UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Analiza kompleksnih omrežij
Course title:	Analysis of complex networks

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Podatkovne znanosti, magistrski študijski program druge stopnje	-	Prvi	Drugi
The second cycle masters study programme Data Sciences	-	First	Second

Vrsta predmeta / Course type	Izbirni / Elective
Univerzitetna koda predmeta / University course code:	2-PZ-MAG-IP-AKO-2020-06-30

Predavanja **Lectures**	**Seminar** **Seminar**	**Vaje** **Tutorial**	**Klinične vaje** **work**	**Druge oblike študija**	**Samost. delo** **Individ. work**	**ECTS**
30	-	30	-	-	90	5

Nosilec predmeta / Lecturer:	Izr. prof. dr. Zoran Levnajić

Jeziki / Languages:	**Predavanja / Lectures:**	Slovenščina/English
	Vaje / Tutorial:	Slovenščina/English

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites:**

Za vključitev v delo mora študent poznati osnovne principe programiranja (v poljubnem programskem jeziku). Zahteva se tudi poznavanje osnov matematike in statistike.	Students need basic familiarity with computer programming (in any programming language). Also, they need solid background in undergraduate mathematics and statistics.

Vsebina:	**Content (Syllabus outline):**
Uvod Empirične ugotovitve o realnih omrežij Šest stopenj ločenosti Zakaj preučujemo omrežja?	**Introduction** empirical observations about real networks six degrees of separation why we study networks?
Osnove teorije grafov Koncept vozlišča in povezave Usmerjena in neusmerjena omrežja Utežena in neutežena omrežja Stopnja in nakopičenost Najkrajše poti, premer Povezana omrežja, glavna povezana komponenta Nekaj enostavnih grafov Dvovrstna in večplastna omrežja	**Basics of graph theory** concept of vertex (node) and link (edge) directed and undirected networks weighted and unweighted networks degree and clustering coefficient shortest paths, diameter connected networks, giant connected component some simple graphs bipartite and multiplex networks
Pisanje elementarnih programov Kako predstaviti omrežje v programski kodi? Matrika sosednosti in seznam sosednosti Programska orodja za analizo omrežij	**Writing simple codes** how to put a network in a programming code? adjacency matrix and adjacency list softwares for network analysis
Mere centralnosti Stopnja kot mera centralnosti Vmesnost Dostopnost PageRank Ostale mere centralnosti	**Centrality measures** degree as centrality measure betweenness centrality closeness centrality PageRank other centrality measures
Osnove analize omrežij Porazdelitev stopenj, statistika najkrajših poti Iskanje skupnosti in particije grafa Kvantifikacija sosednosti vozlišča, grafki in motifi Problem primerjave dveh grafov	**Basic network analysis** degree distribution, statistics of shortes paths community detection and graph partitioning quantification of node's neighborhood, graphlets and motifs problem of graph comparison
Modeli omrežij Zakaj potrebujemo modele realnih omrežij?	**Network models** why we need models of real networks? growing and static networks

Rastoča in statična omrežja Modeliranje strukture in modeliranje dinamike omrežja Modeli strukture: Erdos-Renyi slučajna omrežja, model malega sveta, brezlestvična omrežja Modeli dinamike: širjenje govoric, okužb, igre na omrežjih **Zaključek** Zanimive raziskovalne teme Ideje za diplomske naloge ali projekte	modeling network structure vs modeling network dynamics models of structure: Erdos-Renyi, smallworld, scalefree models of dynamics: spreading processes, games and contagions **Conclusion** interesting research topics ideas for theses and projects

Temeljni literatura in viri / Readings:

- A.-L. Barabási. Network Science, http://networksciencebook.com/
- D. Easley and J. Kleinberg. Networks, Crowds, and Markets, https://www.cs.cornell.edu/home/kleinber/networks-book/
- W. de Nooy, A. Mrvar in V. Batagelj. 2018. Exploratory Social Network Analysis with Pajek. 3rd ed. Cambridge University Press.
- M. Newman. 2012. Networks: An introduction. Reprinted. Oxford University Press.
- S. N. Dorogovtsev. 2010. Lectures on complex networks. Calderon press, Oxford.
- Z. Levnajić: Prosojnice iz predavanj in gradiva iz vaj pri predmetu Analiza kompleksnih omrežij, Moodle, FIŠ.

Cilji in kompetence:

Splošne kompetence:

- Splošno razumevanje pomena podatkov.
- Sposobnost analitičnega in algoritmičnega razmišljanja.
- Sposobnost obvladovanja in pretvorbe realnega problema v obliki lažje predstavljivega modela.

Predmetno-specifične kompetence:

- Poznavanje teorije kompleksnih omrežij
- Sposobnost analize realnih (družbenih) omrežij na različnih ravneh natančnosti
- Sposobnost razvoja domensko-specifičnih modelov kompleksnih omrežij

Objectives and competences:

General competences:

- General understanding of the meaning of data.
- The ability of analytical and algorithmic thinking.

The ability to manage and transform a real problem into a simplified model.

Subject-specific competences:

- expertise in theory of complex networks
- ability to analyze real (social) networks at various levels of sophisitication
- ability to develop of domain-specific models of complex networks
- ability to simulate network structure and dynamics on a computer

• Sposobnost simuliranja omrežne strukture in dinamike omrežja na računalniku	

Predvideni študijski rezultati:	**Intended learning outcomes:**
Po uspešno opravljenem predmetu, bo študent imel: • dobro razumevanje kompleksnih omrežij, v glavnem (vendar ne izključno) družbenih omrežij • dobro razumevanje ideje in namena analize (družbenih) omrežij • poznavanje osnovnih in (nekaterih) naprednih metod analize omrežij • spretnosti pri razvoju modelov omrežij primernih za reševanje specifičnih problemov oziroma raziskovalnih vprašanj • spretnosti pri uporabi modernih programskih orodij za analizo omrežij • osnovno poznavanje trenutnih raziskovalnih problemov v znanosti o omrežjih.	Upon successfully completing this course a student will have: • good understanding of complex networks, primarily social networks, but not exclusively • good understanding of the idea and purpose of analyzing (social) networks • knowledge of basic and (some) advanced network analysis methods • skills in developing network models suited for specific problems or research questions • skills in using modern software for network analysis • basic information about current research problems in network science

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja z aktivno udeležbo študentov. Praktične vaje, kjer študentje uporabljajo metode naučene na predavanjih in razvijajo preproste programe.	Lectures with active participation of students. Practical hands-on exercises, where students use methods learnt at lectures and develop elementary programming codes themselves.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Način (pisni izpit, ustno izpraševanje, naloge, projekt) • tedenske ali dvo-tedenske domače naloge, kjer študentje rešijo zaokroženo celoto nalog (večinoma v	50 % 50 %	Type (examination, oral, coursework, project): • weekly or bi-weekly homeworks where students complete sets of exercises

obliki pisanja programske kode) • zaključni pisni izpit		(mostly writing programming codes). • Final written exan

Reference nosilca / Lecturer's references:

- A. Crnkić, J. Povh, V. Jaćimović, Z. Levnajić, Collective dynamics of phase-repulsive oscillators solves graph coloring problem, Chaos 30, 033128, 2020.
- I. Tokuda, Z. Levnajić, K. Ishimura, A practical method for estimating coupling functions in complex dynamical systems, Philosophical Transactions of the Royal Society A 377, 20190015, 2019.
- M. Grau Leguia, Z. Levnajić, L. Todorovski, B. Ženko, Reconstructing dynamical networks via feature ranking, Chaos 29, 093107, 2019.
- M. Faggian, F. Ginelli, F. Rosas, Z. Levnajić, Synchronization in time-varying random networks with vanishing connectivity, Scientific Reports 9, 10207, 2019.
- N. Simidjievski, J. Tanevski, B. Ženko , Z. Levnajić, L. Todorovski, S. Džeroski, Decoupling approximation robustly reconstructs directed dynamical networks, New Journal of Physics 20, 113003, 2018.