naloge in seminar. Delo bo potekalo po skupinah, pri domačih nalogah, seminarju in konzultacijah pa individualno.

**Learning and teaching methods:**

Lectures combining blackboard with computer projections. Working in groups and individually for homework, seminar and consultations.

**Načini ocenjevanja:**

Delež (v %) /

Weight (in %)

**Assessment:**

Način (pisni izpit, ustno izpraševanje, naloge)	Delež (v %) / Weight (in %)	Type (examination, oral, homework):
Pisni izpit (domače naloge in seminarska naloga se upoštevata pri oceni pisnem izpitu).	50%	Written exam (homeworks and seminar work are used for grading the written exam).
Ustni izpit.	50%	Oral exam.
Ocene: 6-10 pozitivno, 1-5 negativno (v skladu s Statutom UL).		Grades: 6-10 passing, 1-5 failing (according to the Statute of UL).

**Reference nosilca / Lecturer's references:**

Robič B. (2015) *The Foundations of Computability Theory*, Springer, ISBN 978-3-662-44807-6.

Šilc J., Robič B., Ungerer T. (1999) *Processor architecture : from dataflow to superscalar and beyond*. Springer, ISBN 3-540-64798-8.

Ungerer T., Robič B., Šilc J. (2003) A survey of processors with explicit multithreading. *ACM computing surveys*, 35:29-63.

Mihelič J., Mahjoub A., Rapine C., Robič B., (2010) Two-stage flexible-choice problems under uncertainty. *European journal of operational research*, 201(2):399-403.

Trobec R., Šterk M., Robič B. (2009) Computational complexity and parallelization of the meshless local Petrov-Galerkin methods. *Computers & Structures*, 87(1/2):81-90.



**UČNI NAČRT PREDMETA / COURSE SYLLABUS**

<b>Predmet:</b>	Izbrana poglavja iz informatike 1
<b>Course title:</b>	Selected Topics in Informatics 1

<b>Študijski program in stopnja</b> Study programme and level	<b>Študijska smer</b> Study field	<b>Letnik</b> Academic year	<b>Semester</b> Semester
Doktorski študijski program Računalništvo in informatika, 3. stopnja	ni smeri	1, 2	zimski
Doctoral Program in Computer and Information Science, level 3	none	1, 2	fall

**Vrsta predmeta / Course type** izbirni/elective from CS

**Univerzitetna koda predmeta / University course code:** 63826

<b>Predavanja</b> Lectures	<b>Seminar</b> Seminar	<b>Vaje</b> Tutorial	<b>Klinične vaje</b> Laboratory work	<b>Druge oblike študija</b> Field work	<b>Samost. delo</b> Individ. work	<b>ECTS</b>
15	20	15	/	75		5

**Nosilec predmeta / Lecturer:** prof. dr. Denis Trček (predstojnik Katedre za informatiko / Head of Informatics Chair)  
izvajalec se izbere na internem razpisu/the lecturer is selected on the internal call

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

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

Redni vpis na doktorski študij.

Enrollment in the Ph. D. program.

**Vsebina:**

Pri predmetu bodo predstavljena in obdelana izbrana poglavja z naslednjih področij:

- konstruiranje metodologij za razvoj informacijskih sistemov,
- razvoj informacijskih sistemov s pomočjo agentnih tehnologij in večagentnih sistemov,
- uporaba tehnologij semantičnega spleta in ontologij pri načrtovanju in razvoju informacijskih sistemov,
- poslovno-informacijske arhitekture,
- obvladovanje informatike v poslovnih sistemih,
- uporaba informacijskih znanj pri analiziranju poslovanja,
- uporaba analitskih znanj pri razvoju informacijskih sistemov,
- sistemska dinamika - teorija nelinearnih dinamičnih sistemov.

**Content (Syllabus outline):**

The course will cover selected topics from the following areas:

- method engineering for information system development,
- information system development with agent technologies and multi-agent systems,
- semantic web technologies and ontologies for information system design and development,
- enterprise architectures,
- IT governance in enterprises,
- business analysis with IT knowledge,
- analytical knowledge for information system development,
- system dynamics – theory of nonlinear dynamic systems and application for information systems.

**Temeljni literatura in viri / Readings:**

Davies J., Studer R., Warren P. (2006) Semantic Web Technologies - Trends and research in ontology-based systems.

Wooldridge M., (2002) An Introduction to MultiAgent Systems.

Lankhorst M. (2005) Enterprise Architecture at Work: Modelling, Communication and Analysis, Springer.

Foss N. (2005) Strategy, Economic Organization, and the Knowledge, Economy, Oxford University Press, Oxford.

**Cilji in kompetence:**

**Objectives and competences:**

Študenti bodo pri predmetu osvojili napredna znanja s področja informatike oziroma informacijskih sistemov, elektronskega poslovanja, obvladovanja procesov informatike ter razvoja informacijskih sistemov. Teoretična znanja bodo znali uporabiti v praksi ter s priučenimi metodologijami in tehnikami reševati kompleksne probleme na področjih tako informacijskih sistemov kot obvladovanja informatike v različnih poslovnih sistemih, s posebnim poudarkom na usposobljenosti za razvoj tudi kompleksnih sistemov. Naučili se bodo uporabljati napredna orodja, oziroma v izbranem programskem sistemu za razvoj aplikacij razviti svojo rešitev za dani problem.

Through this course the students will gain knowledge on selected advanced topics in the field of informatics, more specifically in electronic business, IT governance processes, and information systems development. They will learn how to use the theoretical knowledge in practice and learn methods and techniques to resolve complex problems in the field of information systems and IT governance in various business systems, with an emphasis on ability to develop complex systems. They will gain familiarity with advanced tools and selected application development systems, which will allow them to develop their own solutions for given problems.

**Predvideni študijski rezultati:**

Znanje in razumevanje:  
Poznavanje izbranih poglavij in naprednih tehnik iz informatike.

Uporaba:  
Uporaba naprednih tehnik v namene analize, modeliranja in zasnove kompleksnih informacijskih sistemov.

Refleksija:  
Razumevanje primernosti teoretičnih metod za reševanje praktičnih problemov ter njihovih omejitev, sposobnost analitičnega razmišljanja, sposobnost analize in reševanja kompleksnih praktičnih problemov.

Prenosljive spretnosti:  
Spretnosti reševanja kompleksnih problemov kar vključuje: iskanje literature, uporabo primerne programske opreme (tudi odprtokodne) in programskih okolij, vrednotenje obstoječih postopkov in razvoj ter vrednotenje novih postopkov.

**Intended learning outcomes:**

Knowledge and understanding:  
Knowledge of the selected topics and advanced techniques from the field of informatics.

Application:  
Application of advanced techniques for analysis, modelling and construction of complex information systems.

Reflection:  
Understanding of suitability of theoretical methods for solving practical problems and their limitations, ability of analytical thinking, ability of analysis and solving complex practical problems.

Transferable skills:  
Skills of solving complex problems what includes: search of literature, use of appropriate software (including open source) and programming environments, evaluation of existing procedures, and development and evaluation of new procedures.

**Metode poučevanja in učenja:**

**Learning and teaching methods:**

Predavanja s podporo avdio-vizualne opreme, aktivna uporaba sistema za upravljanje s študijskimi vsebinami (npr. Moodle). Laboratorijske vaje v računalniški učilnici z ustrezno strojno in programsko opremo. Kombiniranje delo posamezno in v skupinah, ter individualnega dela ter interakcij pri seminarjih in na konzultacijskih urah.

Lectures supported by audio-visual equipment and active use of the system for management of teaching material (e.g., Moodle). Laboratory work in classrooms with appropriate hardware and software. Combination of individual and group-based studies, accompanied with student/teacher interactions at seminars and consulting hours.

Delež (v %) /

**Načini ocenjevanja:**

Weight (in %)

**Assessment:**

<p>Način (pisni izpit, ustno izpraševanje, naloge, projekt) Pisni in ustni izpit, sprotno preverjanje znanja - domače naloge, projekt in predstavitev seminarja.</p>	<p>50% 50%</p>	<p>Type (examination, oral, coursework, project): Written and oral exam, continuing assessment of knowledge – homeworks, project and seminar presentation.</p>
<p>Ocene: 6-10 pozitivno, 1-5 negativno (v skladu s Statutom UL).</p>		<p>Grades: 6-10 passing, 1-5 failing (according to the Statute of UL).</p>

**Reference nosilca / Lecturer's references:**

Trček, D., Brodnik, A. (2013) Hard and soft security provisioning for computationally weak pervasive computing systems in e-health. IEEE wireless communications, ISSN 1536-1284. [Print ed.], vol. 20, no. 4, 8 str., kategorija: 1A1 (Z1, A'', A', A1/2).

Trček, D., Likar, B. (2014) Driving information systems security through innovations : first indications. Cybernetics and systems, ISSN 0196-9722, vol. 45, iss. 1, str. 56-68, kategorija: 1A3 (Z1).

Trček D. (2014) Qualitative assessment dynamics : complementing trust methods for decision making. International journal of information technology & decision making. [Online ed.] , vol. 12, no. 6, str. 1-19, doi: 10.1142/S0219622014500072, kategorija: 1A1 (Z1, A', A1/2).

Šubelj L. Jelenc D., Zupančič E., Lavbič. D., Trček D., Krisper M., Bajec M. (2011) Merging data sources based on semantics, contexts and trust. The IPSI BgD transactions on internet research, ISSN 1820-4503. [Print ed.], vol. 7, no. 1, str. 18-30, ilustr.  
<http://internetjournals.net/journals/tir/2011/January/Full%20Journal.pdf>. [COBISS.SI-ID 7850580], kategorija: 1NK (S).

Zupančič E., Trček D. (2012) Deployment of trust management system in environment of e-commerce. V: JEZIC, Gordan (ur.). Agent and multi-agent systems : technologies and applications : proceedings, (Lecture notes in computer science, ISSN 0302-9743, 7327). Berlin; Heidelberg: Springer, cop., str. 484-493, kategorija: 1A4 (Z1).

**UČNI NAČRT PREDMETA / COURSE SYLLABUS**

<b>Predmet:</b>	Izbrana poglavja iz informatike 2
<b>Course title:</b>	Selected Topics in Informatics 2

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Doktorski študijski program Računalništvo in informatika, 3. stopnja	ni smeri	1, 2	zimski
Doctoral Program in Computer and Information Science, level 3	none	1, 2	fall

**Vrsta predmeta / Course type** izbirni/elective from CS

**Univerzitetna koda predmeta / University course code:** 63827

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje Laboratory work	Druge oblike študija Field work	Samost. delo Individ. work	ECTS
15	20	15	/	75		5

**Nosilec predmeta / Lecturer:** prof. dr. Denis Trček (predstojnik Katedre za informatiko / Head of Informatics Chair)  
izvajalec se izbere na internem razpisu/the lecturer is selected on the internal call

**Jeziki / Languages:**

<b>Predavanja / Lectures:</b>	slovenščina in angleščina Slovene and English
<b>Vaje / Tutorial:</b>	slovenščina in angleščina Slovene and English

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

Redni vpis na doktorski študij.

Enrollment in the Ph. D. program.

**Vsebina:**

Pri predmetu bodo predstavljena in obdelana izbrana poglavja z naslednjih področij:

- modelno usmerjene arhitekture (MDA),
- storitveno usmerjene arhitekture (SOA),
- računalništvo v oblaku,
- sistemi za obvladovanje poslovnih pravil,
- poslovni procesi in avtomatizacija poslovnih procesov,
- arhitekture informacijskih sistemov,
- načrtovalski vzorci,
- arhitekturni vzorci,
- vzorci analize,
- spremljanje učinkovitosti informacijskih sistemov,
- verifikacija in validacija informacijskih sistemov,
- formalne metode pri razvoju IS.

**Content (Syllabus outline):**

The course will cover selected topics from the following areas:

- model-driven architectures (MDA),
- service-oriented architectures (SOA),
- Cloud Computing,
- business rules management systems,
- business processes and business process automation,
- information system architectures,
- design patterns,
- architectural patterns,
- analysis patterns,
- information systems efficiency monitoring,
- verification and validation,
- formal methods in IS development.

**Temeljni literatura in viri / Readings:**

Stephen J. M., Kendall S., Uhl A., Weise D. (2004) MDA Distilled: Principles of Model-Driven Architecture. Addison-Wesley.

Havey M. (2005) Essential Business Process Modeling.

Erl T., Chelliah P., Gee C., Kress J., Maier B., Normann H., Shuster L., Trops B., Utschig C., Wik P., Winterberg T. (2014) Next Generation SOA: A Concise Introduction to Service Technology & Service-Oriented, Prentice Hall.

Erl T., Puttini R., Zaigham M. (2013) Cloud Computing: Concepts, Technology & Architecture, Prentice Hall.

Shalloway A., Trott A. R. (2004) Design Patterns Explained: A New Perspective on Object-Oriented Design (2nd Edition), Addison-Wesley.

**Cilji in kompetence:**

**Objectives and competences:**

Študenti bodo pri predmetu osvojili napredna znanja s področja informatike oziroma informacijskih sistemov, elektronskega poslovanja, obvladovanja procesov informatike ter razvoja informacijskih sistemov in avtomatizacijo poslovnih procesov. Teoretična znanja bodo znali uporabiti v praksi ter s priučenimi metodologijami in tehnikami reševati kompleksne probleme na področjih tako informacijskih sistemov kot obvladovanja informatike v različnih poslovnih sistemih, s posebnim poudarkom na usposobljenosti za razvoj tudi kompleksnih sistemov. Naučili se bodo uporabljati napredna orodja, oziroma v izbranem programskem sistemu za razvoj aplikacij razviti svojo rešitev za dani problem.

Through this course the students will gain knowledge on selected advanced topics in the field of informatics, more specifically in electronic business, IT governance processes, information systems development and business process automation. They will learn how to use the theoretical knowledge in practice and learn methods and techniques to resolve complex problems in the field of information systems and IT governance in various business systems, with an emphasis on ability to develop complex systems. They will gain familiarity with advanced tools and selected application development systems, which will allow them to develop their own solutions for given problems.

**Predvideni študijski rezultati:**

Znanje in razumevanje:  
Poznavanje izbranih poglavij in naprednih tehnik iz arhitektur informacijskih sistemov.

Uporaba:  
Uporaba naprednih tehnik za gradnjo sodobnih arhitektur informacijskih sistemov.

Refleksija:  
Razumevanje primernosti teoretičnih metod za reševanje praktičnih problemov ter njihovih omejitev, sposobnost analitičnega razmišljanja, sposobnost analize in reševanja kompleksnih praktičnih problemov.

Prenosljive spretnosti:  
Spretnosti reševanja kompleksnih problemov kar vključuje: iskanje literature, uporabo primerne programske opreme (tudi odprtokodne) in programskih okolij, vrednotenje obstoječih postopkov in razvoj ter vrednotenje novih postopkov.

**Intended learning outcomes:**

Knowledge and understanding:  
Knowledge of the selected topics and advanced techniques from the architectures of information systems.

Application:  
Application of advanced techniques for building modern information system architectures.

Reflection:  
Understanding of suitability of theoretical methods for solving practical problems and their limitations, ability of analytical thinking, ability of analysis and solving complex practical problems.

Transferable skills:  
Skills of solving complex problems what includes: search of literature, use of appropriate software (including open source) and programming environments, evaluation of existing procedures, and development and evaluation of new procedures.

**Metode poučevanja in učenja:**

**Learning and teaching methods:**

Predavanja s podporo avdio-vizualne opreme, aktivna uporaba sistema za upravljanje s študijskimi vsebinami (npr. Moodle). Laboratorijske vaje v računalniški učilnici z ustrezno strojno in programsko opremo. Kombiniranje delo posamezno in v skupinah, ter individualnega dela ter interakcij pri seminarjih in na konzultacijskih urah.

Lectures supported by audio-visual equipment and active use of the system for management of teaching material (e.g., Moodle). Laboratory work in classrooms with appropriate hardware and software. Combination of individual and group-based studies, accompanied with student/teacher interactions at seminars and consulting hours.

Delež (v %) /

**Načini ocenjevanja:**

Weight (in %)

**Assessment:**

<p>Način (pisni izpit, ustno izpraševanje, naloge, projekt) Pisni in ustni izpit, sprotno preverjanje znanja - domače naloge, projekt in predstavitev seminarja.</p>	<p>50% 50%</p>	<p>Type (examination, oral, coursework, project): Written and oral exam, continuing assessment of knowledge – homeworks, project and seminar presentation.</p>
<p>Ocene: 6-10 pozitivno, 1-5 negativno (v skladu s Statutom UL).</p>		<p>Grades: 6-10 passing, 1-5 failing (according to the Statute of UL).</p>

**Reference nosilca / Lecturer's references:**

Trček, D., Brodnik, A. (2013) Hard and soft security provisioning for computationally weak pervasive computing systems in e-health. IEEE wireless communications, ISSN 1536-1284. [Print ed.], vol. 20, no. 4, 8 str., kategorija: 1A1 (Z1, A'', A', A1/2).

Trček, D., Likar, B. (2014) Driving information systems security through innovations : first indications. Cybernetics and systems, ISSN 0196-9722, vol. 45, iss. 1, str. 56-68, kategorija: 1A3 (Z1).

Trček D. (2014) Qualitative assessment dynamics : complementing trust methods for decision making. International journal of information technology & decision making. [Online ed.], vol. 12, no. 6, str. 1-19, doi: 10.1142/S0219622014500072, kategorija: 1A1 (Z1, A', A1/2).

Šubelj L. Jelenc D., Zupančič E., Lavbič. D., Trček D., Krisper M., Bajec M. (2011) Merging data sources based on semantics, contexts and trust. The IPSI BgD transactions on internet research, ISSN 1820-4503. [Print ed.], vol. 7, no. 1, str. 18-30, ilustr.  
<http://internetjournals.net/journals/tir/2011/January/Full%20Journal.pdf>. [COBISS.SI-ID 7850580], kategorija: 1NK (S).

Zupančič E., Trček D. (2012) Deployment of trust management system in environment of e-commerce. V: JEZIC, Gordan (ur.). Agent and multi-agent systems : technologies and applications : proceedings, (Lecture notes in computer science, ISSN 0302-9743, 7327). Berlin; Heidelberg: Springer, cop., str. 484-493, kategorija: 1A4 (Z1).



## UČNI NAČRT PREDMETA / COURSE SYLLABUS

<b>Predmet:</b>	Izbrana poglavja iz matematičnih metod v računalništvu 1
<b>Course title:</b>	Selected Topics in Mathematical Methods in Computer Sciences 1

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Doktorski študijski program Računalništvo in informatika, 3. stopnja	ni smeri	1, 2	poletni
Doctoral Program in Computer and Information Science, level 3	none	1, 2	spring

Vrsta predmeta / Course type: izbirni/elective from CS

Univerzitetna koda predmeta / University course code: 63828

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje Laboratory work	Druge oblike študija Field work	Samost. delo Individ. work	ECTS
30	15	15	/	65		5

Nosilec predmeta / Lecturer: prof. dr. Bojan Orel (predstojnik Katedre za matematiko in splošne predmete/ Head of Mathematics and Physics Chair)  
izvajalec se izbere na internem razpisu/the lecturer is selected on the internal call

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:**

Redni vpis na doktorski študij.

**Prerequisites:**

Enrollment in the Ph. D. program.

**Vsebina:**

Pri predmetu bodo predstavljena in obdelana izbrana poglavja z naslednjih področij:

- dekompozicije grafov
- parametrizirana računska zahtevnost
- končni obsegi in končne geometrije
- kriptografija in računalniška varnost
- teorije kodiranja
- znanstveno računanje
- računska geometrija in računska topologija
- polkolobarji in njihova uporaba v računalništvu
- algebraične strukture

**Content (Syllabus outline):**

During the course selected chapters from the following areas will be presented:

- Graph decompositions
- Parameterized complexity theory
- Finite fields and finite geometries
- Cryptography and computer security
- Coding theory
- Scientific Computing
- Computational geometry and computational topology
- Semirings and their applications to computer science
- Algebraic structures

**Temeljni literatura in viri / Readings:**

Gibbons A. (1985) Algorithmic graph theory. Cambridge University Press, Cambridge.  
 Niedermeier R. (2006) Invitation to Fixed-Parameter Algorithms, Oxford University Press, Oxford.  
 Cryptography -- Theory and Practice, D. R. Stinson, Chapman and Hall/CRC, 3. izdaja, 2006.  
 An introduction to error correcting codes with applications, P. C. van Oorschot in S. A. Vanstone, Kluwer Academic Publishers, 1989.  
 Strang G. (2007) Computational science and engineering, Wellesley-Cambridge Press.  
 Gondran M., Minoux M. (2008) Graphs, Dioids and Semiring, new models and algorithms, Springer.  
 Goodman J.E., O'Rourke J., eds. (2004) Handbook of Discrete and Computational Geometry, Second Edition, CRC Press LLC, Boca Raton, FL.  
 Edelsbrunner H. and Harer J. (2010) Computational Topology. An Introduction. Amer. Math. Soc., Providence, Rhode Island.  
 Afra Zomorodian (2005) Topology for Computing, Cambridge Monographs on Applied and Computational Mathematics.

**Cilji in kompetence:**

Cilj predmeta je dvojen:

- a) predstaviti in raziskati tista področja matematike, ki z algoritmičnega stališča sodijo na področje računalništva ,
- b) predstaviti zahtevnejša orodja matematike in naravoslovnih znanosti, ki so pomembna za najnovejše raziskovalno delo v računalništvu in informatiki; študenti se bodo poleg uporabe teh metod pri reševanju problemov, ki izvirajo

**Objectives and competences:**

The aim of this course is twofold:

- a) to present and explore the areas of mathematics, which are from the algorithmic point of view close to the field of computer science,
- b) present a sophisticated tools of mathematics and natural sciences, which are important for the latest research in computer science and informatics; students will be, in addition to

iz računalništva in informatike, naučili tudi logičnega sklepanja in dokazovanja, ki se uporablja v matematičnem raziskovalnem delu, in razumevanja eksperimentalnega opazovanja in preverjanja, ki sta značilni za naravoslovje.

applying these methods to solving problems arising in computer science, learn to logical reasoning and evidence used in mathematical research work, and understanding of experimental observation and verification, which are characteristic of science.

**Predvideni študijski rezultati:**

Znanje in razumevanje:  
Študentje naj bi poznali iz znali praktično uporabiti napredne matematične metode za reševanje zahtevnih problemov v računalništvu.

**Intended learning outcomes:**

Knowledge and understanding:  
Students should know and be able to apply advanced mathematical methods for solving difficult problems from computer science.

**Metode poučevanja in učenja:**

Predavanja s podporo avdio-vizualne opreme, aktivna uporaba sistema za upravljanje s študijskimi vsebinami (npr. Moodle). Laboratorijske vaje v računalniški učilnici z ustrežno strojno in programsko opremo. Kombiniranje skupinskega z individualnim delom in z interakcijami na seminarjih in konzultacijah.

**Learning and teaching methods:**

Lectures with the support of audio-visual equipment, active use of the system for managing course content (eg Moodle). Laboratory exercises in computer lab with hardware and software. Combining the group with individual work and interactions in seminars and consultations.

<b>Načini ocenjevanja:</b>	Delež (v %) / Weight (in %)	<b>Assessment:</b>
Način (pisni izpit, ustno izpraševanje, naloge, projekt) Sprotno preverjanje znanja - domače naloge, projekt, predstavitev seminarja. Končni izpit.	50 %  50%	Type (examination, oral, coursework, project): Continuous assessment of knowledge - homework, project and seminar presentation. Final exam.
Ocene: 6-10 pozitivno, 1-5 negativno (v skladu s Statutom UL).		Grades: 6-10 passing, 1-5 failing (according to the Statute of UL).

**Reference nosilca / Lecturer's references:**

Orel B. (2010) Accumulation of global error in Lie group methods for linear ordinary differential equations. *Elec. trans. num. anal.*, 37, 252-262.

Orel B., Perne, A. (2014) Chebyshev-Fourier spectral methods for nonperiodic boundary value problems. *Journal of applied mathematics*, ISSN 1687- 0042, 2014, article ID 572694, str. 1-10.

Orel B., Perne A. (2012) Computations with half-range Chebyshev polynomials. *Journal of*

*Computational and Applied Mathematics*, ISSN 0377-0427. [Print ed.], vol. 236, iss. 7, str. 1753-1765.

Bitenc, M., Podbršček P., Dubček P., Bernstorff S., Dražić, G., Orel B., Pejovnik, S., Crnjak Orel, Z. (2010) In and ex situ studies of the formation of layered microspherical hydrozinciteas precursor for ZnO. *Chemistry*, ISSN 0947-6539. [Print ed.], vol.16, issue 37, str. 11481-11488.

Djerdj I., Škapin S., D., Čeh M., Jagličić Z., Pajić D., Kozlevčar B., Orel B., Crnjak Orel Z. (2012) Interplay between the structural and magnetic probes in the elucidation of the structure of a novel 2D layered  $[V]_4O_4(OH)_2(O)_2CC_6H_4CO_2]_4$  DMF. *Dalton transactions*, ISSN 1477-9226, vol. 41, issue 2, str. 581-589.

**UČNI NAČRT PREDMETA / COURSE SYLLABUS**

<b>Predmet:</b>	Izbrana poglavja iz matematičnih metod v računalništvu 2
<b>Course title:</b>	Selected Topics in Mathematical Methods in Computer Sciences 2

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Doktorski študijski program Računalništvo in informatika, 3. stopnja	ni smeri	1, 2	poletni
Doctoral Program in Computer and Information Science, level 3	none	1, 2	spring

Vrsta predmeta / Course type: izbirni/elective from CS

Univerzitetna koda predmeta / University course code: 63829

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje Laboratory work	Druge oblike študija Field work	Samost. delo Individ. work	ECTS
30	15	15	/	65		5

**Nosilec predmeta / Lecturer:** prof. dr. Bojan Orel (predstojnik Katedre za matematiko in splošne predmete/ Head of Mathematics and Physics Chair)  
izvajalec se izbere na internem razpisu/the lecturer is selected on the internal call

**Jeziki / Languages:**

<b>Predavanja / Lectures:</b>	slovenščina in angleščina Slovene and English
<b>Vaje / Tutorial:</b>	slovenščina in angleščina Slovene and English

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

Redni vpis na doktorski študij.

**Prerequisites:**

Enrollment in the Ph. D. program.

**Vsebina:**

Pri predmetu bodo predstavljena in obdelana izbrana poglavja z naslednjih področij:

- pristopi k reševanju težkih problemov na grafih
- praktično učinkoviti eksponentni algoritmi
- končni obsegi in končne geometrije
- kombinatorična algebra in algebraična kombinatorika
- analiza in simulacija dinamičnih sistemov
- diferencialna geometrija krivulj in ploskev
- teorija iger

**Content (Syllabus outline):**

During the course selected chapters from the following areas will be presented:

- approaching computationally hard graph problems
- efficient exponential algorithms
- finite fields and finite geometries
- algebraic combinatorics
- analysis and simulation of dynamical systems
- topological data analysis
- differential geometry of curves and surfaces
- game theory

**Temeljni literatura in viri / Readings:**

Fomin F. V., Kratsch D. (2010) Exact Exponential Algorithms, Springer/Verlag, Berlin.  
 Van Lint J. H. in Wilson R. M., Course A. (2001) in Combinatorics, Cambridge University Press, 2. Izdaja.  
 Miller E., Sturmfels B. (2005) Combinatorial Commutative Algebra, Springer.  
 Stuart A. M., Humphries A. R. (1996) Dynamical Systems and Numerical Analysis, Cambridge University press.  
 Goodman J. E., O'Rourke J., eds. (2004) Handbook of Discrete and Computational Geometry, Second Edition, CRC Press LLC, Boca Raton, FL.  
 Ferguson T. S. : Game Theory. Elektronska knjiga,  
[http://www.math.ucla.edu/~tom/Game\\_Theory/Contents.html](http://www.math.ucla.edu/~tom/Game_Theory/Contents.html)  
 Afra Zomorodian (2005) Topology for Computing, Cambridge Monographs on Applied and Computational Mathematics.

**Cilji in kompetence:**

Cilj predmeta je dvojen:

- a) predstaviti in raziskati tista področja matematike, ki z algoritmičnega stališča sodijo na področje računalništva ,
- b) predstaviti zahtevnejša orodja matematike in naravoslovnih znanosti, ki so pomembna za najnovejše raziskovalno delo v računalništvu in informatiki; študenti se bodo poleg uporabe teh metod pri reševanju problemov, ki izvirajo iz računalništva in informatike, naučili tudi logičnega sklepanja in dokazovanja, ki se uporablja v matematičnem raziskovalnem delu, in razumevanja eksperimentalnega

**Objectives and competences:**

The aim of this course is twofold:

- a) to present and explore the areas of mathematics, which are from the algorithmic point of view close to the field of computer science,
- b) present a sophisticated tools of mathematics and natural sciences, which are important for the latest research in computer science and informatics; students will be, in addition to applying these methods to solving problems arising in computer science, learn to logical reasoning and evidence used in mathematical research work, and understanding of

opazovanja in preverjanja, ki sta značilni za naravoslovje.

experimental observation and verification, which are characteristic of science.

**Predvideni študijski rezultati:**

Znanje in razumevanje:  
Študentje naj bi poznali iz znali praktično uporabiti napredne matematične metode za reševanje zahtevnih problemov v računalništvu.

**Intended learning outcomes:**

Knowledge and understanding:  
Students should know and be able to apply advanced mathematical methods for solving difficult problems from computer science.

**Metode poučevanja in učenja:**

Predavanja s podporo avdio-vizualne opreme, aktivna uporaba sistema za upravljanje s študijskimi vsebinami (npr. Moodle). Laboratorijske vaje v računalniški učilnici z ustrezno strojno in programsko opremo. Kombiniranje skupinskega z individualnim delom in z interakcijami na seminarjih in konzultacijah.

**Learning and teaching methods:**

Lectures with the support of audio-visual equipment, active use of the system for managing course content (eg Moodle). Laboratory exercises in computer lab with hardware and software. Combining the group with individual work and interactions in seminars and consultations.

<b>Načini ocenjevanja:</b>	Delež (v %) / Weight (in %)	<b>Assessment:</b>
Način (pisni izpit, ustno izpraševanje, naloge, projekt)		Type (examination, oral, coursework, project):
Sprotno preverjanje znanja - domače naloge, projekt, predstavitev seminarja.	50 %	Continuous assessment of knowledge - homework, project and seminar presentation.
Končni izpit.	50 %	Final exam.
Ocene: 6-10 pozitivno, 1-5 negativno (v skladu s Statutom UL).		Grades: 6-10 passing, 1-5 failing (according to the Statute of UL).

**Reference nosilca / Lecturer's references:**

Orel B. (2010) Accumulation of global error in Lie group methods for linear ordinary differential equations. *Elec. trans. num. anal.*, 37, 252-262.

Orel B., Perne, A. (2014) Chebyshev-Fourier spectral methods for nonperiodic boundary value problems. *Journal of applied mathematics*, ISSN 1687- 0042, 2014, vol., article ID 572694, str. 1-10.

Orel B., Perne A. (2012) Computations with half-range Chebyshev polynomials. *Journal of Computational and Applied Mathematics*, ISSN 0377-0427. [Print ed.], vol. 236, iss. 7, str. 1753-1765.

Bitenc, M., Podbršček P., Dubček P., Bernstorff S., Dražič, G., Orel B., Pejovnik, S., Crnjak Orel, Z.

(2010) In and ex situ studies of the formation of layered microspherical hydrozinciteas precursor for ZnO. *Chemistry*, ISSN 0947-6539. [Print ed.], vol.16, issue 37, str. 11481-11488.

Djerdj I., Škapin S., D., Čeh M., Jagličić Z., Pajić D., Kozlevčar B., Orel B., Crnjak Orel Z. (2012) Interplay between the structural and magnetic probes in the elucidation of the structure of a novel 2D layered  $[V_4O_4(OH)_2(O_2CC)_6H_4CO_2]_4$  DMF. *Dalton transactions*, ISSN 1477-9226, vol. 41, issue 2, str. 581-589.



**UČNI NAČRT PREDMETA / COURSE SYLLABUS**

**Predmet:** Izbrana poglavja iz računalniških sistemov 1  
**Course title:** Selected Topics in Computer Systems 1

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Doktorski študijski program Računalništvo in informatika, 3. stopnja	ni smeri	1, 2	zimski
Doctoral Program in Computer and Information Science, level 3	none	1, 2	fall

**Vrsta predmeta / Course type**

izbirni/elective from CS

**Univerzitetna koda predmeta / University course code:**

63830

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje Laboratory work	Druge oblike študija Field work	Samost. delo Individ. work	ECTS
15	20	15	/	75		5

**Nosilec predmeta / Lecturer:**

prof. dr. Miha Mraz (predstojnik Katedre za računalniško logiko, sisteme in mreže / Head of Computer Logic, Systems and Network Chair)  
izvajalec se izbere na internem razpisu/the lecturer is selected on the internal call

**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:**

Redni vpis na doktorski študij.

Enrollment in the Ph. D. program.

**Vsebina:**

Pri predmetu bodo predstavljena in obdelana izbrana poglavja z naslednjih področij:

- biološki sistemi kot preklopni gradniki za procesiranje in pomnjenje informacij.
- računalniško podprto modeliranje, analiza in načrtovanje sintetičnih in naravnih bioloških sistemov,
- procesni gradniki kot kontrolni del aplikacij sintezne biologije,
- naravno računalništvo,
- procesiranje in pomnjenje informacij s kvantnimi celičnimi avtomati (angl. *Quantum Dot Cellular Automata*, krajše QCA),
- modeliranje, simulacija in načrtovanje QCA struktur,
- večvrednostna logika v QCA strukturah.

**Content (Syllabus outline):**

Selected chapters with the emphasis on the following subjects will be covered:

- Biological systems as switching and memory structures for information processing.
- Computer aided design, analysis and modelling of synthetic and natural biological systems.
- Processing structures as control logic of synthetic biology applications.
- Nature inspired computing,
- Quantum Dot Cellular Automata (QCA) as information processing and memory structures.
- Modelling, simulation and design of QCA structures
- Multiple valued logic in QCA structures.

**Temeljni literatura in viri / Readings:**

Alon U. (2007) *An Introduction to Systems Biology*. Chapman & Hall/CRC.  
Ryadnov M., Brunsveld L. and Suga H. (2014) *Synthetic Biology*, The Royal Society of Chemistry.  
Amos M. (2005) *Theoretical and Experimental DNA Computation*.  
Marchisio M. A. (2014) *Computational Methods in Synthetic Biology*, Humana Press.  
Flake G. W. (1998), *The Computational Beauty of Nature*. MIT Press.  
Lombardi F. (2007), *Design and Test of Digital Circuits by Quantum-Dot Cellular Automata*, Artech House.  
Miller D. M., Thornton M. A. (2008) *Multiple Valued Logic*, Morgan & Claypool Publishers.

**Cilji in kompetence:**

**Objectives and competences:**

Študenti bodo pri predmetu osvojili napredna znanja s področja nekonvencionalnega računalništva s posebnim poudarkom na procesiranju biološko navdahnjenem procesiranju, procesiranju z biološkimi sistemi in kvantnimi celičnimi avtomati. V praktičnem smislu se bodo študenti spoznali z modeliranjem, analizo in načrtovanjem tovrstnih sistemov v kontekstu računalniških struktur prihodnosti.

At this subject students will gain advanced knowledge from the fields of natural inspired computing, processing with biological systems and quantum dot cellular automata. They will be able to apply theoretical knowledge in practice with the modelling, analysis and design of these systems in the context of future computer structures.

**Predvideni študijski rezultati:**

Znanje in razumevanje:  
Poznavanje različnih sodobnih metod procesiranja s pomočjo nekonvencionalnih računalniških sistemov.

Uporaba:  
Uporaba računalniških tehnik v namene modeliranja, simulacije, analize in načrtovanja.

Refleksija:  
Razumevanje primernosti teoretičnih metod za reševanje praktičnih problemov ter njihovih omejitev, sposobnost analitičnega razmišljanja, sposobnost analize in reševanja kompleksnih praktičnih problemov.

Prenosljive spretnosti - niso vezane le na en predmet:  
Kombiniranje znanj pridobljenih pri predmetih s področja strojne opreme, nelinearnih dinamičnih sistemov, matematične analize, systemske teorije in adaptivnih sistemov.

**Intended learning outcomes:**

Knowledge and understanding:  
Knowledge of various modern methods for processing with the unconventional platforms.

Application:  
Use of computational approaches for the modelling, simulation, analysis and design.

Reflection:  
Understanding of the appropriateness of theoretical methods to solve practical problems and their limits, the ability of analytical thinking, ability to analyze and solve complex practical problems.

Transferable skills - not tied to just one subject:  
Combining the knowledge gained from the courses in the areas of hardware, nonlinear dynamic systems, mathematical analysis, system theory and adaptive systems.

**Metode poučevanja in učenja:**

**Learning and teaching methods:**

Predavanja bodo potekala s podporo avdio-vizualne opreme, istočasno pa se bo aktivno uporabljalo sistem za upravljanje s študijskimi vsebinami (Moodle). Laboratorijske vaje bodo potekale v računalniški učilnici z ustrezno programsko opremo. Delo bo potekalo tako individualno preko konzultacij, kot tudi v skupinah preko seminarjev.

Lectures will be held with the support of audio-visual equipment, while at the same time the course management system Moodle will be actively used. Laboratory exercises will be held in the computer lab with appropriate software. Work will be done both individually and through consultations, as well as in groups through seminars.

Delež (v %) /

**Načini ocenjevanja:**

Weight (in %)

**Assessment:**

<p>Način (pisni izpit, ustno izpraševanje, naloge, projekt): Pisni in ustni izpit, sprotno preverjanje znanja - domače naloge, projekt in predstavitev seminarja.</p>	<p>50% 50%</p>	<p>Type (examination, oral, coursework, project): Written and oral exam, continuing assessment of knowledge – homeworks, project and seminar presentation.</p>
<p>Ocene: 6-10 pozitivno, 1-5 negativno (v skladu s Statutom UL).</p>		<p>Grades: 6-10 passing, 1-5 failing. (according to the Statute of UL).</p>

**Reference nosilca / Lecturer's references:**

Moškon M., Mraz M. (2014), Systematic Approach to Computational Design of Gene Regulatory Networks with Information Processing Capabilities, IEEE/ACM Transactions of Computational Biology and Bioinformatics, Vol. 11, Issue 2.

Moškon M., Novak Š., Medeot M., Lebar Bajec I., Zimic N., Mraz M. (2013) Solving the logistic problems with optimal resource assignment using fuzzy logic methods. *Journal of advanced transportation*, ISSN 0197-6729, vol. 47, no. 4, str. 447-460, ilustr.

Janež M., Pečar P., Mraz M. (2012) Layout design of manufacturable quantum-dot cellular automata. *Microelectronics journal*, ISSN 0959-8324. [Print ed.], vol. 43, no. 7, str. 501-513, ilustr.

Zimic N., Mraz M. (2006) Decomposition of a complex fuzzy controller for the truck-and-trailer reverse parking problem. *Mathematical and computer modelling*, ISSN 0895-7177. [Print ed.], vol. 43, no. 5/6, str. 632-645.

Lebar Bajec I., Zimic, N., Mraz M. (2006) Towards the bottom-up concept : extended quantum-dot cellular automata. *Microelectronic engineering*, ISSN 0167-9317. [Print ed.] vol. 83, no. 4/9, str. 1826-1829.

**UČNI NAČRT PREDMETA / COURSE SYLLABUS**

**Predmet:** Izbrana poglavja iz računalniških sistemov 2  
**Course title:** Selected Topics in Computer Systems 2

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Doktorski študijski program Računalništvo in informatika, 3. stopnja	ni smeri	1, 2	zimski
Doctoral Program in Computer and Information Science, level 3	None	1, 2	fall

**Vrsta predmeta / Course type**

izbirni/elective from CS

**Univerzitetna koda predmeta / University course code:**

63831

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje Laboratory work	Druge oblike študija Field work	Samost. delo Individ. work	ECTS
15	20	15	/	75		5

**Nosilec predmeta / Lecturer:**

prof. dr. Miha Mraz (predstojnik Katedre za računalniško logiko, sisteme in mreže / Head of Computer Logic, Systems and Network Chair)  
izvajalec se izbere na internem razpisu/the lecturer is selected on the internal call

**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:**

Redni vpis na doktorski študij.

Enrollment in the Ph. D. program.

**Vsebina:**

Pri predmetu bodo predstavljena in obdelana izbrana poglavja z naslednjih področij:

- napredne podrobnosti IP protokolov različice 4 in 6,
- ranljivosti in omrežna varnost v kompleksnih arhitekturnih oblikah (npr. oblak),
- anatomija sodobnih napadov in njihovo preprečevanje,
- virtualna omrežja, programsko določena omrežja, tunnelski mehanizmi in njihova uporaba v sodobnih infrastrukturah (npr. oblak),
- omrežja z gibajočimi se vozlišči, omrežja vozil (VANET, MANET),
- visoko zmogljivo paralelno procesiranje na gručah, omrežjih in v oblakih,
- računanje na heterogenih sistemih (grafične procesne enote, koprocesorji).

**Content (Syllabus outline):**

At the course selected chapters from the following areas will be presented and analysed:

- advanced details of IPv4 and IPv6 network protocols,
- network security and vulnerability of complex architectures (e.g. cloud),
- anatomy of modern attacks and their prevention,
- virtual networks, software defined networking, tunnelling mechanisms and their applications in modern network infrastructures (e.g. cloud),
- mobile and vehicular networks (VANET, MANET),
- high performance parallel computing with clusters and cloud networks,
- computing with heterogeneous systems (e.g. graphical processing units – GPUs, coprocessors)

**Temeljni literatura in viri / Readings:**

Hagen S. (2014), *IPv6 Essentials*, O'Reilly.

Goransson P. (2014) C. Black, *Software Defined Networks: A Comprehensive Approach*, Morgan Kaufmann.

Hartenstein H., Laberteaux K. (2010), *VANET Vehicular Applications and Inter-Networking Technologies*, Wiley.

Kirk D. B. and Hwu W. W. (2012), *Programming Massively Parallel Processors*, Morgan Kaufman.

Erl T., Puttini R. and Mahmood Z. (2013), *Cloud Computing: Concepts, Technology & Architecture*, Prentice Hall.

**Cilji in kompetence:**

**Objectives and competences:**

Študenti bodo pri predmetu osvojili napredna znanja s področja računalniških omrežij, komunikacij in paralelnega procesiranja. Teoretična znanja bodo znali uporabiti v praksi ter z ustreznimi metodološkimi pristopi reševati probleme na predlaganih področjih.

Students will gain advanced knowledge from the fields of computer networks, communications and parallel processing. They will be able to apply theoretical knowledge in practice and use appropriate methodological approaches to solve problems in the proposed areas.

**Predvideni študijski rezultati:**

Znanje in razumevanje:

Osvojitev naprednih znanj s področij računalniških omrežij in paralelnega procesiranja.

Uporaba:

Konfiguracija naprednih modernih omrežij, preprečevanje nevarnosti, izraba paralelnih sistemov za pohitritev procesiranja.

Refleksija:

Razumevanje primernosti teoretičnih metod za reševanje praktičnih problemov ter njihovih omejitev, sposobnost analitičnega razmišljanja, sposobnost analize in reševanja kompleksnih praktičnih problemov.

Prenosljive spretnosti - niso vezane le na en predmet:

Kombiniranje znanj pridobljenih pri predmetih s področja strojne opreme, računalniških arhitektur, računalniških omrežij, računalniških komunikacij in adaptivnih sistemov.

**Intended learning outcomes:**

Knowledge and understanding:

Advanced knowledge from the fields of computer networks and parallel processing.

Application:

Configuration of advanced modern networks, network hazards elimination, optimal exploitation of parallel systems.

Reflection:

Understanding of the appropriateness of theoretical methods to solve practical problems and their limits, the ability of analytical thinking, ability to analyze and solve complex practical problems.

Transferable skills - not tied to just one subject:

Combining the knowledge gained from courses in the areas of hardware, computer architecture, computer networks, computer communications and adaptive systems.

**Metode poučevanja in učenja:**

**Learning and teaching methods:**

Predavanja bodo potekala s podporo avdio-vizualne opreme, istočasno pa se bo aktivno uporabljalo sistem za upravljanje s študijskimi vsebinami (Moodle). Laboratorijske vaje bodo potekale v računalniški učilnici z ustrezno strojno in programsko opremo. Delo bo potekalo tako individualno preko konzultacij, kot tudi v skupinah preko seminarjev.

Lectures will be held with the support of audio-visual equipment, while at the same time the course management system Moodle will be actively used. Laboratory exercises will be held in the computer lab with appropriate hardware and software. Work will be done both individually and through consultations, as well as in groups through seminars.

Delež (v %) /

**Načini ocenjevanja:**

Weight (in %)

**Assessment:**

<p>Način (pisni izpit, ustno izpraševanje, naloge, projekt): Pisni in ustni izpit, sprotno preverjanje znanja - domače naloge, projekt in predstavitev seminarja.</p>	<p>50% 50%</p>	<p>Type (examination, oral, coursework, project): Written and oral exam, continuing assessment of knowledge – homeworks, project and seminar presentation.</p>
<p>Ocene: 6-10 pozitivno, 1-5 negativno (v skladu s Statutom UL).</p>		<p>Grades: 6-10 passing, 1-5 failing. (according to the Statute of UL).</p>

**Reference nosilca / Lecturer's references:**

Moškon M., Mraz M. (2014), Systematic Approach to Computational Design of Gene Regulatory Networks with Information Processing Capabilities, IEEE/ACM Transactions of Computational Biology and Bioinformatics, Vol. 11, Issue 2.

Moškon M., Novak Š., Medeot M., Lebar Bajec I., Zimic N., Mraz M. (2013) Solving the logistic problems with optimal resource assignment using fuzzy logic methods. *Journal of advanced transportation*, ISSN 0197-6729, vol. 47, no. 4, str. 447-460, ilustr.

Janež M., Pečar P., Mraz M. (2012) Layout design of manufacturable quantum-dot cellular automata. *Microelectronics journal*, ISSN 0959-8324. [Print ed.], vol. 43, no. 7, str. 501-513, ilustr.

Zimic N., Mraz M. (2006) Decomposition of a complex fuzzy controller for the truck-and-trailer reverse parking problem. *Mathematical and computer modelling*, ISSN 0895-7177. [Print ed.], Mar. 2006, vol. 43, no. 5/6, str. 632-645.

Lebar Bajec I., Zimic, N., Mraz M. (2006) Towards the bottom-up concept : extended quantum-dot cellular automata. *Microelectronic engineering*, ISSN 0167-9317. [Print ed.] vol. 83, no. 4/9, str. 1826-1829.



**UČNI NAČRT PREDMETA / COURSE SYLLABUS**

**Predmet:** Izbrana poglavja iz računalništva in informatike  
**Course title:** Selected Topics in Computer and Information Science

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Doktorski študijski program Računalništvo in informatika, 3. stopnja	ni smeri	1, 2	poletni
Doctoral Program in Computer and Information Science, level 3	none	1, 2	spring

**Vrsta predmeta / Course type** izbirni predmet / elective course

**Univerzitetna koda predmeta / University course code:** 63818

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje Laboratory work	Druge oblike študija Field work	Samost. delo Individ. work	ECTS
15	20	15	/	75		5

**Nosilec predmeta / Lecturer:** doc. dr. Danijel Skočaj (prodekan za raziskovalno dejavnost/  
Vice Dean for Research)  
izvajalec je vsako leto gostujoči profesor z drugih univerz/  
each year the lecturer is a visiting professor from other universities

**Jeziki / Languages:**

<b>Predavanja / Lectures:</b>	slovenščina, angleščina Slovene, English
<b>Vaje / Tutorial:</b>	slovenščina, angleščina Slovene, English

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

Redni vpis na doktorski študij.

**Prerequisites:**

Enrollment into the doctoral Program in Computer and Information Science.

**Vsebina:**

Predmet bodo izvajali uveljavljeni gostujoči predavatelji iz tujine ali iz prakse. Ti bodo študentom v okviru predmeta predstavili nove odmevne ideje, metodološke novosti ali uporabne rešitve s področja računalništva in informatike, ki kot take še niso vključene v vsebine obstoječih predmetov. Podrobna vsebina predmeta se določi vsako leto posebej glede na predloge in strokovno usmeritev izbranega predavatelja.

**Content (Syllabus outline):**

The course is will be given by established visiting researchers and lecturers or by experts in practical applications of computer and information science. They will introduce students to topics that are interesting due to recent theoretical findings and mehodological breakthroughs or due to their applicative value, and are as such not included into the existing curriculum. The specific focus and syllabus of the course will be defined yearly.

**Temeljni literatura in viri / Readings:**

Temeljna literatura se predpiše vsako leto posebej glede na vsebino in predloge izbranega predavatelja.

Defined yearly, based on the selected lecturer and the current topic of the course.

**Cilji in kompetence:**

Cilj predmeta je spoznati teoretične osnove in praktične implementacije novih metod in tehnologij na področju računalništva in informatike.

**Objectives and competences:**

The goal of the course is to introduce core theoretical ideas as well as practical implementations of new methods and technologies in the field of computer and information science.

**Predvideni študijski rezultati:**

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.

**Intended learning outcomes:**

Knowledge and understanding: A broader overview and understanding of the field of study, and of recently introduced methods and concepts.

Application: Applying current approaches and techniques from the specific field of computer and information 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.

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**Metode poučevanja in učenja:**

Predavanja, demonstracijske vaje, laboratorijske vaje

**Learning and teaching methods:**

Lectures, pracial demonstrations, hands-on excersises

Delež (v %) /

**Načini ocenjevanja:**

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, 1-5 negativno (v skladu s Statutom UL).		Grading: 6-10 pass, 1-5 fail (according to the Statute of UL).

**Reference nosilca / Lecturer's references:**

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

Skočaj D, Leonardis A, Bischof H (2007) Weighted and robust learning of subspace representations. Pattern Recogn 40 (5): [1556]-1569.

Skočaj D, Leonardis A. (2008) Incremental and robust learning of subspace representations. Image vis. comput., vol. 26, no. 1, str. 27-38.

Skočaj D, Kristan M, Vrečko A, Leonardis A, Fritz M, Stark M, Schiele B, Hongeng S, Wyatt JL. (2010) Multi-modal learning. V: Cognitive systems, (Cognitive systems monographs, vol. 8). Berlin; Heidelberg: Springer, cop., str. 265-309.

Vrečko A, Leonardis A, Skočaj D. (2012) Modeling binding and cross-modal learning in Markov logic networks. Neurocomputing, ISSN 0925-2312. [Print ed.], vol. 96, str. 29-36.

**UČNI NAČRT PREDMETA / COURSE SYLLABUS**

**Predmet:** Izbrana poglavja iz razvoja programske opreme 1  
**Course title:** Selected Topics in Software Development 1

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Doktorski študijski program Računalništvo in informatika, 3. stopnja	ni smeri	1, 2	zimski
Doctoral Program in Computer and Information Science, level 3	none	1, 2	fall

**Vrsta predmeta / Course type** izbirni/elective from CS

**Univerzitetna koda predmeta / University course code:** 63832

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje Laboratory work	Druge oblike študija Field work	Samost. delo Individ. work	ECTS
15	20	15	/	75		5

**Nosilec predmeta / Lecturer:** prof. dr. Franc Jager (predstojnik Katedre za programsko opremo/Head of Software Chair)  
izvajalec se izbere na internem razpisu/the lecturer is selected on the internal call

**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:**

Redni vpis na doktorski študij.

**Prerequisites:**

Enrollment in the Ph. D. program.

## Vsebina:

Pri predmetu bodo predstavljena in obdelana izbrana poglavja z naslednjih področij:

- principi razvoja programske opreme,
- vizualizacija in predstavljanje biomedicinskih signalov in slik (bioelektrični vzorci),
- izbrana poglavja razvoja in vrednotenja razpoznavnih tehnik za avtomatizacijo analize bioelektričnih vzorcev,
- standardizirane podatkovne baze za študije fizioloških mehanizmov in za evaluacijo zmogljivosti ter robustnosti razpoznavnih tehnik,
- razvoj biomedicinskih informacijskih tehnologij in programske opreme.

## Content (Syllabus outline):

At the course selected topics from the following fields will be represented and treated:

- software development principles,
- visualizing and representing biomedical signal and imaging data (bioelectric patterns),
- selected topics from development and evaluating recognition techniques to automatize the analysis of bioelectric patterns,
- standardized databases to study physiologic mechanisms, and to evaluate the performance and robustness of recognition techniques,
- developing biomedical information technologies and software.

## Temeljni literatura in viri / Readings:

Clifford G., Azuaje F. (2006) *Advanced Methods and Tools for ECG Data Analysis*, McSharry PE (editors) Artech House, Inc.

Sornmo L., Laguna P. (2005) *Biological Signal Processing in Cardiac and Neurological Applications*, Elsevier, Inc.

Najarian K., Splinter R. (2006) *Biomedical Signal and Image Processing*, CRC Press.

Sanei, Chambers (2008) *EEG Signal Processing*, Wiley.

Gonzalez R. C., Woods R. E. (2008) *Digital Image Processing*, 3rd edition, Prentice Hall.

## Cilji in kompetence:

Cilji:

Študenti bodo pri predmetu osvojili znanja iz izbranih naprednih tem obdelave biomedicinskih signalov in slik (bioelektričnih vzorcev).

Teoretična znanja bodo znali uporabiti v praksi, s priučenimi tehnikami in postopki pa bodo reševali kompleksne probleme na teh področjih. Naučili se bodo razvijanja ustreznih rešitev za dani problem in razvoja programske opreme.

Kompetence:

Razvijanje veščin kritičnega, analitičnega in

## Objectives and competences:

Objectives:

At the course students will acquire knowledge of selected advanced topics from the fields of biomedical signal and image processing (bioelectric patterns).

They will know how to use theoretical knowledge in praxis, and will solve complex problems in these fields using acquired techniques and procedures. Students will learn how to develop solutions given particular problem and development of software.

Competences:

Developing skills in critical, analytical and

sintetičnega razmišljanja; sposobnost definiranja, razumevanja in reševanja kreativnih profesionalnih izzivov v računalništvu in informatiki; sposobnost prenosa znanja in pisnih veščin v materinem kot tudi v tujem jeziku; sposobnost samostojnega prenašanja pridobljenega znanja za reševanje tehničnih in znanstvenih problemov v računalništvu in informatiki; sposobnost nadgrajevanja pridobljenega znanja; sposobnost razumevanja in prenosa znanj računalništva in informatike na druga tehnična in relevantna področja.

synthetic thinking; 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:**

Znanje in razumevanje:  
Poznavanje izbranih poglavij in naprednih tehnik na področjih obdelave biomedicinskih signalov in slik (bioelektričnih vzorcev)

Uporaba:  
Uporaba naprednih tehnik z namenom analize podatkov v biomedicinskem inženirstvu.

Refleksija:  
Razumevanje primernosti teoretičnih metod za reševanje praktičnih problemov ter njihovih omejitev, sposobnost analitičnega razmišljanja, sposobnost analize in reševanja kompleksnih praktičnih problemov s področij z razvojem avtomatskih postopkov.

Prenosljive spretnosti:  
Spretnosti reševanja kompleksnih problemov kar vključuje: iskanje literature, uporabo primerne programske opreme (tudi odprtokodne) in programskih okolij, vrednotenje obstoječih postopkov in razvoj ter vrednotenje novih postopkov.

### **Intended learning outcomes:**

Knowledge and understanding:  
Knowledge of the selected topics and advanced techniques from the fields of biomedical signal and image processing (bioelectric patterns)

Application:  
Application of advanced techniques with the aim to analyse data in biomedical engineering.

Reflection:  
Understanding of suitability of theoretical methods for solving practical problems and their limitations, ability of analytical thinking, ability of analysis and solving complex practical problems in the fields with development of automated procedures.

Transferable skills:  
Skills of solving complex problems what includes: search of literature, use of appropriate software (including open source) and programming environments, evaluation of existing procedures, and development and evaluation of new procedures.

### **Metode poučevanja in učenja:**

### **Learning and teaching methods:**

<p>Predavanja s podporo avdio-vizualne opreme. Aktivna uporaba sistema za upravljanje s študijskimi vsebinami (npr. Moodle). Laboratorijske vaje v računalniški učilnici z ustrezno strojno in programsko opremo. Delo posamezno in v skupinah, seminarji in konzultacijske ure.</p>	<p>Combined lecturing with simultaneous use of audio-visual equipment. Active use of system to maintain students contents. (e.g., Moodle). Laboratory work in computer-equipped lecture room. Individual and team work in groups, seminars and consultant hours.</p>
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<b>Načini ocenjevanja:</b>	Delež (v %) / Weight (in %)	<b>Assessment:</b>
<p>Način (pisni izpit, ustno izpraševanje, naloge, projekt): Pisni in ustni izpit, sprotno preverjanje znanja - domače naloge, projekt in predstavitev seminarja.  Ocene: 6-10 pozitivno, 1-5 negativno (v skladu s Statutom UL).</p>	<p>50% 50%</p>	<p>Type (examination, oral, coursework, project): Written and oral exam, frequent checking of knowledge – homeworks, project and presentation of seminar.  Grades: 6-10 passing, 1-5 failing. (according to the Statute of UL).</p>

**Reference nosilca / Lecturer's references:**

Jager F. (2006) two chapters in *Advanced Methods and Tools for ECG Data Analysis*, Clifford G, Azuaje F., McSharry PE (editors) Artech House, Inc.

Jager F., Taddei A., Moody G.B., Emdin M., Antolič G., Dorn R., Smrdel A., Marchesi C., Mark R. G. (2003) 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.* 41:172-182.

Fele-Žorž G., Kavšek G., Novak-Antolič Ž. and Jager F. (2008) A comparison of various linear and non-linear signal processing techniques to separate uterine EMG records of term and pre-term delivery groups. *Med. Biol. Eng. Comput.* 46(9):911-922.

Jager F., Moody G. B. and Mark R. G. (2004) Protocol to assess robustness of ST analysers : a case study. *Physiological measurement*, 25(3):629-643.

Minchole A., Jager F. and Laguna P. (2010) Discrimination between ischemic and artifactual ST segment events in Holter recordings. *Biomedical signal processing and control*, 5(1):21-31.

## UČNI NAČRT PREDMETA / COURSE SYLLABUS

**Predmet:** Izbrana poglavja iz razvoja programske opreme 2  
**Course title:** Selected Topics in Software Development 2

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Doktorski študijski program Računalništvo in informatika, 3. stopnja	ni smeri	1, 2	zimski
Doctoral Program in Computer and Information Science, level 3	none	1, 2	fall

**Vrsta predmeta / Course type** izbirni/elective from CS

**Univerzitetna koda predmeta / University course code:** 63833

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje Laboratory work	Druge oblike študija Field work	Samost. delo Individ. work	ECTS
15	20	15	/	75		5

**Nosilec predmeta / Lecturer:** prof. dr. Franc Jager(predstojnik Katedre za programsko opremo/Head of Software Chair)  
izvajalec se izbere na internem razpisu/the lecturer is selected on the internal call

**Jeziki / Languages:**

<b>Predavanja / Lectures:</b>	slovenščina in angleščina Slovene and English
<b>Vaje / Tutorial:</b>	slovenščina in angleščina Slovene and English

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

Redni vpis na doktorski študij.

**Prerequisites:**

Enrollment in the Ph. D. program.



**Vsebina:**

Pri predmetu bodo predstavljena in obdelana izbrana poglavja z naslednjih področij:

- metodologije razvoja programske opreme,
- napredni teoretični pristopi na področju razvoja algoritmov in podatkovnih struktur,
- iskanje informacij v multimedijskih gradivih,
- izbrana poglavja iz razvoja algoritmov računalniške grafike,
- napredne teme iz vsepovsodnega računanja.

**Content (Syllabus outline):**

At the course selected topics from the following fields will be represented and treated:

- software development methodologies,
- advanced theoretical approaches in the field of algorithms and data structures development,
- seeking for information in multimedia data,
- selected topics from development of computer graphics algorithms,
- advanced topics from ubiquitous computing.

**Temeljni literatura in viri / Readings:**

Graham R. L., Knuth D.E., Patashnik O. (1994) Concrete Mathematics, Reading, Massachusetts: Addison-Wesley.

Braß P. (2008) Advanced Data Structures, Cambridge University Press.

Varghese G. (2004) Network Algorithmics, Elsevier Science.

Grossman D. A., Frieder O. (2004) Information Retrieval: Algorithms and Heuristics, Springer.

Qusay M. (2004) Middleware for Communications, Wiley.

Glassner A. S. (1999) Graphics Gems, Morgan Kaufmann.

**Cilji in kompetence:**

Cilji:

Študenti bodo pri predmetu osvojili znanja iz naprednih teoretičnih pristopov na področju razvoja algoritmov in podatkovnih struktur, na področju razvoja algoritmov računalniške grafike, na področju iskanja informacij v multimedijskih gradivih in na področju naprednih tem vsepovsodnega računanja.

Teoretična znanja bodo znali uporabiti v praksi, s priučeni tehnikami in postopki pa bodo reševali kompleksne probleme na teh področjih. Naučili se bodo razvijanja ustreznih rešitev za dani problem in razvoja programske opreme.

Kompetence:

Razvijanje veščin kritičnega, analitičnega in sintetičnega razmišljanja; sposobnost

**Objectives and competences:**

Objectives:

At the course students will acquire knowledge from advanced theoretical approaches in the field of development of algorithms and data structures, in the field of development of computer graphics algorithms, in the field of seeking for information in multimedia data, and in the field of ubiquitous computing topics.

They will know how to use theoretical knowledge in praxis, and will solve complex problems in these fields using acquired techniques and procedures. Students will learn how to develop solutions given particular problem and development of software.

Competences:

Developing skills in critical, analytical and synthetic thinking; the ability to define,

definiranja, razumevanja in reševanja kreativnih profesionalnih izzivov v računalništvu in informatiki; sposobnost prenosa znanja in pisnih veščin v materinem kot tudi v tujem jeziku; sposobnost samostojnega prenašanja pridobljenega znanja za reševanje tehničnih in znanstvenih problemov v računalništvu in informatiki; sposobnost nadgrajevanja pridobljenega znanja; sposobnost razumevanja in prenosa znanj računalništva in informatike na druga tehnična in relevantna področja.

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:**

#### Znanje in razumevanje:

Poznavanje izbranih poglavij in naprednih tehnik na področju teoretičnih pristopov pri razvoju algoritmov in podatkovnih struktur, področju algoritmov v računalniški grafiki, področju iskanja informacij v multimedijskih gradivih in področjih vsepovsodnega računanja.

#### Uporaba:

Uporaba naprednih tehnik z namene analize podatkov v računalniški grafiki, multimedijskih gradivih in pri vsepovsodnem računanju.

#### Refleksija:

Razumevanje primernosti teoretičnih metod za reševanje praktičnih problemov ter njihovih omejitev, sposobnost analitičnega razmišljanja, sposobnost analize in reševanja kompleksnih praktičnih problemov s področij z razvojem avtomatskih postopkov.

#### Prenosljive spretnosti:

Spretnosti reševanja kompleksnih problemov kar vključuje: iskanje literature, uporabo primerne programske opreme (tudi odprtokodne) in programskih okolij, vrednotenje obstoječih postopkov in razvoj ter vrednotenje novih postopkov.

### **Intended learning outcomes:**

#### Knowledge and understanding:

Knowledge of the selected topics and advanced techniques on the field of theoretical approaches at development of algorithms and data structures, on the field of computer graphics algorithms, the field of seeking for information in multimedia data, and on the field of ubiquitous computing.

#### Application:

Application of advanced techniques with the aim to analyse data in computer graphics, multimedia-data analysis, and in the field of ubiquitous computing.

#### Reflection:

Understanding of suitability of theoretical methods for solving practical problems and their limitations, ability of analytical thinking, ability of analysis and solving complex practical problems in the fields with development of automated procedures.

#### Transferable skills:

Skills of solving complex problems what includes: search of literature, use of appropriate software (including open source) and programming environments, evaluation of existing procedures, and development and evaluation of new procedures.

**Metode poučevanja in učenja:**

Predavanja s podporo avdio-vizualne opreme. Aktivna uporaba sistema za upravljanje s študijskimi vsebinami (npr. Moodle). Laboratorijske vaje v računalniški učilnici z ustrezno strojno in programsko opremo. Delo posamezno in v skupinah, seminarji in konzultacijske ure.

**Learning and teaching methods:**

Combined lecturing with simultaneous use of audio-visual equipment. Active use of system to maintain students contents. (e.g., Moodle). Laboratory work in computer-equipped lecture room. Individual and team work in groups, seminars and consultant hours.

**Načini ocenjevanja:**

Način (pisni izpit, ustno izpraševanje, naloge, projekt):  
Pisni in ustni izpit, sprotno preverjanje znanja - domače naloge, projekt in predstavitev seminarja.

Ocene: 6-10 pozitivno, 1-5 negativno (v skladu s Statutom UL).

Delež (v %) /

Weight (in %)

50%

50%

**Assessment:**

Type (examination, oral, coursework, project):

Written and oral exam, frequent checking of knowledge – homeworks, project and presentation of seminar.

Grades: 6-10 passing, 1-5 failing. (according to the Statute of UL).

**Reference nosilca / Lecturer's references:**

Jager F. (2006) two chapters in *Advanced Methods and Tools for ECG Data Analysis*, Clifford G, Azuaje F., McSharry PE (editors) Artech House, Inc.

Jager F., Taddei A., Moody G.B., Emdin M., Antolič G., Dorn R., Smrdel A., Marchesi C., Mark R. G. (2003) 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.* 41:172-182.

Fele-Žorž G., Kavšek G., Novak-Antolič Ž. and Jager F. (2008) A comparison of various linear and non-linear signal processing techniques to separate uterine EMG records of term and pre-term delivery groups. *Med. Biol. Eng. Comput.* 46(9):911-922.

Jager F., Moody G. B. and Mark R. G. (2004) Protocol to assess robustness of ST analysers : a case study. *Physiological measurement*, 25(3):629-643.

Minchole A., Jager F. and Laguna P. (2010) Discrimination between ischemic and artifactual ST segment events in Holter recordings. *Biomedical signal processing and control*, 5(1):21-31.

**UČNI NAČRT PREDMETA / COURSE SYLLABUS**

**Predmet:** Izbrana poglavja iz umetne inteligence 1  
**Course title:** Selected Topics in Artificial Intelligence 1

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Doktorski študijski program Računalništvo in informatika, 3. stopnja	ni smeri	1, 2	poletni
Doctoral Program in Computer and Information Science, level 3	none	1, 2	spring

**Vrsta predmeta / Course type** izbirni/elective from CS

**Univerzitetna koda predmeta / University course code:** 63834

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje Laboratory work	Druge oblike študija Field work	Samost. delo Individ. work	ECTS
15	20	15	/	75		5

**Nosilec predmeta / Lecturer:** prof. dr. Igor Kononenko (predstojnik katedre za umetno inteligenco/Head of Artificial Intelligence Chair)  
izvajalec se izbere na internem razpisu/the lecturer is selected on the internal call

**Jeziki / Languages:**

<b>Predavanja / Lectures:</b>	slovenščina in angleščina Slovene and English
<b>Vaje / Tutorial:</b>	slovenščina in angleščina Slovene and English

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

Redni vpis na doktorski študij.

Enrollment in the Ph. D. program.

**Vsebina:**

Pri predmetu bodo predstavljena in obdelana izbrana poglavja z naslednjih področij:

- mehanizmi sklepanja in obravnavanje negotovosti,
- strojno učenje (napredne metode uvrščanja in razvrščanja, učenje v dinamičnih sistemih, učenje v slabo strukturiranih domenah, učenje iz časovno in prostorsko opredeljenih podatkov),
- odkrivanje znanj iz podatkov in vizualizacija podatkov in modelov,
- ansambelske metode v podatkovni analitiki
- razumljivi modeli v strojnem učenju: mehka pravila, zanimive podskupine, asociacijska pravila in razlaga odločitvenih modelov
- procesiranje naravnega jezika in rudarjenje besedil
- zlivanje podatkov
- metode matrične faktorizacije v podatkovnem rudarjenju
- učenje iz podatkovnih tokov
- ocenjevanje zanesljivosti predikcij
- biološko motivirane arhitekture sistemov umetne inteligence,
- aplikacije umetne inteligence (npr. biomedicina, biometrija, ekologija, poslovne aplikacije, ...).
- napredni modeli za interpretacijo slikovnih podatkov
- optimizacijske metode za inferenco v računalniškem vidu

**Content (Syllabus outline):**

Syllabus outline: selected chapters in the following topics:

- reasoning and decision making under uncertainty,
- machine learning (advanced classification and clustering, learning in dynamical systems, learning in weakly structured domains, learning of spatially and temporally defined data),
- data mining and visualization of data and models,
- ensemble methods in data analytic
- comprehensible machine learning: (soft) rules, subgroup discovery, association rules, explanation of decision models
- natural language processing and text mining
- data fusion
- matrix factorization methods in data mining
- learning from data streams
- estimation of prediction reliability
- biologically motivated architectures of artificial intelligence
- applications of artificial intelligence (e.g., bio-medicine, biometrics, ecology, business applications, ...).
- advanced models for image interpretation
- optimization methods for inference in computer vision

**Temeljni literatura in viri / Readings:**

Eldén L. (2007) *Matrix Methods in Data Mining and Pattern Recognition*; Society for Industrial and Applied Mathematics.

Hastie T., Tibshirani R., Friedman J. (2009) *The elements of statistical learning, 2<sup>nd</sup> edition*, Springer.

Gama J., et al. (2014) A survey on concept drift adaptation; *ACM Computing Surveys (CSUR)* 46.4, 44.

Andrienko N., Andrienko G. (2006) *Exploratory Analysis of Spatial and Temporal Data*, Springer.

Forsyth D.A., Ponce, J. (2011) *Computer Vision: A Modern Approach*, Prentice Hall

### **Cilji in kompetence:**

Študenti bodo pri predmetu osvojili napredna znanja s področja umetne inteligence in načrtovanja ter razvoja inteligentnih sistemov. Teoretična znanja bodo znali uporabiti v praksi ter s priučenimi tehnikami reševati kompleksne probleme na klasičnih področjih umetne inteligence in na področju umetnega zaznavanja. Naučili se bodo uporabljati napredna orodja, oziroma v izbranem programskem sistemu za razvoj aplikacij s področja umetne inteligence razviti svojo rešitev za dani problem.

#### **Kompetence:**

- uporaba naprednih metod strojnega učenja
- sposobnost samostojne izbire metod za analizo podatkov
- poznavanje in uporaba algoritmov za podatkovno rudarjenje besedil, časovnih, prostorskih podatkov ter vizualne informacije
- poznavanje in uporaba metod za matrično faktorizacijo in zlivanje podatkov
- uporaba metod za razlago predikcij in za ocenjevanje zanesljivosti predikcij

### **Objectives and competences:**

The students will acquire knowledge in the area of artificial intelligence. They will learn how to design and develop intelligent systems as well as how to transfer theoretical knowledge into practice and use various techniques to solve complex problems in the areas of classical artificial intelligence and machine perception. The students will also learn how to use sophisticated tools, and/or using a selected programming language how to develop their own solutions for a given problem.

#### **Competences:**

- using advanced machine learning algorithms
- ability to independently select the methods for data analysis
- knowing and using the algorithms for text mining, and mining spatial and temporal data and visual information
- knowing and using the methods for matrix factorization and data fusion
- using the methods for prediction explanation and for estimation of prediction reliability

### **Predvideni študijski rezultati:**

#### **Znanje in razumevanje:**

Poznavanje različnih tehnik in metod, ki se uporabljajo pri razvoju sistemov umetne inteligence. Sposobnost za analizo, sintezo in predvidevanje rešitev ter njihovih posledic na konkretnih problemih z uporabo znanstvenih metod.

#### **Uporaba:**

### **Intended learning outcomes:**

#### **Knowledge and understanding:**

Expertise in several techniques and methods, used for development of AI systems. The ability for analysis, synthesis and anticipation of solutions and their consequences for target problems using the scientific methodology.

#### **Application:**

Uporaba predstavljenih metod na konkretnih problemih iz znanstvenega in poslovnega okolja. Poznavanje in uporaba orodij za statistično modeliranje in podatkovno rudarjenje.

**Refleksija:**

Spoznavanje in razumevanje pomena poglobljenega matematičnega in statističnega znanja, uglasenosti med teorijo in njeno aplikacijo na konkretnih primerih s področja umetne inteligence. Avtonomnost, (samo)kritičnost, (samo)refleksivnost, prizadevanje za kakovost.

**Prenosljive spretnosti:**

Prenos naučenih principov na načrtovanje obsežnih sistemov, kjer lahko principi inteligentnih rešitev pomagajo izboljšati uporabnost in uspešnost sistema. Sposobnost pridobivanja, selekcije in ocenjevanja novih informacij in zmožnost ustrezne interpretacije v kontekstu. Pisanje poročil in člankov. Sposobnost povezovanja znanja z različnih področij in njegova uporaba v praksi.

The use of the presented methods on target problems from scientific and business environment. The understanding and usage of tools for statistical modeling and data mining.

**Reflection:**

The recognition and understanding of the meaning of advanced mathematical and statistical knowledge, the relation between theory and its application in concrete examples from the field of AI. Autonomy, (self) criticalness, (self) reflexivity, aspiration for quality.

**Transferable skills:**

The transfer of the learned principles to planning of large systems where the principles of intelligent solutions help to improve the usability and the system performance. The ability to receive, select and evaluate new information and a proper interpretation in a context. Writing of reports and articles, public presentations. The ability to combine the knowledge from different fields and to apply it in practice.

**Metode poučevanja in učenja:**

Predavanja s podporo avdio-vizualne opreme, aktivna uporaba sistema za upravljanje s študijskimi vsebinami (npr. Moodle). Laboratorijske vaje v računalniški učilnici z ustrezno strojno in programsko opremo. Kombiniranje dela posamezno in v skupinah, ter individualnega dela ter interakcij pri seminarjih in na konzultacijskih urah.

**Learning and teaching methods:**

Lectures (using audio-visual equipment); supported by a software system for managing study material (e.g., Moodle). Lab exercises in laboratories equipped with appropriate hardware and software. Individual work and in groups. Interactive work in seminars and at consultation hours.

Delež (v %) /

**Načini ocenjevanja:**

Weight (in %)

**Assessment:**

<p>Način (pisni izpit, ustno izpraševanje, naloge, projekt) Pisni in ustni izpit, sprotno preverjanje znanja - domače naloge, projekt in predstavitev seminarja.</p>	<p>50% 50%</p>	<p>Type (examination, oral, coursework, project): Written and oral examinations, continuous assessment: homeworks, projects, seminars.</p>
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<p><b>Sprotno preverjanje:</b> domače naloge, kolokviji in projektno delo.</p> <p><b>Končno preverjanje:</b> pisni in ustni izpit.</p> <p>Ocene: 6-10 pozitivno, 1-5 negativno (v skladu s Statutom UL).</p>		<p><b>Continuing:</b> homework, project work.</p> <p><b>Final:</b> written and oral exam.</p> <p>Grades: 6-10 passing, 1-5 failing (according to the Statute of UL).</p>
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**Reference nosilca / Lecturer's references:**

Petelin B., Kononenko I., Malačič V., Kukar M. (2014) Dynamic fuzzy paths and cycles in multi-level directed graphs. *Engineering applications of artificial intelligence*, ISSN 0952-1976, vol. 37, str. 194-206

Štrumbelj, E., Kononenko I. (2013) Explaining prediction models and individual predictions with feature contributions. *Knowledge and information systems*, str. 1-19.

Canhasi E., Kononenko I. (2013) Multi-document summarization via Archetypal Analysis of the content-graph joint model. *Knowledge and information systems*, str. 1-22.

Štrumbelj E., Kononenko I. (2010) An efficient explanation of individual classifications using game theory. *Journal of machine learning research*, ISSN 1532-4435 vol. 11, no. [1], str. 1-18.

Kononenko I., Kukar M. (2007) *Machine learning and data mining : introduction to principles and algorithms*. Chichester: Horwood Publishing, cop., XIX, 454 str.



**UČNI NAČRT PREDMETA / COURSE SYLLABUS**

**Predmet:** Izbrana poglavja iz umetne inteligence 2  
**Course title:** Selected Topics in Artificial Intelligence 2

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Doktorski študijski program Računalništvo in informatika, 3. stopnja	ni smeri	1, 2	poletni
Doctoral Program in Computer and Information Science, level 3	none	1, 2	spring

**Vrsta predmeta / Course type** izbirni/elective from CS

**Univerzitetna koda predmeta / University course code:** 63835

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje Laboratory work	Druge oblike študija Field work	Samost. delo Individ. work	ECTS
15	20	15	/	75		5

**Nosilec predmeta / Lecturer:** prof. dr. Igor Kononenko (predstojnik katedre za umetno inteligenco/Head of Artificial Intelligence Chair)  
izvajalec se izbere na internem razpisu/the lecturer is selected on the internal call

**Jeziki / Languages:**

<b>Predavanja / Lectures:</b>	slovenščina in angleščina Slovene and English
<b>Vaje / Tutorial:</b>	slovenščina in angleščina Slovene and English

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

Redni vpis na doktorski študij.

Enrollment in the Ph. D. program.

**Vsebina:**

Pri predmetu bodo predstavljena in obdelana izbrana poglavja z naslednjih področij:

- planiranje,
- umetni vizualni spoznavni sistemi,
- vizualne predstavitve objektov, aktivnosti, prizorov,
- vizualno sledenje in analiza gibanja
- napredne metode detekcije in razpoznavanja v računalniškem vidu
- računalniški vid za mobilne robote
- metode UI v biometriji
- umetna inteligenca v multimediji,
- hevristični preiskovalni algoritmi,
- kvalitativno modeliranje,
- agentne tehnologije,
- programiranje z omejitvami
- umetna inteligenca in igre,
- Bayesova statistika
- statistična analiza podatkov
- statistično modeliranje
- priporočilni sistemi
- aplikacije umetne inteligence (npr. biomedicina, biometrija, ekologija, poslovne aplikacije, ...).

**Content (Syllabus outline):**

Syllabus outline: selected chapters in the following topics:

- Planning,
- Artificial visual cognitive systems
- Visual representations of objects, activities and scenes,
- Visual tracking and motion analysis
- Advanced methods of detection and recognition in computer vision
- Mobile vision-based robotics
- AI methods in biometrics
- Artificial intelligence in multimedia,
- Heuristic search algorithms,
- Qualitative modeling,
- Agent technologies
- Programming with constraints
- Artificial intelligence and games
- Bayesian statistics
- statistical data analysis
- statistical modeling
- Recommender systems
- Applications of artificial intelligence (e.g., bio-medicine, biometrics, ecology, business applications, ...).

**Temeljni literatura in viri / Readings:**

Russel S. J., Norvig P. (2003) Artificial Intelligence: A Modern Approach, Prentice-Hall, 2nd edition.  
Gelman A., Carlin J.B., Stern H. S., Dunson D. B., Vehtari A., Rubin D. B. (2013) Bayesian data analysis. CRC press.  
Jain A. K., Flynn P., Ross A. (2008). Handbook of Biometrics, Springer.  
Rossi F., van Beek P., Walsh T. (2006) Handbook of Constraint Programming, Elsevier.  
Jannach D., et al. (2011) Recommender Systems: An Introduction, Cambridge University Press.  
Simon J.D. Prince (2012) Computer Vision: Models, Learning, and Inference, Cambridge University Press

Corke, P. (2013 ) Robotics, Vision and Control: Fundamental Algorithms in MATLAB, Springer

### **Cilji in kompetence:**

Študenti bodo pri predmetu osvojili napredna znanja s področja umetne inteligence in načrtovanja ter razvoja inteligentnih sistemov. Teoretična znanja bodo znali uporabiti v praksi ter s priučenimi tehnikami reševati kompleksne probleme na klasičnih področjih umetne inteligence in na področju umetnega zaznavanja. Naučili se bodo uporabljati napredna orodja, oziroma v izbranem programskem sistemu za razvoj aplikacij s področja umetne inteligence razviti svojo rešitev za dani problem.

#### **Kompetence:**

- uporaba naprednih metod računalniškega vida
- sposobnost samostojne izbire metod za heuristično preiskovanje in planiranje
- poznavanje in uporaba algoritmov za učenje in preiskovanje v igrah
- poznavanje in uporaba metod programiranja z omejitvami
- poznavanje in uporaba metod za statistično modeliranje in analizo podatkov

### **Objectives and competences:**

The students will acquire knowledge in the area of artificial intelligence. They will learn how to design and develop intelligent systems as well as how to transfer theoretical knowledge into practice and use various techniques to solve complex problems in the areas of classical artificial intelligence and machine perception. The students will also learn how to use sophisticated tools, and/or using a selected programming language how to develop their own solutions for a given problem.

#### **Competences:**

- using advanced computer vision algorithms
- ability to independently select the methods for heuristic search and planning
- knowing and using the algorithms for learning and search in games
- knowing and using the methods for programming with constraints
- knowing and using the methods for statistical modeling and data analysis

### **Predvideni študijski rezultati:**

#### **Znanje in razumevanje:**

Poznavanje različnih tehnik in metod, ki se uporabljajo pri razvoju sistemov umetne inteligence. Sposobnost za analizo, sintezo in predvidevanje rešitev ter njihovih posledic na konkretnih problemih z uporabo znanstvenih metod.

#### **Uporaba:**

Uporaba predstavljenih metod na konkretnih problemih iz znanstvenega in poslovnega

### **Intended learning outcomes:**

#### **Knowledge and understanding:**

Expertise in several techniques and methods, used for development of AI systems. The ability for analysis, synthesis and anticipation of solutions and their consequences for target problems using the scientific methodology.

#### **Application:**

The use of the presented methods on target problems from scientific and business environment. The understanding and usage of

okolja. Poznavanje in uporaba orodij za statistično modeliranje in podatkovno rudarjenje.

**Refleksija:**  
Spoznavanje in razumevanje pomena poglobljenega matematičnega in statističnega znanja, uglasenosti med teorijo in njeno aplikacijo na konkretnih primerih s področja umetne inteligence. Avtonomnost, (samo)kritičnost, (samo)refleksivnost, prizadevanje za kakovost.

**Prenosljive spretnosti:**  
Prenos naučenih principov na načrtovanje obsežnih sistemov, kjer lahko principi inteligentnih rešitev pomagajo izboljšati uporabnost in uspešnost sistema. Sposobnost pridobivanja, selekcije in ocenjevanja novih informacij in zmožnost ustrezne interpretacije v kontekstu. Pisanje poročil in člankov. Sposobnost povezovanja znanja z različnih področij in njegova uporaba v praksi.

tools for statistical modeling and data mining.

**Reflection:**  
The recognition and understanding of the meaning of advanced mathematical and statistical knowledge, the relation between theory and its application in concrete examples from the field of AI. Autonomy, (self) criticalness, (self) reflexivity, aspiration for quality.

**Transferable skills:**  
The transfer of the learned principles to planning of large systems where the principles of intelligent solutions help to improve the usability and the system performance. The ability to receive, select and evaluate new information and a proper interpretation in a context. Writing of reports and articles, public presentations.  
The ability to combine the knowledge from different fields and to apply it in practice.

**Metode poučevanja in učenja:**

Predavanja s podporo avdio-vizualne opreme, aktivna uporaba sistema za upravljanje s študijskimi vsebinami (npr. Moodle). Laboratorijske vaje v računalniški učilnici z ustrezno strojno in programsko opremo. Kombiniranje dela posamezno in v skupinah, ter individualnega dela ter interakcij pri seminarjih in na konzultacijskih urah.

**Learning and teaching methods:**

Lectures (using audio-visual equipment); supported by a software system for managing study material (e.g., Moodle). Lab exercises in laboratories equipped with appropriate hardware and software. Individual work and in groups. Interactive work in seminars and at consultation hours.

Delež (v %) /

Weight (in %)

**Načini ocenjevanja:**

**Assessment:**

<p>Način (pisni izpit, ustno izpraševanje, naloge, projekt) Pisni in ustni izpit, sprotno preverjanje znanja - domače naloge, projekt in predstavitev seminarja. <b>Sprotno preverjanje:</b> domače naloge, kolokviji in projektno delo.</p>	<p>50% 50%</p>	<p>Type (examination, oral, coursework, project): Written and oral examinations, continuous assessment: homeworks, projects, seminars. <b>Continuing:</b> homework, project work.</p>
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<p><b>Končno preverjanje:</b> pisni in ustni izpit.</p> <p>Ocene: 6-10 pozitivno, 1-5 negativno (v skladu s Statutom UL).</p>		<p><b>Final:</b> written and oral exam.</p> <p>Grades: 6-10 passing, 1-5 failing (according to the Statute of UL).</p>
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**Reference nosilca / Lecturer's references:**

Petelin B., Kononenko I., Malačič V., Kukar M. (2014) Dynamic fuzzy paths and cycles in multi-level directed graphs. *Engineering applications of artificial intelligence*, ISSN 0952-1976, vol. 37, str. 194-206

Štrumbelj, E., Kononenko I. (2013) Explaining prediction models and individual predictions with feature contributions. *Knowledge and information systems*, str. 1-19.

Canhasi E., Kononenko I. (2013) Multi-document summarization via Archetypal Analysis of the content-graph joint model. *Knowledge and information systems*, str. 1-22.

Štrumbelj E., Kononenko I. (2010) An efficient explanation of individual classifications using game theory. *Journal of machine learning research*, ISSN 1532-4435 vol. 11, no. [1], str. 1-18.

Kononenko I., Kukar M. (2007) *Machine learning and data mining : introduction to principles and algorithms*. Chichester: Horwood Publishing, cop., XIX, 454 str.

**UČNI NAČRT PREDMETA / COURSE SYLLABUS**

**Predmet:** Seminar 1, 2, 3, 4  
**Course title:** Seminar 1, 2, 3, 4

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Doktorski študijski program Računalništvo in informatika, 3. stopnja	ni smeri	1, 2	zimski / poletni
Doctoral Program in Computer and Information Science, level 3	none	1, 2	fall / spring

**Vrsta predmeta / Course type**

obvezen/compulsory

**Univerzitetna koda predmeta / University course code:**

63804, 63805, 63806, 63807

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje Laboratory work	Druge oblike študija Field work	Samost. delo Individ. work	ECTS
/	20	/	/	105		5

**Nosilec predmeta / Lecturer:**

doc. dr. Tomaž Curk (skrbnik študijskega programa/programme coordinator)  
 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:**

Redni vpis na doktorski študij.

**Prerequisites:**

Enrollment in the Ph. D. program.

**Vsebina:**

Študent za izbrano raziskovalno temo opravi pregled sorodnih raziskav, prebere do deset izbranih člankov in napiše lasten članek ter ga predstavi ustno pred avditorijem.

**Content (Syllabus outline):**

For the selected research topic student prepares a review of related research, read up to ten selected articles, write your own article and present it orally in front of the auditorium.

**Temeljni literatura in viri / Readings:**

Bourne P. E. (2005) Ten simple rules for getting published, PLoS Computational Biology 1(5): e57.  
Bourne P. E. (2007) Ten simple rules for making good oral presentations, PLoS Computational Biology 3(4): e77.  
Bourne P. E., Korngreen A. (2006) Ten simple rules for reviewers, PLoS Computational Biology 2(0): e110.

**Cilji in kompetence:**

Cilj predmeta je izdelava članka in ustne predstavitve le-tega v obliki seminarja. Študentje pri tem poslušajo tudi ostale predstavitve doktorskih študentov, ter se na ta način seznanijo z različnimi (bolj ali manj uspešnimi) tehnikami predstavitev, se seznanijo z raziskovalnim področjem svojih kolegov, ter na ta način spoznavajo širše teme s področja računalništva in informatike. Obvezno redno obiskovanje tega predmeta oz. redno poslušanje seminarjev je tudi način gradnje pripadnosti študentov fakulteti ter sklepanja vezi med študijskimi kolegi.

**Objectives and competences:**

The aim of the course is to produce a paper and oral presentation in the form of a seminar. Students also listen to the other presentations of doctoral students, and in this way become acquainted with different (more or less successful) presentation techniques, become familiar with the research area of their colleagues, and in this way learn about broader themes in the field of computer and information science. Compulsory attendance of this course and regularly listening to seminars is also a way of building relationships to college students and ties between fellow students.

**Predvideni študijski rezultati:**

Znanje in razumevanje:  
Poznavanje znanstvenih člankov iz izbranega študijskega področja.

Uporaba:  
Uporaba naprednih tehnik v namene znanstveno-raziskovalnega dela.

**Intended learning outcomes:**

Knowledge and understanding:  
Knowledge of scientific articles from the selected studies filed.

Application:  
Application of advanced techniques for scientific and research work.

<p><b>Refleksija:</b> Razumevanje primernosti teoretičnih metod za reševanje problemov ter njihovih omejitev, sposobnost analitičnega razmišljanja, sposobnost analize in reševanja kompleksnih praktičnih problemov.</p> <p><b>Prenosljive spretnosti:</b> Spretnosti reševanja kompleksnih problemov kar vključuje: iskanje literature, uporabo primerne programske opreme (tudi odprtokodne) in programskih okolij, vrednotenje obstoječih postopkov in razvoj ter vrednotenje novih postopkov.</p>	<p><b>Reflection:</b> Understanding of suitability of theoretical methods for solving problems and their limitations, ability of analytical thinking, ability of analysis and solving complex practical problems.</p> <p><b>Transferable skills:</b> Skills of solving complex problems what includes: search of literature, use of appropriate software (including open source) and programming environments, evaluation of existing procedures, and development and evaluation of new procedures.</p>
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**Metode poučevanja in učenja:**

Delo pri predmetu je individualno, članek, ki ga napiše študent, je recenziran (predvidoma tako s strani izvajalcev predmeta kot s strani študentskih kolegov), ocenjeni in komentirani so tudi elementi ustne predstavitve.

**Learning and teaching methods:**

The work is an individual, the work produced by the student is rated by the Commission for doctoral work, evaluated and commented are also the elements of oral presentation.

Delež (v %) /  
Weight (in %)

**Načini ocenjevanja:**

**Assessment:**

Končna ocena predmeta je sestavljena iz ocene članka in ocene njegove ustne predstavitve.	50%	Final evaluation of the course consists of article evaluation and the assessment of its oral presentation.
Ocena: »je opravil« oz. »ni opravil« (v skladu s Statutom UL).	50%	
		Grade: "Passed" or "Failed" (according to the Statute of UL).

**Reference nosilca / Lecturer's references:**

Demšar J., Curk T., Erjavec A., Gorup Č., Hočevnar T., Milutinović M., Možina M., Polajnar M., Toplak M., Starič A., Štajdohar M., Umek L., Žagar L., Žbontar J., Žitnik M., Zupan B. (2013) Orange: data mining toolbox in Python, Journal of Machine Learning Research 14: 2349-2353. [COBISS.SI-ID 10118740]

Curk T., Rot G., Zupan B. (2011) SNPsyn : detection and exploration of SNP-SNP interactions, Nucleic Acids Research 39(2): 444-449. [COBISS.SI-ID 8352596]

James R. Tollervey\*, Curk T.\*, Rogelj B.\*, Briese M., Cereda M., Kayikci M., König J., Hortobágyi T., Nishimura L. A., Župunski V., Patani R., Chandran S., Rot G., Zupan B., Shaw E. C., Ule J. (2011) Characterizing the RNA targets and position - dependent splicing regulation by TDP-43, Nature



Neuroscience 14(4): 452-459. [COBISS.SI-ID 8278100]

König J., Zarnack K., Rot G., Curk T., Kayikci M., Zupan B., Turner D. J., Luscombe N.M., Ule J. (2010) ICLIP reveals the function of hnRNP particles in splicing at individual nucleotide resolution, *Nature Structural and Molecular Biology* 17(7): 909-916. [COBISS.SI-ID 7800916]

Curk T., Petrovič U., Shaulsky G., Zupan B. (2009) Rule-based clustering for gene promoter structure discovery, *Methods of Information in Medicine* 48(3): 229-235. [COBISS.SI-ID 22605095]

Bosnić Z., Kononenko I. (2008) Comparison of approaches for estimating reliability of individual regression predictions. *Data & Knowledge Engineering*, ISSN 0169-023X. [Print ed.], vol. 67, no. 3, str. 504-516.

Bosnić Z., Demšar J., Kešpret G., Rodrigues P. P., Gama J., Kononenko I. (2014) Enhancing data stream predictions with reliability estimators and explanation. *Engineering applications of artificial intelligence*, ISSN 0952-1976. [Print ed.], vol. 34, str. 178-192.

Bosnić Z., Vračar P., Radović M. D., Devedžić G., Filipović N. D., Kononenko I. (2012) Mining data from hemodynamic simulations for generating prediction and explanation models. *IEEE transactions on information technology in biomedicine*, ISSN 1089-7771. [Print ed.], vol. 16, no. 2, str. 248-254.

Pogorelc B., Bosnić Z., Gams M. Automatic recognition of gait-related health problems in the elderly using machine learning. *Multimedia tools and applications*, ISSN 1380-7501, 2012, vol. 58, no. 2, str. 333-354.

Bosnić Z., Kononenko, I. (2008) Estimation of individual prediction reliability using the local sensitivity analysis. *Applied intelligence*, ISSN 0924-669X. [Print ed.], vol. 29, no. 3, str. 187-203.

**UČNI NAČRT PREDMETA / COURSE SYLLABUS**

<b>Predmet:</b>	<b>Seminar 5</b>
<b>Course title:</b>	<b>Seminar 5</b>

<b>Študijski program in stopnja</b> Study programme and level	<b>Študijska smer</b> Study field	<b>Letnik</b> Academic year	<b>Semester</b> Semester
Doktorski študijski program Računalništvo in informatika, 3. stopnja	ni smeri	3	poletni
Doctoral Program in Computer and Information Science, level 3	none	3	spring

**Vrsta predmeta / Course type** obvezen/compulsory

**Univerzitetna koda predmeta / University course code:** 63808

<b>Predavanja</b> Lectures	<b>Seminar</b> Seminar	<b>Vaje</b> Tutorial	<b>Klinične vaje</b> Laboratory work	<b>Druge oblike študija</b> Field work	<b>Samost. delo</b> Individ. work	<b>ECTS</b>
/	40	/	/	210		10

**Nosilec predmeta / Lecturer:** doc. dr. Danijel Skočaj (prodekan za raziskovalno dejavnost /Vice Dean for Research)

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

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

**Prerequisites:**

Redni vpis na doktorski študij.

Enrollment in the Ph. D. program.

**Vsebina:**

Študent za izbrano raziskovalno temo pripravi podrobno predstavitev znanstveno raziskovalnih rezultatov, pregleda sorodnih raziskav, doprinosov k znanosti, načina evaluacije rezultatov, primerjave s sorodnimi deli in usmeritev za naprej.

**Content (Syllabus outline):**

For selected for the research topic student prepares a detailed presentation of scientific research results, review of related work, contributions to science, evaluation methods, comparisons with related work and directions for the future work.

**Temeljni literatura in viri / Readings:**

Bourne P. E. (2005) Ten simple rules for getting published, PLoS Computational Biology 1(5): e57.  
Bourne P. E. (2007) Ten simple rules for making good oral presentations, PLoS Computational Biology 3(4): e77.  
Bourne P. E., Korngreen A (2006) Ten simple rules for reviewers, PLoS Computational Biology 2(0): e110.

**Cilji in kompetence:**

Cilj predmeta je priprava predstavitve, ki vključuje podrobno predstavitev znanstveno raziskovalnih rezultatov, pregleda sorodnih raziskav, doprinosov k znanosti, načina evaluacije rezultatov, primerjave s sorodnimi deli in usmeritev za naprej. Predstavitev omogoča članom komisije za oceno doktorskega dela podroben vpogled v kandidatovo delo. Člani komisije lahko kandidatu med predstavitvijo zastavijo ključna vsebinska vprašanja in podajo predloge za izboljšave kandidatovih raziskav. Tekom predstavitve lahko prepoznajo in opozorijo na morebitne pomanjkljivosti ali napake ter dodatno pozovejo kandidata, da ta razjasni izbrane aspekte raziskav. S tem kandidatu pravočasno omogočijo, da njihove pripombe vključi v svojo disertacijo. V kolikor je kandidat pred tem že pripravil predlog disertacije, lahko člani komisije po njeni predstavitvi kandidata pozovejo, da pripravi popravljeno verzijo, ki upošteva pripombe komisije, in to pošlje v pregled članom komisije še pred pripravo

**Objectives and competences:**

The aim of this course is to prepare the presentation, which includes a detailed presentation of scientific research results, review of related work, contributions to science, evaluation method, comparisons with related work and directions for the future work. Presentation allows the members of the doctoral committee to get detailed insight into the candidate's work. Members of the committee ask questions during the presentation and make suggestions for improvement of student research. During the presentation they can identify and draw attention to any shortcomings or errors, and invite the candidate to clarify selected aspects of this research. The candidate must include their comments in the dissertation. If a candidate has already prepared a draft of the dissertation, the members of the committee request the student to prepare a revised version, taking into account the observations of the committee. This is reviewed by the members of the committee before formal

uradnih pisnih ocen. Obvezno redno obiskovanje tega predmeta oz. redno poslušanje seminarjev je tudi način gradnje pripadnosti študentov fakulteti ter sklepanja vezi med študijskimi kolegi.

written evaluations are prepared. Compulsory attendance of this course and regularly listening to seminars is also a way of building relationships to college students and ties between fellow students.

**Predvideni študijski rezultati:**

**Znanje in razumevanje:**  
Poznavanje znanstvenega področja iz izbranega študijskega področja.

**Uporaba:**  
Uporaba naprednih tehnik v namene znanstveno-raziskovalnega dela.

**Refleksija:**  
Razumevanje primernosti teoretičnih metod za reševanje problemov ter njihovih omejitev, sposobnost analitičnega razmišljanja, sposobnost analize in reševanja kompleksnih praktičnih problemov.

**Prenosljive spretnosti:**  
Spretnosti reševanja kompleksnih problemov kar vključuje: iskanje literature, uporabo primerne programske opreme (tudi odprtokodne) in programskih okolij, vrednotenje obstoječih postopkov in razvoj ter vrednotenje novih postopkov.

**Intended learning outcomes:**

**Knowledge and understanding:**  
Knowledge of scientific field from the selected studies filed.

**Application:**  
Application of advanced techniques for scientific and research work.

**Reflection:**  
Understanding of suitability of theoretical methods for solving problems and their limitations, ability of analytical thinking, ability of analysis and solving complex practical problems.

**Transferable skills:**  
Skills of solving complex problems what includes: search of literature, use of appropriate software (including open source) and programming environments, evaluation of existing procedures, and development and evaluation of new procedures.

**Metode poučevanja in učenja:**

Delo pri predmetu je individualno, delo, ki ga pripravi študent, je ocenjeno s strani Komisije za doktorsko delo, ocenjeni in komentirani so tudi elementi ustne predstavitve.

**Learning and teaching methods:**

The work is an individual, the work produced by the student is rated by the Commission for doctoral work, evaluated and commented are also the elements of oral presentation.

Delež (v %) /

Weight (in %) **Assessment:**

**Načini ocenjevanja:**

Končna ocena predmeta je sestavljena iz ocene individualnega raziskovalnega dela in ocene njegove ustne predstavitve.	50 % 50 %	Final evaluation of the course consists of individual research work evaluation and the assessment of its oral presentation.
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Ocena: »je opravil« oz. »ni opravil« (v skladu s Statutom UL).		Grade: "Passed" or "Failed" (according to the Statute of UL).
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**Reference nosilca / Lecturer's references:**

Fidler S., Skočaj D., Leonardis A. (2008) Combining reconstructive and discriminative subspace methods for robust classification and regression by subsampling. IEEE trans. pattern anal. mach. intell., vol. 28, no. 3, str. 337-350.

Skočaj D., Leonardis A., Bischof H. (2007) Weighted and robust learning of subspace representations. Pattern Recogn 40 (5): [1556]-1569.

Skočaj D., Leonardis A. (2008) Incremental and robust learning of subspace representations. Image vis. comput., vol. 26, no. 1, str. 27-38.

Skočaj D., Kristan M., Vrečko A., Leonardis A., Fritz M., Stark M., Schiele B., Hongeng S., Wyatt JL. (2012) Multi-modal learning. V: Cognitive systems, (Cognitive systems monographs, vol. 8). Berlin; Heidelberg: Springer, cop., str. 265-309.

Vrečko A., Leonardis A., Skočaj D. (2012) Modeling binding and cross-modal learning in Markov logic networks. Neurocomputing, ISSN 0925-2312. [Print ed.], vol. 96, str. 29-36

## UČNI NAČRT PREDMETA / COURSE SYLLABUS

<b>Predmet:</b>	Izbrana poglavja iz razvoja programske opreme 2
<b>Course title:</b>	Selected Topics in Software Development 2

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Doktorski študijski program Računalništvo in informatika, 3. stopnja	ni smeri	1, 2	zimski
Doctoral Program in Computer and Information Science, level 3	none	1, 2	fall

**Vrsta predmeta / Course type** izbirni/elective from CS

**Univerzitetna koda predmeta / University course code:** 63833

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje Laboratory work	Druge oblike študija Field work	Samost. delo Individ. work	ECTS
15	20	15	/	75		5

**Nosilec predmeta / Lecturer:** prof. dr. Franc Jager(predstojnik Katedre za programsko opremo/Head of Software Chair)  
izvajalec se izbere na internem razpisu/the lecturer is selected on the internal call

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

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

Redni vpis na doktorski študij.

**Prerequisites:**

Enrollment in the Ph. D. program.

**Vsebina:**

Pri predmetu bodo predstavljena in obdelana izbrana poglavja z naslednjih področij:

- metodologije razvoja programske opreme,
- napredni teoretični pristopi na področju razvoja algoritmov in podatkovnih struktur,
- iskanje informacij v multimedijskih gradivih,
- izbrana poglavja iz razvoja algoritmov računalniške grafike,
- napredne teme iz vsepovsodnega računanja.

**Content (Syllabus outline):**

At the course selected topics from the following fields will be represented and treated:

- software development methodologies,
- advanced theoretical approaches in the field of algorithms and data structures development,
- seeking for information in multimedia data,
- selected topics from development of computer graphics algorithms,
- advanced topics from ubiquitous computing.

**Temeljni literatura in viri / Readings:**

Graham R. L., Knuth D.E., Patashnik O. (1994) Concrete Mathematics, Reading, Massachusetts: Addison-Wesley.

Braß P. (2008) Advanced Data Structures, Cambridge University Press.

Varghese G. (2004) Network Algorithmics, Elsevier Science.

Grossman D. A., Frieder O. (2004) Information Retrieval: Algorithms and Heuristics, Springer.

Qusay M. (2004) Middleware for Communications, Wiley.

Glassner A. S. (1999) Graphics Gems, Morgan Kaufmann.

**Cilji in kompetence:**

Cilji:

Študenti bodo pri predmetu osvojili znanja iz naprednih teoretičnih pristopov na področju razvoja algoritmov in podatkovnih struktur, na področju razvoja algoritmov računalniške grafike, na področju iskanja informacij v multimedijskih gradivih in na področju naprednih tem vsepovsodnega računanja.

Teoretična znanja bodo znali uporabiti v praksi, s priučeni tehnikami in postopki pa bodo reševali kompleksne probleme na teh področjih. Naučili se bodo razvijanja ustreznih rešitev za dani problem in razvoja programske opreme.

Kompetence:

Razvijanje veščin kritičnega, analitičnega in sintetičnega razmišljanja; sposobnost

**Objectives and competences:**

Objectives:

At the course students will acquire knowledge from advanced theoretical approaches in the field of development of algorithms and data structures, in the field of development of computer graphics algorithms, in the field of seeking for information in multimedia data, and in the field of ubiquitous computing topics.

They will know how to use theoretical knowledge in praxis, and will solve complex problems in these fields using acquired techniques and procedures. Students will learn how to develop solutions given particular problem and development of software.

Competences:

Developing skills in critical, analytical and synthetic thinking; the ability to define,

definiranja, razumevanja in reševanja kreativnih profesionalnih izzivov v računalništvu in informatiki; sposobnost prenosa znanja in pisnih veščin v materinem kot tudi v tujem jeziku; sposobnost samostojnega prenašanja pridobljenega znanja za reševanje tehničnih in znanstvenih problemov v računalništvu in informatiki; sposobnost nadgrajevanja pridobljenega znanja; sposobnost razumevanja in prenosa znanj računalništva in informatike na druga tehnična in relevantna področja.

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:**

#### Znanje in razumevanje:

Poznavanje izbranih poglavij in naprednih tehnik na področju teoretičnih pristopov pri razvoju algoritmov in podatkovnih struktur, področju algoritmov v računalniški grafiki, področju iskanja informacij v multimedijskih gradivih in področjih vsepovsodnega računanja.

#### Uporaba:

Uporaba naprednih tehnik z namene analize podatkov v računalniški grafiki, multimedijskih gradivih in pri vsepovsodnem računanju.

#### Refleksija:

Razumevanje primernosti teoretičnih metod za reševanje praktičnih problemov ter njihovih omejitev, sposobnost analitičnega razmišljanja, sposobnost analize in reševanja kompleksnih praktičnih problemov s področij z razvojem avtomatskih postopkov.

#### Prenosljive spretnosti:

Spretnosti reševanja kompleksnih problemov kar vključuje: iskanje literature, uporabo primerne programske opreme (tudi odprtokodne) in programskih okolij, vrednotenje obstoječih postopkov in razvoj ter vrednotenje novih postopkov.

### **Intended learning outcomes:**

#### Knowledge and understanding:

Knowledge of the selected topics and advanced techniques on the field of theoretical approaches at development of algorithms and data structures, on the field of computer graphics algorithms, the field of seeking for information in multimedia data, and on the field of ubiquitous computing.

#### Application:

Application of advanced techniques with the aim to analyse data in computer graphics, multimedia-data analysis, and in the field of ubiquitous computing.

#### Reflection:

Understanding of suitability of theoretical methods for solving practical problems and their limitations, ability of analytical thinking, ability of analysis and solving complex practical problems in the fields with development of automated procedures.

#### Transferable skills:

Skills of solving complex problems what includes: search of literature, use of appropriate software (including open source) and programming environments, evaluation of existing procedures, and development and evaluation of new procedures.



**Metode poučevanja in učenja:**

Predavanja s podporo avdio-vizualne opreme. Aktivna uporaba sistema za upravljanje s študijskimi vsebinami (npr. Moodle). Laboratorijske vaje v računalniški učilnici z ustrezno strojno in programsko opremo. Delo posamezno in v skupinah, seminarji in konzultacijske ure.

**Learning and teaching methods:**

Combined lecturing with simultaneous use of audio-visual equipment. Active use of system to maintain students contents. (e.g., Moodle). Laboratory work in computer-equipped lecture room. Individual and team work in groups, seminars and consultant hours.

**Načini ocenjevanja:**

Način (pisni izpit, ustno izpraševanje, naloge, projekt):  
Pisni in ustni izpit, sprotno preverjanje znanja - domače naloge, projekt in predstavitev seminarja.

Ocene: 6-10 pozitivno, 1-5 negativno (v skladu s Statutom UL).

Delež (v %) /

Weight (in %)

50%

50%

**Assessment:**

Type (examination, oral, coursework, project):

Written and oral exam, frequent checking of knowledge – homeworks, project and presentation of seminar.

Grades: 6-10 passing, 1-5 failing. (according to the Statute of UL).

**Reference nosilca / Lecturer's references:**

Jager F. (2006) two chapters in *Advanced Methods and Tools for ECG Data Analysis*, Clifford G, Azuaje F., McSharry PE (editors) Artech House, Inc.

Jager F., Taddei A., Moody G.B., Emdin M., Antolič G., Dorn R., Smrdel A., Marchesi C., Mark R. G. (2003) 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.* 41:172-182.

Fele-Žorž G., Kavšek G., Novak-Antolič Ž. and Jager F. (2008) A comparison of various linear and non-linear signal processing techniques to separate uterine EMG records of term and pre-term delivery groups. *Med. Biol. Eng. Comput.* 46(9):911-922.

Jager F., Moody G. B. and Mark R. G. (2004) Protocol to assess robustness of ST analysers : a case study. *Physiological measurement*, 25(3):629-643.

Minchole A., Jager F. and Laguna P. (2010) Discrimination between ischemic and artifactual ST segment events in Holter recordings. *Biomedical signal processing and control*, 5(1):21-31.

**UČNI NAČRT PREDMETA / COURSE SYLLABUS**

**Predmet:** Veščine v znanstvenem delu 1  
**Course title:** Scientific Skills 1

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Doktorski študijski program Računalništvo in informatika, 3. stopnja	ni smeri	1	zimski
Doctoral Program in Computer and Information Science, level 3	none	1	fall

**Vrsta predmeta / Course type** obvezen/compulsory

**Univerzitetna koda predmeta / University course code:** 63802

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje Laboratory work	Druge oblike študija Field work	Samost. delo Individ. work	ECTS
30	20	20	/	55		5

**Nosilec predmeta / Lecturer:** doc. dr. Danijel Skočaj (prodekan za raziskovalno dejavnost / Vice Dean for Research)

**Jeziki / Languages:**

<b>Predavanja / Lectures:</b>	slovenščina in angleščina Slovene and English
<b>Vaje / Tutorial:</b>	slovenščina in angleščina Slovene and English

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

Redni vpis na doktorski študij.

**Prerequisites:**

Enrollment in the Ph. D. program.

**Vsebina:**

**Content (Syllabus outline):**

Pri predmetu bodo predstavljena in obdelana izbrana poglavja z naslednjih področij:

- etika v znanosti in raziskovanju,
- osnovni principi znanstvenega sporočanja,
- pisno sporočanje, oblikovni elementi v pisnem sporočanju, citiranje, večšine pisanja člankov in poročil,
- ustno sporočanje in retorika, elementi dobre ustne predstavitve oz. predavanja,
- sporočanje v obliki plakata,
- orodja za oblikovanje dokumentov sporočanja, tehnike urejanja besedil, orodja za vodenje in urejanje bibliografskih zapisov,
- načrtovanje in pisanje doktorskih disertacij,
- oblike znanstvenega sporočanja na svetovnem spletu, lastnosti dobre predstavitve na spletnih straneh,
- sporočanje v angleškem jeziku (dobre prakse, tipične napake),
- kako se pripraviti na intervju,
- javne bibliografske baze podatkov in njihova uporaba v znanstveno raziskovalnem delu, osnove scientometrije,
- postopek recenziranja, elementi recenzijskega poročila, kako napisati dobro recenzijsko poročilo,
- zaščita intelektualne lastnine, patenti in patentna zaščita, pregled aktualnih licenc (npr. public domain, GNU GPL, GNU LGPL, CC, EULA, ...), copyleft,
- modeli financiranja raziskav doma in v svetu, tipi projektov, domače in tuje agencije, ki financirajo znanstvene projekte, postopek prijave projekta in poročanja o poteku,
- znanost in mediji.

During the course the selected lectures from the following fields will be given:

- ethics in science and research,
- basic principles of scientific communication,
- written communication, citation, articles and report writing skills,
- verbal communication and rhetoric, the elements of good oral presentations or lecture,
- poster presentation,
- tools for creating documents, editing techniques, bibliographic records managing and editing tools
- planning and writing of doctoral thesis,
- forms of scientific communication on the Internet, the characteristics of a good presentation on the Web
- communicating in English; good practice and typical errors,
- how to prepare for an interview,
- public bibliographic databases and their use in scientific research work, basics of scientometrics,
- peer-review process, reviewers report elements, how to write a good review report
- protection of intellectual property, patents and patent protection, an overview of current licenses (e.g. public domain, GNU GPL, GNU LGPL, CC, EULA, ...), copy-left,
- models of research funding at home and abroad, types of projects, both domestic and foreign agencies that finance scientific projects, the application process, and reporting on project progress,
- Science and the media.

**Temeljni literatura in viri / Readings:**

- Bourne PE (2005) Ten simple rules for getting published, PLoS Computational Biology 1(5): e57.
- Vicens Q, Bourne PE (2007) Ten simple rules for a successful collaboration, PLoS Computational Biology 3(3): e44.
- Bourne PE, Korngreen A (2006) Ten simple rules for reviewers, PLoS Computational Biology 2(0): e110.
- Bourne PE (2007) Ten simple rules for making good oral presentations, PLoS Computational Biology 3(4): e77.
- Erren TC, Bourne PE (2007) Ten simple rules for a good poster presentation, PLoS Computational Biology 3(5): e102.

#### **Cilji in kompetence:**

Cilj predmeta je študenta na predavanjih seznaniti z osnovnimi veščinami in znanji, ki jih bo potreboval pri znanstvenem delu, ter v okviru seminarjev in vaj uporabiti to znanje in izdelati ustrezne predstavitve ter sodelovati v recenzentskem procesu.

#### **Objectives and competences:**

The course is designed to acquaint students with basic skills that are needed in scientific work. With practical work on seminars and exercises, students are encouraged to apply the gained knowledge.

#### **Predvideni študijski rezultati:**

Tekom predmeta se bodo študentje na ta način seznanili s temami s področja etike v znanosti, spoznali principe pisnega in ustnega sporočanja in retorike, podajanja znanja, ki so potrebna za pisanje znanstvenih člankov, sestavljanja poročil in disertacij. Pridobili bodo znanja s področja znanosti in medijev, spoznali tipičen recenzentski postopek in glavne sestavine recenzentskega poročila (članki), ter obravnavali osnovne teme s področja patentov in zaščite intelektualne lastnine.

#### **Intended learning outcomes:**

During the course, students will become more familiar with topics like ethics in science, principles of written and oral communication and rhetoric, writing of academic papers, reports and dissertations. They will also acquire knowledge of science in the media, learn about a typical peer review process and the major elements of a peer review report, as well as about basic issues regarding patents and protection of the intellectual property.

#### **Metode poučevanja in učenja:**

Predavanja s podporo avdio-vizualne opreme. Praktični del predmeta je sestavljen iz izdelave predstavitvene spletne strani (npr. predstavitev določene znanstvene teme na slovenskih straneh Wikipedie), izdelave članka iz izbrane znanstvene teme ter njegove ustne predstavitve. Članek je recenziran, recenzije

#### **Learning and teaching methods:**

Lectures supported with audio-visual equipment. The practical part of the course consists of web site design (e.g. presentation of a particular scientific topic on the Wikipedia), writing of an article on selected scientific topics and their oral presentations. This article is peer-reviewed by students. The work is done

oblikujejo študentje sami. Delo posamezno in v skupinah, konzultacijske ure.

individually or in groups, and includes consultations with lecturers.

<b>Načini ocenjevanja:</b>	Delež (v %) / Weight (in %)	<b>Assessment:</b>
Način: seminarske in domače naloge  Ocena predmeta je sestavljena iz delnih ocen tedenskih seminarских in domačih nalog.  Ocena: je »opravil« oz. »ni opravil« (v skladu s Statutom UL).	100%	Type: seminar and homework exercises  The final grade is given as a weighted sum of grades obtained for the weekly seminar works and exercises.  Grade: "Passed" or "Failed" (according to the Statute of UL).

**Reference nosilca / Lecturer's references:**

Fidler S., Skočaj D., Leonardis A. (2008) Combining reconstructive and discriminative subspace methods for robust classification and regression by subsampling. IEEE trans. pattern anal. mach. intell., vol. 28, no. 3, str. 337-350.

Skočaj D., Leonardis A., Bischof H. (2007) Weighted and robust learning of subspace representations. Pattern Recogn 40 (5): [1556]-1569.

Skočaj D., Leonardis A. (2008) Incremental and robust learning of subspace representations. Image vis. comput., vol. 26, no. 1, str. 27-38.

Skočaj D., Kristan M., Vrečko A., Leonardis A., Fritz M., Stark M., Schiele B., Hongeng S., Wyatt JL. (2012) Multi-modal learning. V: Cognitive systems, (Cognitive systems monographs, vol. 8). Berlin; Heidelberg: Springer, cop., str. 265-309.

Vrečko A., Leonardis A., Skočaj D. (2012) Modeling binding and cross-modal learning in Markov logic networks. Neurocomputing, ISSN 0925-2312. [Print ed.], vol. 96, str. 29-36

**UČNI NAČRT PREDMETA / COURSE SYLLABUS**

<b>Predmet:</b>	Veščine v znanstvenem delu 2
<b>Course title:</b>	Scientific Skills 2

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Doktorski študijski program Računalništvo in informatika, 3. stopnja	ni smeri	3	zimski
Doctoral Program in Computer and Information Science, level 3	none	3	fall

**Vrsta predmeta / Course type** obvezen/compulsory

**Univerzitetna koda predmeta / University course code:** 63803

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje Laboratory work	Druge oblike študija Field work	Samost. delo Individ. work	ECTS
5	10	/	/	110		5

**Nosilec predmeta / Lecturer:** doc. dr. Danijel Skočaj (prodekan za raziskovalno dejavnost/Vice Dean for Research)

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

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

Redni vpis na doktorski študij.

Enrollment in the Ph. D. program.

**Vsebina:**

Študentom so podana znanja okrog priprave raziskovalnih projektov, tako temeljnih, kakor aplikativnih. Razloženi in opisani so posamezni sklopi projektnih prijav, na primerih prikazani najboljše pristopi in prakse. Prav tako so študenti seznanjeni z glavnimi financirji v EU in Sloveniji.

Na osnovi pridobljenega znanja študenti pripravijo projektno prijavo. V ta namen najprej pripravijo I. fazo (predprijavo). Izvajalci predmeta (komisija) na osnovi predprijave študentom podajo mnenja in usmeritve. Na osnovi tega študent v roku enega meseca in pol v skladu z navodili razpisa izbrane agencije (npr. v skladu z ARRS razpisi za podoktorske projekte, EU FP7 razpisi ali podobnimi) pripravi pisni predlog projekta. Predlog odda v pregled izvajalcem predmeta, ki tega pregledajo in predajo študentu v morebitne končne popravke in dopolnitve. Končni izdelek študent odda ter ga predstavi v kratki predstavitvi. Na podlagi projektne prijave in predstavitve izvajalci oblikujejo oceno.

**Content (Syllabus outline):**

Students get familiar with the know-how about the preparation of research projects, basic and applied. Several parts of project applications are presented. They are explained on examples. Best approaches and practices are shown and explained. Students also get familiar with major financiers from EU and Slovenia.

Based on this knowledge, students prepare a project application. To achieve this they first prepare phase I (pre-application). Based on the pre-application lecturers will give students directions and hints. Based on the feedback, in one and a half month students prepare the project application according with the directions of the selected agency/financer (i.e. ARRS tenders for post-doctoral projects, EU FP7 tenders, or similar). Students submit the project application for evaluation to the lecturers, who provide evaluation feedback for final project application. Students prepare the final application and submit it. They also present the project in a short presentation. Based on the application and presentations, lecturers grade the students.

**Temeljna literatura in viri / Readings:**

Coombs P. (2005) IT Project Proposals: Writing to Win, Cambridge University Press.  
Bourne P. E., Chalupa LM (2006) Ten simple rules for getting grants, PLoS Computational Biology 2(2): e12.  
Razpisne dokumentacije in priporočila agencij na spletnih straneh ARRS (<http://www.arrs.gov.si/>) in CORDIS (<http://cordis.europa.eu/>).  
Slovenski forum inovacij: <http://www.foruminovacij.si/>  
GUIDE FOR APPLICANTS, Information and Communication Technologies, ICT, Funding scheme: Collaborative projects, Large-scale integrating projects (IP)

[http://cordis.europa.eu/fp7/ict/participating/home\\_en.html](http://cordis.europa.eu/fp7/ict/participating/home_en.html)

#### **Cilji in kompetence:**

Cilj predmeta je izdelava predloga projekta v skladu z razpisom domače ali tuje agencije, ter predstavitev le-tega pred komisijo. Izobraževalni cilji so tako seznanitev s postopkom priprave projekta, izbora zanimive in aktualne teme, ter spoznavanje praktičnih veščin pisanja projekta in njegovega ustnega zagovora.

#### **Objectives and competences:**

The objective of the course is the preparation of project application in accordance with the tender published by domestic or international agency/financer, and presentation of the project in front of lecturers. Students will gain competences on how to prepare project application, how to choose a relevant project topic, get familiar with practical skills for writing project applications and presenting and defending the project in front of the commission.

#### **Predvideni študijski rezultati:**

Znanje in razumevanje:  
Oblikovanje koncepta, ideje in projektnega načrta raziskovalnih projektov.  
Poznavanje specifik raziskovalnih in aplikativnih projektov.  
Razumevanje strukture raziskovalnih projektov.  
Razumevanje postopkov prijave raziskovalnih projektov.  
Uporaba:  
Uporaba tehnik in postopkov pisanja projektne prijave za raziskovalne projekte.  
Refleksija:  
Razumevanje primernosti vsebin in postopkov ter pristopov k pripravi raziskovalnih projektov.  
Prenosljive spretnosti - niso vezane le na en predmet:  
Kombiniranje znanj pridobljenih pri ostalih predmetih za oblikovanje vsebin raziskovalnih projektov. Spretnosti iskanja in uporabe domače in tuje literature pri pripravi projektne prijave.

#### **Intended learning outcomes:**

Knowledge and understanding:  
Creating the concept, idea and project plan for research projects.  
Knowing and understanding the specifics of research and applied projects.  
Understanding the structure of research projects.  
Understanding the application procedure for research projects.  
Application:  
Application of techniques and procedures for project application preparation for research projects.  
Reflection:  
Understanding of suitability of topics, procedures and approaches for preparation for research projects.  
Transferable skills:  
To combine the knowledge from other courses to prepare the content for research projects. To gain skills in literature search for preparation of project proposals.



**Metode poučevanja in učenja:**

Predavanja na pričetku semestra (predstavitelj ciljev predmeta, kratak uvod v pristope pisanja projekta, predstavitev izbranega obrazca oz. ustreznega projektnega klica). Ostali del semestra se izvaja individualno, ob kombinaciji kontaktnih ur ter do dveh sestankov s komisijo – izvajalci predmeta.

**Learning and teaching methods:**

Lectures at the beginning of semester (overview of objectives, introduction to project proposal applications, presentation of forms and project calls). Individual student work with contact hours and two meetings with the commission.

Delež (v %) /

**Načini ocenjevanja:**

Weight (in %)

**Assessment:**

<p>Način (pisni izpit, ustno izpraševanje, naloge, projekt) Končna ocena predmeta je sestavljena iz posameznih ocen izdelkov študenta, ki vključujejo izbor teme projekta (predprijava), projekt v pisni obliki in ustno predstavitev projekta.</p> <p>Ocena: »je opravil« oz. »ni opravil« (v skladu s Statutom UL).</p>	100%	<p>Type (examination, oral, coursework, project): Final grade of the course consists of grades for pre-application (selection of the topic), written project application and presentation.</p> <p>Grade: "Passed" or "Failed" (according to the Statute of UL).</p>
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**Reference nosilca / Lecturer's references:**

Fidler S., Skočaj D., Leonardis A. (2008) Combining reconstructive and discriminative subspace methods for robust classification and regression by subsampling. IEEE trans. pattern anal. mach. intell., vol. 28, no. 3, str. 337-350.

Skočaj D., Leonardis A., Bischof H. (2007) Weighted and robust learning of subspace representations. Pattern Recogn 40 (5): [1556]-1569.

Skočaj D., Leonardis A. (2008) Incremental and robust learning of subspace representations. Image vis. comput., vol. 26, no. 1, str. 27-38.

Skočaj D., Kristan M., Vrečko A., Leonardis A., Fritz M., Stark M., Schiele B., Hongeng S., Wyatt JL. (2012) Multi-modal learning. V: Cognitive systems, (Cognitive systems monographs, vol. 8). Berlin; Heidelberg: Springer, cop., str. 265-309.

Vrečko A., Leonardis A., Skočaj D. (2012) Modeling binding and cross-modal learning in Markov logic networks. Neurocomputing, ISSN 0925-2312. [Print ed.], vol. 96, str. 29-36

