UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Umetna inteligenca in znanost
Course title:	Artificial Intelligence for Science

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
3. stopnja	Skupni predmet	1	1
3rd cycle	Common course	1	1

Vrsta predmeta / Course type Izbirni/Elective

Univerzitetna koda predmeta / University course code: SPL-903

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje work	Druge oblike študija	Samost. delo Individ. work	ECTS
20		10		15	105	5

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

Nosilec predmeta / Lecturer: prof. dr. Sašo Džeroski, prof. dr. Ljupčo Todorovski, doc. dr. Panče Panov

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

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

Izpolnjeni morajo biti pogoji za vpis na doktorski študij: zaključena druga stopnja bolonjskega študija ali diploma univerzitetnega študijskega programa. Potrebna so tudi osnovna znanja računalništva oz. informatike.

Prerequisites:

Students must fulfill the formal requirements for enrolling to the doctoral study program: completed Bologna second level study program or an equivalent pre-Bologna university study program. Basic knowledge of computer science or informatics is also required.

Vsebina:

Umetna inteligenca (UI) in znanost: Uvod
- Osnovni gradniki znanja v znanosti
- Principi avtomatizirane znanosti in računalniškega odkrivanja znanstvenih zakonitosti
- Strojno učenje in napovedno modeliranje
- Odprta znanost

Formalizmi za predstavitev znanja v znanosti
- Od podatkov, preko modelov, do teorij
- Znanstvene taksonomije in ontologije
- Metode sklepanja za ontologije

Content (Syllabus outline):

Introduction: Artificial Intelligence (AI) for science
- The basic components of scientific knowledge
- Principles of automated science and computational scientific discovery
- Machine learning (ML) and predictive modeling
- Open science

Formal representation of scientific knowledge
- From data through models to theories
- Scientific taxonomies and ontologies
- Reasoning methods for ontologies

Principi odprte znanosti Reproducibilnost znanstvenih poskusov Večkratna uporaba raziskovalnih rezultatov Principi FAIR (najdljivost, dostopnost, interoperabilnost, večkratna uporabnost) za znanstvene podatke in modele Meta-podatki in ontologije za znanost	Principles of open science Reproducibility of scientific experiments Reusability of research outputs FAIR (findable, accessible, interoperable and reusable) principles for scientific data and models Meta-data and ontologies for science
Strojno učenje za analizo znanstvenih podatkov Simbolične metode strojnega učenja Obravnava strukturiranih podatkov Umetne nevronske mreže in globoko učenje Obravnava nestrukturiranih in visokodimenzionalnih podatkov	Machine learning for the analysis of scientific data Symbolic machine learning methods Handling structured and semi-structured data Artificial neural networks and deep learning Handling unstructured and high-dimensional data
Primeri uporabe: Študije primerov uporabe metod umetne inteligence in strojnega učenja v znanosti Uporaba metod UI v fiziki Primeri iz fizike delcev Primeri iz znanosti o materialih Uporaba metod UI v znanostih o življenju Napovedovanje funkcij genov Analiza mikrobiomskih podatkov Virtualno presejalno testiranje spojin	Applications: Case studies of using artificial intelligence and machine learning in science Applications of AI in physics Particle physics Materials science Applications of AI in life sciences Gene function prediction Analzying microbiome data Virtual compound screening

Temeljni literatura in viri / Readings:

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

- Džeroski S., and Todorovski L., editors. Computational Discovery of Scientific Knowledge: Introduction, Techniques, and Applications in Environmental and Life Sciences. Springer, 2007. ISBN 978-3-540-73919-7.
- S. Džeroski, B. Goethals, and P. Panov, Eds. *Inductive Databases and Constraint-Based Data Mining*. Springer, 2010. ISBN 978-1-4419-7737-3
- James G., Witten D., Hastie T., and Tibshirani R. An Introduction to Statistical Learning. Springer, 2013. ISBN 978-1-4614-7138-7.
- Arp R., Smith B., and Spear A.D. Building Ontologies with the Basic Formal Ontology. MIT Press, 2015.
- Goodfellow I., Bengio, Y., and Courville, A. Deep learning. MIT Press, 2016. ISBN 978-0262035613.
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Cilji in kompetence:	**Objectives and competences:**
Cilj predmeta je seznaniti študenta s področji umetne inteligence in strojnega učenja, vključno z osnovnimi koncepti in sodobnimi metodami, s poudarkom na njihovi uporabi v znanosti.	The course objective is to familiarize the student with the fields of artificial intelligence and machine learning, including basic concepts and state of the art methods, with a focus on their applications in science.
Kompetence študenta z uspešno zaključenim predmetom bodo vključevale razumevanje osnovnih pojmov iz področja UI in strojnega učenja, poznavanje sodobnih metod in sposobnost samostojne uporabe teh metod pri reševanju	The competencies of the students successfully completing this course will include the understanding of basic concepts from the field, familiarity with the state-of-the art methods, capability of independent use of AI and ML methods

znanstvenih problemov v skladu s principi odprte znanosti.	for solving scientific problems while following the principles of open science.

Predvideni študijski rezultati:	**Intended learning outcomes:**
• Dobiti pregled obstoječih nalog in metod v umetni inteligenci in strojnem učenju, kot tudi študij primerov njihove uporabe na področju fizike in znanostih o življenju • Pridobiti sposobnost formulacije konkretnih problemov iz posameznega izbranega znanstvenega področja kot problemov strojnega učenja • Pridobiti sposobnost ugotavljanja primernosti različnih metodoloških pristopov za reševanje posameznih problemov s strojnim učenjem • Pridobiti sposobnost slediti splošnim principom odprte znanosti pri lastnem raziskovalnem delu	• Acquiring an overview of existing tasks and methods in artificial intelligence and machine learning and case studies of their use in physics and life sciences • Obtaining the ability to formulate problems specific to a selected scientific discipline as machine learning problems • Obtaining the ability to identify the best methodological approach available for solving specific problems with machine learning • Obtaining the ability to follow the general principles of reproducible science

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

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
• ustni izpit	50 %	• oral exam
• seminarska naloga	25 %	• seminar work
• ustni zagovor seminarske naloge	25 %	• oral defense of the seminar work

Reference nosilca / Lecturer's references:

Simidjievski, N., Tanevski J., Ženko B., Levnajić Z., **Todorovski L.**, **Džeroski S.** (2018). Decoupling approximation robustly reconstructs directed dynamical networks, *New Journal of Physics, 20*:113003.

Kuzmanovski, V., **Todorovski, L.**, **Džeroski, S.** (2018). Extensive evaluation of the generalized relevance network approach to inferring gene regulatory networks. *GigaScience, 7(11)*:giy118.

Tanevski, J., **Todorovski, L.**, and **Džeroski, S.** (2016). Process-based design of dynamical biological systems, *Scientific Reports, 6*:34107

Panov, P., Soldatova, L., and **Džeroski, S.** (2016). Generic ontology of datatypes. *Information Sciences*, 329: 900-920.

Panov, P., Soldatova, L., and **Džeroski, S.** (2014) Ontology of core data mining entities. *Data Mining and Knowledge Discovery*, 28: 1222-1265