UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Mere centralnosti in modeli omrežij
Course title:	Centrality Measures and Network Models

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Informacijske znanosti, doktorski študijski program tretje stopnje	Matematika kompleksnih omrežij	Drugi	Tretji ali četrti
Information Sciences, third cycle Doctoral Study Programme	Mathematics of Complex Networks	Second	Third or fourth

Vrsta predmeta / Course type	Izbirni/ Optional
Univerzitetna koda predmeta / University course code:	1-IZ-DR-MKO-IP-MCMO-2024-04-24

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje work	Druge oblike študija	Samost. delo Individ. work	ECTS
10	20	/	/	/	270	10

Nosilec predmeta / Lecturer:	prof. dr. Riste Škrekovski

Jeziki / Languages:	**Predavanja / Lectures:**	Slovenski / Slovenian, Angleški / English
	Vaje / Tutorial:	Slovenski / Slovenian, Angleški / English

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisits:**
Vpis v prvi ali drugi letnik študija.	Enrolment in the first or second year of studies.

Vsebina:	**Content (Syllabus outline):**
Predmet je posvečen matematičnemu pristopu pri študiju in razumevanju velikih omrežij. Sestavljen je iz več delov: ● *Grafi*: grafovske invariante, usmerjeni grafi, spekter grafa, verjetnostna metoda. Grafovski algoritmi. ● *Omrežja*: socialna omrežja, računalniška omrežja, biološka omrežja, analiza omrežja. ● *Mere središčnosti*: stopnja točke, središčnost Estrade, bližinska središčnost, ekscentričnost, grafleti, središčnost lastnega vektorja, Katzova središčnost, Vmesnostna središčnost in njene	The course is dedicated to mathematical approach to the study and understanding of large networks. It is comprised of several parts: ● *Graphs:* graph invariants, directed graphs, graph spectra, probabilistic method. Graph algorithms. ● *Networks:* social networks, computer networks, biological networks, network analysis. ● *Centrality measures:* vertex degree, Estrada centrality, closeness centrality, eccentricity, graphlets, eigenvalue centrality, Katz centrality. Betweenness

različice. Googlov PageRank. Grafovski algoritmi za njihovo računanje.
- *Modeli in lastnosti velikih omrežij*: verjetnostni model Erdos-a in Renyi-a ter pragovne funkcije, velika komponenta, eksponentni slučajni grafi, razne deterministične konstrukcije malih svetov, njihov premer in povprečna razdalja v omrežjih, stopničasto-prosta omrežja in distribucija stopenj, sebi-podobna omrežja, socialna omrežja, web graf in njegova oblika metuljčka.
- Dodatna uporaba spektra grafov in verjetnostne metode pri omrežjih.

centrality and its variations. Google's PageRank. Graph algorithms for evaluating some of these centralities.
- *Models and properties of large networks:* the probabilistic Erdos-Reny and threshold functions, the giant component, exponential random graphs, various deterministic constructions of small worlds, their diameter and average distance networks, scale-free networks and degree distributions, self-similar networks, Web graph and its bow-tie shape.
- Additional applications of spectra and probabilistic methods in networks.

Temeljni literatura in viri / Readings:

- Newman M. J. (2018). *Networks,* 2nd Edition. Oxford University Press, New York.
- Estrada, E. (2016). *The Structure of Complex Networks: Theory and Applications.* Reprinted Edition. Oxford University Press, New York.
- van Steen, M. (2010). *Graph theory and complex networks: an introduction*. Samozaložba.
- Cohen, R., &Havlin, S. (2010). *Complex Networks: Structure, Robustness and Function*. Cambridge.
- Brandes, U., & Erlebach, T. (eds.) (2005). *Network Analysis - Methodological Foundations*, LNCS 3418, Springer.

Cilji in kompetence:

Učna enota prispeva k razvoju naslednjih splošnih in predmetno-specifičnih kompetenc:

Splošne kompetence:

- 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.

Predmetno-specifične kompetence:

- Sposobnost analiziranja in modeliranja omrežij.

Objectives and competences:

Learning unit contributes to the development of the following general and subject-specific competences:

General competences:

- Ability to identify a given research problem, analyse it, evaluate it and formulate possible solutions.
- Ability to create new knowledge, which represents a contribution to science .
- Ability to master standard methods, procedures and processes of research work in the scientific field of study.

Subject-specific competences:

- Ability to analyze and model networks.
- Ability to apply more complex mathematical methods of network analysis.

• Sposobnost apliciranj kompleksnejših matematičnih metod analize omrežij. • Sposobnost apliciranj različnih modelov omrežij v realnih problemih.	• Ability to apply different network models in real problems.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Znanje in razumevanje: *Študent/študentka:* • Analizira teorijo in praktične vidike sodobne teorije omrežij, • razlikuje metode in algoritme za analizo in modeliranje velikih družbenih in informacijskih omrežij ter si zamisli uporabo obstoječih orodij in programskih paketov, • vrednoti metode teoretičnega računalništva in analize ter načrtovanja algoritmov na primeru velikih omrežij, • oceni algoritme in metode, njihovo primernost za analizo majhnih in velikih omrežij.	Knowledge and understanding: *The student:* • analyses the theory and practical perspectives of modern network analysis, • differentiates methods and algorithms for analysis and modeling of large social and information networks, and conceive the use of existing tools and software packages, • evaluate theoretical computer science methods and analysis and algorithm design using the example of large-scale networks, • evaluates algorithms and methods and their suitability for the analysis of small and large networks.

Metode poučevanja in učenja:	**Learning and teaching methods:**
• Predavanja z aktivno udeležbo študentov (razlaga, diskusija, vprašanja, primeri, reševanje problemov). • Seminar (izvajanje predstavljenih metod, reševanje problemov). • Individualno delo študentov (samostojen študij literature, izdelava seminarske raziskovalne naloge in njena ustna predstavitev, programiranje).	• Lectures with the active participation of students (explanation, discussion, questions, examples, problem-solving). • Seminar (implementation of the presented methods, problem-solving). • Individual work of students (study of literature, seminar research paper and its oral presentation, programming).

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Način (pisni izpit, ustno izpraševanje, naloge, projekt): ● Projektna raziskovalna naloga ● Ustni izpit	60 40	Type (examination, oral, coursework, project): ● project research paper ● Oral exam

Reference nosilca / Lecturer's references:

- Andova, V., Dimovski, P., Knor, M., & Škrekovski, R. (2024) Diameter of nanotori. *Applied mathematics and computation*, 462, 128342.
- Knor, M., Škrekovski, R., & Tepeh A. (2021). Domination versus independent domination in regular graphs. *Journal of Graph Theory 98*(3), 525–530.
- Sedlar, J., & Škrekovski, R. (2021). Mixed metric dimension of graphs with edge disjoint cycles. *Discrete Applied Mathematics*, 300, 1–8.
- Ojakian, K., &Škrekovski, R. (2021). A Tepeh, Bounding the k-rainbow total domination number. *Discrete Mathematics 344*(8), 112425.
- Savnik, I., Akulich, M., Krnc, M., & Škrekovski, R. (2021). Data structure set-trie for storing and querying sets: Theoretical and empirical analysis. *Plos one 16*(2), 0245122.