Univerza v Mariboru

Fakulteta za naravoslovje in matematiko

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Matematični temelji podatkovnih znanosti
Course title:	Mathematical fundamentals of data science

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Matematika, 3.stopnja		1. ali 2.	1., 2., 3. ali 4.
Mathematics, 3rd cycle		1st or 2nd	1st, 2nd, 3rd or 4th

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

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje work	Druge oblike študija	Samost. delo Individ. work	ECTS
30					150	6

Nosilec predmeta / Lecturer:	Drago Bokal

Jeziki / Languages:	**Predavanja / Lectures:**	**Slovenski jezik / Slovene**
	Vaje / Tutorial:	

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites:**
Poznavanje temeljnih konceptov diskretne matematike, statistike in verjetnosti, matematičnega modeliranja in operacijskih raziskav.	Basic knowledge of fundamental concepts of discrete mathematics, statistics and probability, mathematical modeling and operations research.

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

Izbrana so posebna poglavja iz matematičnih modelov procesov pridobivanja znanja (učni prostori, teorija medijev, povezane predstavitve procesov učenja) ter predstavitev znanja (matematični programi, metoda podpornih vektorjev, odločitvena drevesa, formalna analiza konceptov) in operacijskih raziskav, kot npr. evolucijska teorija iger, teorija foresighta, zrelostni modeli, markovska jedra, genetski algoritmi, teorija vrst. Vsebina se prilagaja interesu in raziskovalni usmerjenosti študentov. Našteta literatura praviloma služi le kot osnova in je nadgrajena z literaturo, prilagojeno izbranim vsebinam.	Selected are topics in mathematical modeling of knowledge acquisition processes (learning spaces, media theory, associated models of learning processes) and knowledge representations (mathematical programs, support vector machines, decision trees, concept lattices) and specific topics from operations research, such as evolutionary game theory, foresight theory, maturity models, Markov kernels, genetic algorithms, queueing theory. The content is tailored to the interests and research orientations of the students. The listed literature typically serves only as a foundation and is supplemented with literature adapted to the selected topics.

Temeljni literatura in viri / Readings:

- Falmagne, Jean-Claude, and Jean-Paul Doignon. Learning spaces: Interdisciplinary applied mathematics. Springer Science & Business Media, 2010.
- Krokhin, Andrei, and Stanislav Zivny. *The constraint satisfaction problem: Complexity and approximability*. Schloss Dagstuhl, 2017.
- Cristianini, N., & Shawe-Taylor, J. (2000). *An introduction to support vector machines and other kernel-based learning methods*. Cambridge university press.
- Eppstein, David, Jean-Claude Falmagne, and Sergei Ovchinnikov. Media theory: interdisciplinary applied mathematics. Springer Science & Business Media, 2007.
- Azad, M., Chikalov, I., Hussain, S., Moshkov, M., & Zielosko, B. (2022). Decision Trees with Hypotheses. Springer Nature.
- Smole, A., Jagrič, T., & Bokal, D. (2021). Principal/Two-Agent model with internal signal. Central European Journal of Operations Research, 29(3), 791-808.
- Bokal, D., & Steinbacher, M. (2019). Phases of psychologically optimal learning experience: task-based time allocation model. Central European Journal of Operations Research, 27(3), 863-885.

Dodatna literatura, ki se uporablja ob prilagoditvi temeljne literature temam po izboru študentov:

- Khaled Ghédira, Bernard Dubuisson. Constraint Satisfaction Problems. John Wiley & Sons, Inc., 2013.
- Steinwart, Ingo, and Andreas Christmann. Support vector machines. Springer Science & Business Media, 2008.
- Ganter, B., & Wille, R. (2012). Formal concept analysis: mathematical foundations. Springer Science & Business Media.
- Puterman, M. L. (2014). *Markov decision processes: discrete stochastic dynamic programming*. John Wiley & Sons.
- Kochenderfer, M. J., & Wheeler, T. A. (2019). *Algorithms for optimization*. Mit Press.
- Korte, B. H., Vygen, J., Korte, B., & Vygen, J. (2011). *Combinatorial optimization* (Vol. 1, pp. 1-12). Berlin: Springer.
- Simon, D. (2013). *Evolutionary optimization algorithms*. John Wiley & Sons.
- Pérez-Castrillo, D., Sotomayor, M., & Castiglione, F. (2020). *Complex Social and Behavioral Systems:: Game Theory and Agent-Based Models*. Springer New York.
- Katuu, S. (Ed.). (2018). *Diverse applications and transferability of maturity models*. IGI Global.
- Conforti, M., Cornuéjols, G., Zambelli, G., Conforti, M., Cornuéjols, G., & Zambelli, G. (2014). *Integer programming*. Springer International Publishing.
- Shortle, J. F., Thompson, J. M., Gross, D., & Harris, C. M. (2018). *Fundamentals of queueing theory* (Vol. 399). John Wiley & Sons.
- Hillier, F. S., & Lieberman, G. J. (2024). *Introduction to operations research*. McGraw-Hill.

Cilji in kompetence:

- Študentu predstaviti matematične temelje podatkovnih znanosti, ki bodo služile kot osnova za nadaljnji razvoj teorije formalnega predstavljanja znanja in procesov njegovega usvajanja;
- doseči poglobljeno razumevanje teoretskih in metodoloških konceptov s področja matematičnih podlag predstavitev znanja;
- razviti sposobnost za samostojno reševanje formalnih problemov na področju matematične teorije podatkovnih znanosti.
- Študentu predstaviti izbrana poglavja operacijskih raziskav in aktualni vpogled v to znanstveno področje,
- doseči poglobljeno razumevanje konceptov operacijski hraziskav, njihovega razvoja in metodologije njihove uporabe;
- razviti sposobnost za samostojno izdelavo formalnih modelov in uporabo metodoloških orodij operacijskih raziskav.

Objectives and competences:

- To present mathematical fundamentals of data science to students. These serve as the basis for the students to develop formal representations of knowledge and the processes of its acquisition;
- to achieve an in-depth understanding of theoretical and methodological concepts of mathematical fundamentals of data science;
- to develop the ability for independent solving of formal problems in mathematical theory of data science.
- To present selected chapters of operations research and provide a current insight into this scientific field,
- to achieve an in-depth understanding of the concepts of operations research, their development, and the methodology of their use;
- to develop the ability to independently create formal models and utilize methodological tools of operations research.

Predvideni študijski rezultati:

Znanje in razumevanje:

- samostojno razumeti problemsko situacijo v kontekstu predstavljanja in/ali usvajanja znanja,
- samostojno razviti, opisati, ovrednotiti in predstaviti matematični model izbranega procesa pridobivanja znanja,
- v procesu uporabiti koncepte in metodologije izbranega temeljnega podpodročja (teorije učnih prostorov, teorije izpolnjevanja omejitev, teorije matematičnih programov, teorije odločitvenih dreves, teorije medijev).

Prenesljive/ključne spretnosti in drugi atributi:

- .
- sposobnost za raziskovalno delo na izbranem področju matematičnih podlag podatkovnih znanosti in uporaba teh podlag v drugih znanstvenih disciplinah.

Intended learning outcomes:

Knowledge and understanding:

- independently understanding a problem situation in the context of representation and acquisition of knowledge,
- independently develop, describe, evaluate and present a mathematical model of a selected knowledge acquisition process,
- apply the concept and methodologies of selected fundamental subfield (learning spaces theory, constraint satisfaction theory, mathematical programming theory, decision trees theory, media theory).

Transferable/Key Skills and other attributes:

-
- ability of research in a selected area of mathematical fundamentals to data sciences and its applications in other scientific disciplines.

Metode poučevanja in učenja:

Learning and teaching methods:

● Predavanja; ● priprava seminarja; ● konzultacije; ● samostojni študij.	● Lectures; ● seminar work; ● consultations; ● self-study.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Način (pisni izpit, ustno izpraševanje, naloge, projekt) ● ustna predstavitev ; ● projekt; ● ustni izpit; ● medvrstniško vrednotenje.	 **30%** **50%** **15 %** **5%**	Type (examination, oral, coursework, project): ● oral presentation ; ● project; ● oral examination; ● peer evaluation.

Reference nosilca / Lecturer's references:

- Bokal, D., Dvořák, Z., Hliněný, P., Leaños, J., Mohar, B., & Wiedera, T. (2022). Bounded degree conjecture holds precisely for c-crossing-critical graphs with c≤12. *Combinatorica*, *42*(5), 701-728.
- Bokal, D., & Jerebic, J. (2022). Guarding a subgraph as a tool in pursuit-evasion games. Discussiones Mathematicae Graph Theory, 42(1), 123-138.
- Bokal, D., Chimani, M., Nover, A., Schierbaum, J., Stolzmann, T., Wagner, M. H., & Wiedera, T. (2021). Properties of large 2-crossing-critical graphs. Journal of Graph Algorithms and Applications, *26, no. 1, pp. 111-147, 2022.*
- Vegi Kalamar, A., Žerak, T., & Bokal, D. (2021). Counting Hamiltonian cycles in 2-tiled graphs. Mathematics, 9(6), 693.
- Smole, A., Jagrič, T., & Bokal, D. (2021). Principal/Two-Agent model with internal signal. Central European Journal of Operations Research, 29(3), 791-808.
- Bokal, D., & Steinbacher, M. (2019). Phases of psychologically optimal learning experience: task-based time allocation model. Central European Journal of Operations Research, 27(3), 863-885.