

UČNI NAČRT PREDMETA / COURSE SYLLABUS							
Predmet:		Modeliranje, analiza in učenje iz podatkov					
Course title:		Modeling, Analysis, and Learning from Data					
Študijski program in stopnja Study programme and level		Študijska smer Study field			Letnik Academic year		Semester Semester
Informacijske znanosti, doktorski študijski program tretje stopnje		Obe smeri			Prvi		Prvi
Information sciences, third cycle Doctoral Study Programme		Both fields			First		First
Vrsta predmeta / Course type				Obvezni / Mandatory			
Univerzitetna koda predmeta / University course code:				1-IZ-DR-MKO-RZ-MAUP-2024-04-24			
Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje work	Druge oblike študija	Samost. delo Individ. work		ECTS
40	/	/	/	/	260		10
Nosilec predmeta / Lecturer:				prof. dr. Biljana Mileva Boshkoska,			
Jeziki / Languages:		Predavanja / Lectures: Slovenski / Slovenian, Angleški / English					
		Vaje / Tutorial:					
Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:				Prerequisites:			
Vpis v prvi letnik študija.				Enrolment in the first year of studies.			
Vsebina:				Content (Syllabus outline):			
<ul style="list-style-type: none"> • Transformacije podatkov in pred obdelava podatkov. Transformacije naključnih spremenljivk. • Naloge strojnega učenja. • Pregled nadzorovanega učenja in glavnih pristopov klasifikacije. Globoke ansamble. • Pregled nenadzorovanega učenja in glavnih algoritmov gručenja. • Koncept pol-nadzorovanega učenja. • Zaznavanje anomalij. • Rudarjenje besedil in analiza sentimenta. Generativni modeli umetne inteligence. 				<ul style="list-style-type: none"> • Data transformations and data pre-processing. Transformations of random variables. • Machine learning tasks. • Overview of supervised learning and main classification approaches. Deep ensembles. • Overview of unsupervised learning and main clustering algorithms. • Concept of semi-supervised learning. • Anomaly detection. • Text mining and sentiment analysis. Generative AI models. 			

<ul style="list-style-type: none"> • Vizualizacija podatkov in koncept 'oblike' podatkov. Grafični modeli. • Topološka analiza podatkov. • Modeliranje časovnih vrst. • Uporaba modeliranja podatkov v različnih vedah (fizika, biologija, itd.). 	<ul style="list-style-type: none"> • Data visualization and the concept of 'shape' of data. Graphical models. • Topological data analysis. • Modelling time series data. • Applications of data modelling in various domain sciences (physics, biology, etc.).
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Temeljni literatura in viri / Readings:

- Newman, M. (2018). *Networks: An introduction*. Oxford University Press.
- Leskovec, J., Rajaraman, A., & Ullman, J. (2022). *Mining of Massive Datasets*. Cambridge University Press.
- James, G., Witten, D., Hastie, T., & Tibshirani, R. (2021). *An Introduction to Statistical Learning*. Springer Texts in Statistics.
- Murphy, K. P. (2023). *Probabilistic Machine Learning. Advanced Topics*. The MIT Press.

Cilji in kompetence:

Učna enota prispeva k razvoju naslednjih splošnih kompetenc:

- Sposobnost identificiranja danega raziskovalnega problema, njegove analize, ovrednotenja ter oblikovanja možnih rešitev.
- Ustvarjanje novega znanja, ki pomeni relevanten prispevek k razvoju znanosti.
- Sposobnost obvladanja standardnih metod, postopkov in procesov raziskovalnega dela na znanstvenem področju študija.
- Sposobnost samostojnega raziskovalno-razvojnega dela in vodenje raziskovalne skupine.
- Prizadevanje za kakovost znanstveno-raziskovalnega dela skozi avtonomnost, (samo)kritičnost, - (samo)refleksivnost in (samo)evalviranje.
- Zavezanost profesionalni etiki.
- Sposobnost inovativne uporabe in kombiniranja raziskovalnih metod.
- Sposobnost za reševanje konkretnih raziskovalnih problemov na posameznem znanstvenem področju.
- Razvoj veščin in spretnosti v uporabi znanja na raziskovalnem področju doktorske disertacije.

Objectives and competences:

Learning unit contributes to development of the following general competencies:

- Ability to identify a given research problem, analyse it, evaluate it and formulate possible solutions.
- Ustvarjanje novega znanja, ki pomeni relevanten prispevek k razvoju znanosti.
- Ability to master standard methods, procedures and processes of research work in the scientific field of study.
- Conduct independent research and development work and lead a research team.
- Striving for quality in scientific research through autonomy, (self-)criticism, (self)reflexivity and (self-)evaluation.
- Be committed to professional ethics.
- Ability to innovatively use and combine diverse research methods.
- Ability to solve specific research problems in a particular scientific field.
- Development of skills and abilities in usage of knowledge in the scientific field of doctoral dissertation.
- Ability to innovatively use and combine diverse research methods.

- Sposobnost inovativne uporabe in kombiniranja raznih raziskovalnih metod.

in predmetno-specifičnih kompetenc:

- Uporaba tehnik statistične analize: uporaba statističnih metod za preoblikovanje in predobdelavo podatkov ter preoblikovanje naključnih spremenljivk.
- Razvijanje modelov strojnega učenja: analizirati realne in laboratorijske vele podatke z uporabo nadzorovanih, delno nadzorovanih in nenadzorovanih tehnik: usposobljenost za gradnjo in izpopolnjevanje algoritmov, ki lahko izvajajo različne naloge strojnega učenja.
- Kritično razmišljati in razlagati rezultate analize podatkov.
- Razvijanje generativnih UI modelov, ki temeljijo na umetni inteligenci.
- Usposobljenost za uporabo topoloških tehnik za preučevanje oblike in značilnosti podatkov; obravnava in analiza večdimenzionalnimi podatki s pomočjo topoloških okvirov.
- Sposobnost uporabe statističnih metod za napovedovanje prihodnjih podatkovnih točk na podlagi predhodno opazovanih podatkov. Usposobljenost za prepoznavanje in modeliranje odvisnosti in časovnih trendov v zbirkah podatkov.
- Sposobnost učinkovitega dela na različnih znanstvenih področjih ter povezovanja metod in spoznanj.
- Prepoznavanje in prilagajanje potrebam in strukturam podatkov, ki so značilne za posamezna znanstvena področja.
- Kritično ocenovanje širokega spektra metodoloških pristopov s področij podatkovnih in računalniških znanosti ter sposobnost njihove uporabe.
- Ovrednotiti realističnih omejitev obravnavanih metod in presoditi možnosti za izboljšave.

and subject-specific competencies:

- Apply statistical analysis techniques: utilizing statistical methods to transform and preprocess data and transformation of random variables,
- Develop machine learning models: Competence in building and refining algorithms that can perform various machine learning tasks, analyse experimental real and laboratory big data using supervised, semi-supervised and unsupervised techniques.
- Think critically and interpret data analysis results.
- Develop AI-based generative models.
- Proficiency in using topological techniques to study the shape and features of data; handling and analyzing data with multiple dimensions through topological frameworks.
- Ability to use statistical methods to forecast future data points based on previously observed data. Proficiency in recognizing and modeling dependencies and trends over time in datasets.
- Ability to work effectively across different scientific domains, integrating methods and insights.
- Recognizing and adapting to the unique data needs and structures specific to each scientific field
- Critical evaluation of a wide range of methodological approaches from the fields of data and computer sciences and the ability to apply them .
- Evaluate the realistic limitations of considered methods and identification of possibilities for improvements.

Predvideni študijski rezultati:

Intended learning outcomes:

Znanje in razumevanje:

Študent/študentka:

- preuči, analizira, primerja, široko paleto metod in pristopov na področju podatkovnih znanosti in različnih vidikov računalništva;
- uporablja vse obravnavane metode, zlasti v zvezi z lastnim doktorskim raziskovalnim delom ter zna konstruirati rešitev zadanega problema s pomočjo metode;
- je seznanjen/a s trenutnimi metodologijami podatkovnih in računalniških znanosti in je sposoben/a predlagati nadgradnje in izboljšave;
- presodi, katere metode želi uporabiti ali naprej razvijati v svojem doktorskem delu.

Knowledge and understanding:

The student:

- examine, analyze, compare a vast array of methods and approaches pertaining to data science and diverse aspects of computer science;
- Applies each of the discussed methods, especially in relation to their own doctoral research work, and is able to construct a solution to a given problem using the method; understands the state-of-the-art in data and computer science methodologies and is able to propose upgrades and improvements;
- judges what methods he or she wants to use or develop in the doctoral work.

Metode poučevanja in učenja:

- Predavanja z aktivno udeležbo študentov (razlaga, diskusija, vprašanja, primeri).
- Individualno delo.

Learning and teaching methods:

- Lectures with active participation of students (explanation, discussion, questions, examples).
- Individual work.

Načini ocenjevanja:

Delež (v %) /
Weight (in %)

Assessment:

Način (pisni izpit, ustno izpraševanje, naloge, projekt):	Delež (v %) / Weight (in %)	Type (examination, oral, coursework, project):
<ul style="list-style-type: none">• Pisni izpit	100	<ul style="list-style-type: none">• written exam

Reference nosilca / Lecturer's references:

- Mileva Boshkoska, B., Miljković, D., Valmarska, A., Gatsios, D., Rigas, G., Konitsiotis, S., Tsiouris, K. M., Fotiadis, D., & Bohanec, M. (2020). Decision support for medication change of Parkinson's disease patients. *Computer methods and programs in biomedicine*, 196, 105552. <https://doi.org/10.1016/j.cmpb.2020.105552>.
- Andonovikj, V., Boškosi, P., Džeroski, S., & Boshkoska, B. Mileva. (2024). Survival analysis as semi-supervised multi-target regression for time-to-employment prediction using oblique predictive clustering trees. *Expert Systems with Applications*, 121246, 1–23. <https://doi.org/10.1016/j.eswa.2023.121246>
- TRPIN, A., MILEVA BOSHKOSKA, B. (2024). Deep learning approach to identifying cancer subtypes using convolutional hyperbolic k nearest neighbours method. *Journal of decision systems*, 1–12.
- Tolic, A., Mileva Boshkoska, B., & Skansi, S. (2023). Upgrading the JANET neural network by introducing a new storage buffer of working memory. *Neural network*

world : international journal on non-standard computing and artificial intelligence, 33, 6, 433–459.

- Zhao, G., Liu, S., Lopez, C., Lu, H., Elgueta, S., Chen, H., Mileva Boshkoska, B. (2019). Blockchain technology in agri-food value chain management : a synthesis of applications, challenges and future research directions. *Computers in industry*, 109, 83–99.