



Univerza v Mariboru

Fakulteta za naravoslovje
in matematiko

UČNI NAČRT PREDMETA / COURSE SYLLABUS

Predmet:	Napredne računske metode za biofizikalne in biomedicinske aplikacije
Course title:	Advanced computational methods for biophysical and biomedical applications

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
FIZIKA, 3. stopnja		1. ali 2.	1., 2. ali 4.
PHYSICS, 3 rd cycle		1. or 2.	1. or 2.

Vrsta predmeta / Course type

Izbirni za vse module

Univerzitetna koda predmeta / University course code:

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje work	Druge oblike študija	Samost. delo Individ. work	ECTS
10	5				165	6

Nosilec predmeta / Lecturer:

Marko Gosak

Jeziki /

Languages:

Predavanja /

Lectures:

Vaje / Tutorial:

Slovenski/ Slovenian

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

Priporočljivo je predznanje osnov programiranja.

Vsaka obveznost študenta v načinih ocenjevanja mora biti opravljena s pozitivno oceno.

Prerequisites:

Basic programming skills are recommended.

Each student requirement within the assessment methods must be completed with a passing grade.

Vsebina:

Content (Syllabus outline):

Linearna in nelinearna analiza časovnih vrst, valčna analiza, filtriranje podatkov, statistične analize, vizualizacija podatkov.

Teorija kompleksnih mrež, korelacijska analiza, ekstrakcija funkcionalne povezanosti, večplastne mreže.

Metode za kvantitativno obdelavo in procesiranje biomedicinskih slik in video posnetkov.

Deterministično in stohastično modeliranje bioloških sistemov na različnih nivojih organiziranosti, večslakni modeli, stabilnostna analiza.

Linear and non-linear time series analysis, wavelet analysis, data filtration, statistical analyses, data visualization.

Complex network theory, correlation analysis, functional connectivity patterns, multilayer networks.

Methods for quantitative biomedical image and video processing and analysis.

Deterministic and stochastic modelling of biological systems at different levels of biological organization, multiscale models, stability analysis.

Temeljna literatura in viri / Readings:

1. Shumway, R. H., & Stoffer, D. S. (2011). *Time series analysis and its applications*. Springer. **Celotno besedilo dostopno v SpringerLink Books**
2. Fall, C. P. (2002). *Computational cell biology*. Springer-Verlag. <https://plus.cobiss.net/cobiss/si/sl/bib/pefmb/3280724>
3. ZMAZEK, Jan, SKELIN, Maša, MARKOVIČ, Rene, DOLENŠEK, Jurij, MARHL, Marko, STOŽER, Andraž, GOSAK, Marko. Assessing different temporal scales of calcium dynamics in networks of beta cell populations. *Frontiers in physiology*. Mar. 2021, vol. 12, 16 str., ISSN 1664-042X. DOI: 10.3389/fphys.2021.612233. [COBISS.SI-ID 56986115]
4. Keener, J., & Sneyd, J. (1998). *Mathematical physiology*. Springer-Verlag. <https://plus.cobiss.net/cobiss/si/sl/bib/pefmb/1182804>

Dodatna:

5. Etchings, J. A. (2017). *Strategies in biomedical data science: Driving force for innovation*. John Wiley & Sons.
6. Barabási, A.-L. (2016). *Network science*. Cambridge University Press.
7. Sameshima, K., & Baccalá, L. A. (2014). *Methods in brain connectivity inference through multivariate time series analysis*. CRC Press.

Cilji in kompetence:

Študentje pridobijo poglobljeno znanje s področja teoretičnih in računskih metod pri preučevanju realnih biomedicinskih podatkov in biofizikalnih sistemov. Spoznajo najnovejše raziskave na tem področju.

Objectives and competences:

Students acquire advanced knowledge on theoretical and computational methods for exploring real biomedical data and biophysical systems. Students become familiar with recent research activities in this field.

Predvideni študijski rezultati:

Znanje in razumevanje:

Sposobnost izdelave lastnih algoritmov za napredne analize konkretnih primerov biomedicinskih sistemov, poglobljanje znanj s področij biofizikalnega modeliranja in numeričnih metod.

Prenosljive ključne spretnosti in drugi atributi:

Sposobnost oblikovanja in implementacije izvirnih znanstvenih rešitev v danih biofizikalnih in medicinskih problemih.

Sposobnost predstavitve pridobljenih znanstvenih izsledkov in rezultatov s področja biofizike in biomedicine na nivoju mednarodnih konferenc in publikacij.

Intended learning outcomes:

Knowledge and understanding:

The ability to create own algorithms for advanced analysis of concrete examples of biomedical systems, upgrading the knowledge of biophysical modelling and numerical methods.

Transferable/key skills and other attributes:

Ability of defining and implementing unique scientific solution within defined biophysical and medical problems.

Ability of presenting the acquired results and scientific findings on biophysical and biomedical systems on the level of international conferences and publications.

Metode poučevanja in učenja:

Predavanja, seminar, individualno raziskovalno delo.

Learning and teaching methods:

Lectures, seminar, individual research work.

Načini ocenjevanja:

Delež (v %) /

Weight (in %)

Assessment:

Način (pisni izpit, ustno izpraševanje, naloge, projekt):

Ustni izpit

Sprotne naloge

Projekt

25

25

50

Type (examination, oral, coursework, project):

Oral exam

Coursework

Project

Reference nosilca / Lecturer's references:

1 DUH, Maja, ŠTERK, Marko, KRIŽANČIĆ BOMBEEK, Lidija, MACDONALD, Patrick E., STOŽER, Andraž, GOSAK, Marko. Spatially bound functional heterogeneity drives modular organization in β -cell networks. Biophysical journal. Oct. 7, 2025, vol. 124, str. 1-15, ilustr. ISSN 1542-0086.

<https://www.sciencedirect.com/science/article/pii/S0006349525004928?via%3Dihub#sec7>, DOI: 10.1016/j.bpj.2025.07.043. [COBISS.SI-ID 246139139].

2 ŠTERK, Marko, ZHANG, Yaowen, POHOREC, Viljem, PARADIŽ, Eva, DOLENŠEK, Jurij, BENNINGER, Richard K. P., STOŽER, Andraž, KRAVETS, Vira, GOSAK, Marko. Network representation of multicellular activity in pancreatic islets : Technical considerations for functional connectivity analysis. PLoS computational biology. Maj 2024, vol. 20, iss. 5, 33 str., ilustr. ISSN 1553-7358. Digitalna knjižnica Univerze v Mariboru – DKUM, DOI: 10.1371/journal.pcbi.1012130. [COBISS.SI-ID 195539971]

3 BARAČ, Uroš, PERC, Matjaž, GOSAK, Marko. Determinants of collective failure in excitable networks. Chaos. 2023, vol. 33, iss. 4, [article no.] 043120, 9 str. ISSN 1054-1500. Digitalna knjižnica Univerze v Mariboru – DKUM, DOI: 10.1063/5.0149578, DOI: 20.500.12556/DKUM-88144. [COBISS.SI-ID 149413891]