

UČNI NAČRT PREDMETA / COURSE SYLLABUS							
Predmet:		Kompleksna omrežja v družboslovju					
Course title:		Complex networks in Social sciences					
Študijski program in stopnja Study programme and level		Študijska smer Study field			Letnik Academic year		Semester Semester
Informacijska družba, doktorski študijski program tretje stopnje		-			Prvi		Prvi
Information Society, third cycle Doctoral Study Programme		-			First		First
Vrsta predmeta / Course type					Izbirni/Elective		
Univerzitetna koda predmeta / University course code:					1-ID-DR-IP-KOD-2025-01-29		
Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje work	Druge oblike študija	Samost. delo Individ. work		ECTS
20	20	/	/	/	410		15
Nosilec predmeta / Lecturer:		izr. prof. dr. Zoran Levnajič, red. prof. dr. Riste Škrekovski					
Jeziki / Languages:		Predavanja / Lectures:		Slovenski / Slovenian, Angleški / English			
		Vaje / Tutorial:					
Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:				Prerequisites:			
/				/			
Vsebina:				Content (Syllabus outline):			
<ul style="list-style-type: none"> • Uvod: <ul style="list-style-type: none"> - Kaj so omrežja in zakaj jih preučujemo? - Socialna, informacijska in biološka omrežja; - Socialni mediji. • Dvovrstna omrežja, več nivojska in večplastna omrežja, hiper grafi. • Analiza kompleksnih omrežij: <ul style="list-style-type: none"> - Vozlišča, stopnje; - Usmerjenost in uteženost; - Nakopičenost, najkrajša pot, premer, gostota omrežij; - Vizualizacija omrežij; - Podomrežja. • Glavni algoritmi analize omrežij: 				<ul style="list-style-type: none"> • Introduction: <ul style="list-style-type: none"> - What are networks and why we study them? - Social, Information, and Biological Networks; - Social media. • Bipartite networks, multiplex and multilayer networks, hypergraphs. • Complex network analysis: <ul style="list-style-type: none"> - Nodes, degrees; - Directions and weights; - Clustering, shortest path, diameter, density of networks; - Visualization of networks; - Subnetworks. • Main algorithms for network analysis: 			

<ul style="list-style-type: none"> - Dostopen software; - Matrika in lista sosednosti; - Iskanje po obsegu; - računska zahtevnost; - shranjevanje podatkov omrežij. • Statistična analiza omrežij: <ul style="list-style-type: none"> - različne meritve centralnosti; - distribucije stopenj; - potenčni zakoni za omrežja; - vmesnost, dostopnost; - komponente. • Modeli omrežij: <ul style="list-style-type: none"> - Slučajni grafi, majhni svetovi; - Brezlestvični in ostali modeli; - izbira ustreznega modela za podano omrežje. • Struktura skupnosti: <ul style="list-style-type: none"> - omrežja s skupnostmi, odkrivanje skupnosti, modularnost in modularna omrežja, prekrivanje skupnosti; - poravnava omrežij, primerjava omrežij. • Dinamika na omrežjih: <ul style="list-style-type: none"> - širjenje, difuzija, perkolacija; - časovna omrežja; - sinhronizacija na omrežjih. • Pomen za družboslovje in glavna področja uporabe 	<ul style="list-style-type: none"> - Available software; - Adjacency matrix and list; - Breadth-first search; - Computational complexity; - Storing network data. • Statistical network analysis: <ul style="list-style-type: none"> - Measures of centrality; - Degree distribution; - Power laws in networks; - Closeness and betweenness; - Components. • Network models: <ul style="list-style-type: none"> - Random graphs, Small worlds; - Scale-free networks, other models; - Inference of network models from empirical data. • Community structure: <ul style="list-style-type: none"> - Networks with communities, community detection, modularity and modular networks, overlapping communities; - Network alignment, network comparison. • Dynamics on networks: <ul style="list-style-type: none"> - Dispersion, diffusion, percolation; - Temporal networks; - Synchronization on networks. • Relevance for social sciences and main areas of applications
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Temeljni literatura in viri / Readings:

<ul style="list-style-type: none"> • Newman, M. (2018). <i>Networks</i>. 2nd edition. Oxford University Press. • Menczer, F., Fortunato, S., & Davis, C. A. (2020). <i>A First Course in Network Science</i>. Cambridge University Press. • Balabantaray, B., Atroshi, C. A., Galety M. G., Mohanty S. N. (2022). <i>Social Network Analysis: Theory and Applications</i>. John Wiley & Sons. • Dorogovtsev, S. N., Mendes, J. F. F. (2022). <i>The Nature of Complex Networks</i>. Oxford University Press.
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Cilji in kompetence:

<p><i>Učna enota prispeva k razvoju naslednjih splošnih kompetenc:</i></p> <ul style="list-style-type: none"> • Sposobnost identificiranja danega raziskovalnega problema, njegove analize, ovrednotenja ter oblikovanja možnih rešitev. • Ustvarjanje novega znanja, ki pomeni relevanten prispevek k razvoju znanosti. • Sposobnost obvladavanja standardnih metod, postopkov in procesov
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Objectives and competences:

<p><i>Learning unit contributes to development of the following general competencies:</i></p> <ul style="list-style-type: none"> • 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.
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raziskovalnega dela na znanstvenem področju študija.

- Razvoj veščin in spretnosti v uporabi znanja na raziskovalnem področju doktorske disertacije.
- Sposobnost inovativne uporabe in kombiniranja raznih raziskovalnih metod.

in predmetno-specifičnih kompetenc:

- Oblikovanje rešitev raziskovalnih problemov iz analize omrežij.
- Iznajdljivost pri prepoznavanju raziskovalnih problemov, ki se jih da formulirati kot omrežne probleme.
- Pridobivanje znanstveno relevantnih informacij iz danega omrežja skozi izbiro ustrezne metodologije.
- Uporaba standardne programske opreme za analizo omrežij
- ter programskih paketov za specifične metode, kot je npr. iskanje skupnosti.

- 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.

and subject-specific competencies:

- Creating the solutions of research problems in network analysis.
- Ingenuity in identifying research problems that can be formulated as network science problems.
- Extracting scientifically relevant information from a network via most suitable methodology.
- Usage of standard software for network analysis and of software packages for specific methods, such as community detection.

Predvideni študijski rezultati:

Znanje in razumevanje:

Študent/študentka:

- se seznani z naprednimi koncepti analize omrežij,
- analizira metode za modeliranje velikih socialnih in informacijskih omrežij,
- zna kritično oceniti in prioritizirati uporabo tovrstnih metod v praktičnih primerih,
- zna oblikovati in ovrednotiti razne metodološke okvirje v analizi omrežij,
- se nauči uporabljati obstoječe programske pakete za analizo omrežij.

Intended learning outcomes:

Knowledge and understanding:

The student:

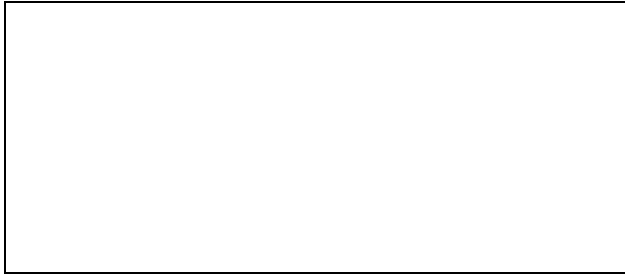
- becomes familiar with advanced concepts in network analysis,
- analyses methods and algorithms for modeling of large social and information networks,
- is able to evaluate and prioritize the usage of such method in practical cases,
- can apprise and compare various methodological frameworks behind network analysis,
- masters the usage of the existing software packages for network analysis.

Metode poučevanja in učenja:

- *Predavanja* z aktivno udeležbo študentov (razlaga, diskusija, razprava o konkretnih primerih).
- *Seminariji in projekti*, kjer študenti ponovijo in preizkusijo svoje razumevanje skozi reševanje raziskovalnih problemov.

Learning and teaching methods:

- *Lectures* with the active participation of students (explanation, discussion, debate on specific cases).
- *Seminars and projects* where students test the acquired



knowledge and skills by solving research problems.

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 v katerem se preveri teoretično znanje. • Projektna raziskovalna naloga prilagojena doktorski temi posameznega študenta. • Zagovor projektne raziskovalne naloge. 	<p>50</p> <p>25</p> <p>25</p>	<ul style="list-style-type: none"> • Written exam to check the theoretical knowledge. • Project research assignment customized to each student's dissertation focus. • Defense of that project assignment.

Reference nosilca / Lecturer's references:

Izr. prof. dr. Zoran Levnajić

- Crnkic, A., Povh, J., Jacimovic, V., & Levnajic, Z. (2020). Collective dynamics of phase-repulsive oscillators solves graph coloring problem, *Chaos*, 30, 033128.
- Faggian, M., Ginelli, F., Rosas, F., & Levnajic, Z. (2019). Synchronization in time-varying random networks with vanishing connectivity. *Scientific Reports*, 9, 10207.
- Simidjievski, N., Tanevski, J., Zhenko, B., Levnajic, Z., Todorovski, L., & Dzeroski, S. (2018). Decoupling approximation robustly reconstructs directed dynamical networks. *New Journal of Physics*, 20, 113003.

Red. prof. dr. Riste Škrekovski

- Sedlar, J., & Škrekovski, R. (2021). Mixed metric dimension of graphs with edge disjoint cycles. *Discrete Applied Mathematics*, 300, 1–8.
- Krnc, M., & Škrekovski, R. (2020). Group degree centrality and centralization in networks, *Mathematics*, 8, 10.

Petruševski, M., & Škrekovski, R. (2022). Colorings with neighborhood parity condition. *Discrete Applied Mathematics*, 321, 385–391.