UČNI NAČRT PREDMETA / COURSE SYLLABUS (leto / year 2017/18)			
Predmet:	Strojno učenje		
Course title:	Machine learning		

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Interdisciplinarni magistrski študijski program Računalništvo in matematika	ni smeri	1 ali 2	prvi
Interdisciplinary Master's study programme Computer Science and Mathematics	none	1 or 2	first

Vrsta predmeta / Course type	izbirni / elective
Univerzitetna koda predmeta / University course code:	63519

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

Nosilec predmeta / Lecturer:	prof. dr. Igor Kononenko

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

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites:**
Vpis v letnik študija.	Enrolment in the programme.
Vsebina:	**Content (Syllabus outline):**

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

obravnavali na predavanjih, tako da jo bodo uporabili pri reševanju praktičnih problemov. Pri tem bodo poudarki na samostojnem delu študentov ob pomoči asistentov. Študenti bodo v manjših skupinah samostojno reševali realen problem pod mentorstvom različnih strokovnjakov s področja strojnega učenja in odkrivanja znanj iz podatkov. Skupine bodo svoje naloge in rešitve opisale v pisnem poročilu in predstavile ostalim v obliki kratke predstavitve, ter s tem dobili oceno iz vaj.	independently solve real-life problems under the supervision of different experts in ML and DM. The groups will describe their solutions in written reports and present them in short presentations and through those will receive their mark from lab. work.

Temeljni literatura in viri / Readings:

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

Dodatna/Additional:

- David J. Hand, Heikki Mannila, Padhraic Smyth: Principles of Data Mining. The MIT Press, 2001.

- Ian H. Witten, Eibe Frank: Data Mining: Practical Machine Learning Tools and Techniques. Morgan Kaufmann, 1999.

Cilji in kompetence:	**Objectives and competences:**
Cilj predmeta je predstaviti teoretične osnove in osnovne principe metod strojnega učenja, osnovne algoritme strojnega učenja in njihove uporabe v praksi za iskanje zakonitosti iz podatkov ter za učenje klasifikacijskih in regresijskih modelov. Študenti bodo teoretično znanje praktično uporabili na realnih problemih iz znanstvenega in poslovnega okolja. Študenti bodo za dani problem sposobni presoje, katero od predstavljenih tehnik uporabiti, ter sestaviti prototip rešitve. Kompetence: Kompetence iz računalništva in informatike, ki omogočajo nadaljevanje študija na 3. stopnji (doktorski študij). Zmožnost prenosa znanja na sodelavce v tehnoloških in raziskovalnih	The goal is to present the basics and the basic principles of machine learning (ML) methods, the basic ML algorithms and their usage in practice for knowledge discovery from data, data mining (DM) and for learning classification and regression models. Students will practically apply the theoretical knowledge on real problems from scientific and business environment. The students shall be able to decide for a given problem which of the presented techniques should be used, and to develop a prototype solution. Competences: Competences in computer and information science granting access to further study at 3rd cycle doctoral programmes. The ability to

skupinah. Zmožnost razumevanja in uporabe znanja iz računalništva in informatike v ostalih tehničnih in relevantnih področjih (ekonomija, organizacijske vede itd.). Zmožnost uporabiti pridobljenega znanja za reševanje tehničnih in znanstvenih problemov v računalništvu in informatiki, zmožnost nadgrajevanja pridobljenega znanja. Zmožnost preiskovanja virov znanja in iskanja virov in kritično oceniti informacijo. Zmožnost kritičnega, analitičnega in sintetičnega razmišljanja.	transmit knowledge to co-workers in technology and research groups. The ability to understand and apply computer and information science knowledge to other technical and relevant fields (economics, organisational science, etc); The ability to apply acquired knowledge in independent work for solving technical and scientific problems in computer and information science; the ability to upgrade acquired knowledge. The ability to search knowledge sources and to search for resources and critically evaluate information. Developing skills in critical, analytical and synthetic thinking.
Predvideni študijski rezultati:	**Intended learning outcomes:**
Znanje in razumevanje: Poznavanje različnih tehnik in metod, ki se uporabljajo pri modeliranju podatkov s strojnim učenjem. Sposobnost za analizo, sintezo in predvidevanje rešitev ter njihovih posledic konkretnih problemov z uporabo znanstvenih metod. Uporaba: Uporaba predstavljenih metod na konkretnih problemih iz znanstvenega in poslovnega okolja. Poznavanje in uporaba orodij za modeliranje in podatkovno rudarjenje. Fleksibilna uporaba znanja v praksi. Koherentno obvladanje temeljnega znanja, pridobljenega pri obveznih predmetih, ter sposobnost povezovanja znanja z različnih področij in njegova uporaba v praksi. Refleksija: Spoznavanje in razumevanje pomena temeljnega matematičnega in statističnega znanja, uglašenosti med teorijo in njeno aplikacijo na konkretnih primerih s področja modeliranja in učenja iz podatkov. Avtonomnost, (samo)kritičnost, (samo)refleksivnost, prizadevanje za kakovost. Prenosljive spretnosti - niso vezane le na en predmet: Prenos naučenih principov na načrtovanje obsežnih sistemov, kjer lahko principi modelov, naučenih iz podatkov,	Knowledge and understanding: Expertise in several techniques and methods, used for data modeling with ML. 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 tools for modeling and DM. Flexible usage of knowledge in practice. Coherent mastering of basic knowledge, gained through mandatory courses, and the ability to bind together the knowledge from different fields to apply it in practice. Reflection: The recognition and understanding of the meaning of basic mathematical and statistical knowledge, the relation between theory and its application in concrete examples of modeling and learning from data. Autonomy, (self)criticalness, (self)reflexivity, aspiration for quality. Transferable skills: The transfer of the learned principles for planning of large systems where the principles of models, learned from data, help to improve the usability and the system performance. The ability to receive, select and evaluate of new information and the proper

pomagajo izboljšati uporabnost in uspešnost sistema. Sposobnost pridobivanja, selekcije in ocenjevanja novih informacij in zmožnost ustrezne interpretacije v kontekstu. Sposobnost za upravljanje s časom, za samo pripravo in načrtovanje ter samokontrolo izvajanja načrtov in postopkov. Timsko delo, pisanje poročil in člankov.	interpretation in a context. The ability to administrate with time for preparation and planning and for self-control of implementation of plans and processes. Team work, writing of reports and articles.

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

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Način (pisni izpit, ustno izpraševanje, naloge, projekt): Sprotno preverjanje (domače naloge, kolokviji in projektno delo) Končno preverjanje (pisni in ustni izpit) Ocene: 6-10 pozitivno, 1-5 negativno (v skladu s Statutom UL)	50% 50%	Type (examination, oral, coursework, project): Continuing (homework, midterm exams, project work) Final (written and oral exam) Grading: 6-10 pass, 1-5 fail (according to the rules of University of Ljubljana)

Reference nosilca / Lecturer's references:

KONONENKO, Igor, KUKAR, Matjaž. Machine learning and data mining : introduction to principles and algorithms. Chichester: Horwood Publishing, cop. 2007. XIX, 454 str., ilustr. ISBN 1-904275-21-4. ISBN 978-1-904275-21-3. [COBISS.SI-ID 5961556]

ŠTRUMBELJ, Erik, KONONENKO, Igor. An efficient explanation of individual classifications using game theory. Journal of machine learning research, ISSN 1532-4435. [Print ed.], Jan. 2010, vol. 11, no. [1], str. 1-18, ilustr. [COBISS.SI-ID 7543636]

BOSNIĆ, Zoran, KONONENKO, Igor. Automatic selection of reliability estimates for individual regression predictions. Knowledge engineering review, ISSN 0269-8889, 2010, vol. 25, no. 1, str.

27-47, graf. prikazi. [COBISS.SI-ID 7606356]

ROBNIK ŠIKONJA, Marko, KONONENKO, Igor. Theoretical and empirical analysis of ReliefF and RReliefF. Machine learning, ISSN 0885-6125. [Print ed.], 2003, vol. 53, str. 23-69, graf. prikazi. [COBISS.SI-ID 3813460]

KONONENKO, Igor. Machine learning for medical diagnosis : history, state of the art and perspective. Artificial intelligence in medicine, ISSN 0933-3657. [Print ed.], 2001, vol. 23, no. 1, str. 89-109. [COBISS.SI-ID 2545236]