UČNI NAČRT PREDMETA / COURSE SYLLABUS			
Predmet:	Obdelava biomedicinskih signalov in slik		
Course title:	Biomedical signal and image processing		

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Interdisciplinarni magistrski študijski program Računalništvo in matematika	ni smeri	1 in 2	prvi
Interdisciplinary Masters study programme Computer Science and Mathematics	none	1 in 2	first

Vrsta predmeta / Course type	izbirni
Univerzitetna koda predmeta / University course code:	63514

Predavanja **Lectures**	**Seminar** **Seminar**	**Vaje** **Tutorial**	**Klinične vaje** **work**	**Druge oblike študija**	**Samost. delo** **Individ. work**	**ECTS**
45		**30**			**105**	**6**

Nosilec predmeta / Lecturer:	Franc Jager

Jeziki / Languages:	**Predavanja / Lectures:**	slovenski/Slovene, angleški/English
	Vaje / Tutorial:	slovenski/Slovene, angleški/English

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites:**
Vsebina:	**Content (Syllabus outline):**

Predavanja: Predstavitev biomedicinskih signalov in slik kot so: kardiološki signali (EKG), nevrofiziološki signali (EEG, EMG), medicinske slike (CT, MRI, ultrazvok) ter predstavitev modernih računalniških tehnologij v izbranih kliničnih okoljih. Mednarodne standardizirane referenčne podatkovne baze medicinskih vzorcev (MIT/BIH DB, LTST DB, TPEHG DB, EEGMMI DS, Internetni strežniki). Izločanje značilk (časovni prostor, Fourierjeva transformacija, valčki, principalne komponente – transformacija Karhunena in Loeveja, predstavitve značilk). Izločanje motenj (linearni postopki v časovnem prostoru, postopki v prostorih značilk, uteženo povprečenje, robustni pristopi). Spektralna analiza ter karakterizacija vzorcev in značilk (časovno frekvenčne predstavitve, prostori diagnostičnih in morfoloških značilk). Analiza časovnih vrst in nestacionarnih signalov. Modeliranje (linearni naključni in nelinearni modeli, avtoregresivno modeliranje). Odkrivanje dogodkov, rojenje in klasifikacije (tehnike v časovnem prostoru in prostoru značilk). Procesiranje slik in 3-dimenzionalnih CT ter MRI slik z namenom redukcije motenj, izločanja kontur ter segmentacije in vizualizacije anatomskih struktur. Vrednotenje zmogljivosti biomedicinskih računalniških sistemov (metrike, protokoli, napovedovanje zmogljivosti v realnem svetu,		Lectures: Introduction to biomedical signals and images like: electrocardiographic signals (ECG), neurophysiological signals (EEG, EMG), medical images (CT, MRI, ultrasound) and introduction to modern computer technologies in selected clinical settings. International standardized reference databases of medical samples (MIT/BIH BD, LTST DB, TPEHG DB, EEGMMI DS, Internet servers). Feature extraction (time domain, Fourier transform, wavelets, principal components – Karhunen-Loeve transform, feature representations). Noise extraction (linear procedures in time domain, feature space procedures, weighted averaging, robust approaches). Spectral analysis and characterization of samples and features (time-frequency representations, spaces of diagnostic and morphologic features). Analysis of time series and nonstationary signals. Modelling (linear stochastic and non-linear models, autoregressive modelling). Event detection, clustering and classification (techniques in time domain and in feature space). Image processing and processing of 3-dimensional CT and MRI images with the aim of noise reduction, conture extraction, and segmentation and visualization of anatomical structures. Performance evaluation of biomedical computer systems (metrics, protocols, predictioning performance in real world,

ocene robustnosti, standardi). Vaje: Vaje bodo potekale v obliki projektnega dela v primerno opremljenih študentskih laboratorijih. Študentje v okviru projektov samostojno implementirajo postopke. Obvezno delo na projektih omogoča poglobljeno in kritično razumevanje obravnavane snovi in spodbuja k samostojnosti in kreativnosti.	assessing robustness, standards). Laboratory work: Practical work will be performed in the form of project work in suitable equipped student laboratories. Students in the scope of projects independently implement procedures. Obligatory work on projects allows deepen and critical understanding of the subject topics and stimulates to independence and creativity.

Temeljni literatura in viri / Readings:

Kayvan Najarian, Robert Splinter, Biomedical Signal and Image Processing, CRC Press., 2012.

Advanced Methods and Tools for ECG Data Analysis, Clifford G, Azuaje F, McSharry PE (editors), Artech House, Inc., 2006.

Sornmo L, Laguna P, Biological Signal Processing in Cardiac and Neurological Applications, Elsevier, Inc., 2005

Gonzales Rafael C., Woods Richard E. Digital Image Processing, Pearson Prentice Hall., 2008.

Selected articles from journals: IEEE Transactions on Biomedical Engineering, Medical and Biological Engineering and Computing, Physiological Measurements, PLOS ONE.

Cilji in kompetence:	**Objectives and competences:**
Cilj predmeta je študentom računalništva in informatike predstaviti osnovne obdelave biomedicinskih signalov in slik s poudarkom na problemih biomedicinskih raziskav in klinične medicine. Predmet pokriva principe in postopke za obdelavo deterministič nih signalov, naključnih signalov in slik. Teme pokrivajo zajemanje signalov, standardizirane podatkovne baze vzorcev signalov, filtriranje, izločanje značilk, vizualizacijo, spektralno analizo, modeliranje, odkrivanje dogodkov, rojenje, klasifikacije, analizo slik in vrednotenje zmogljivosti avtomatskih postopkov. Kompetence: Sposobnost definiranja, razumevanja in reševanja kreativnih profesionalnih izzivov v	Objectives of the course are to represent students of computer and information science the basics of biomedical signal and image processing with the emphasis on the problems of biomedical researches and clinical medicine. The course covers principles and procedures for processing of deterministic signals, stochastic signals and images. The course topics cover signal acquisition, standardized databases of signal samples, filtering, feature extraction, visualization, spectral analysis, modelling, event detection, clustering, classification, image analysis and performance evaluation of automatic procedures. Competences:The ability to define, understand and solve creative professional challenges in computer and information science, The ability

računalništvu in informatiki, sposobnost prenosa znanj in pisnih veščin v materinem jeziku kot tudi tujem jeziku, sposobnost uporabe pridobljenega znanja za samostojno delo pri reševanju tehničnih in znanstvenih problemov v računalništvu in informatiki, sposobnost nadgrajevanja pridobljenega znanja, sposobnost razumevanja in uporabe znanj računalništva in informatike na drugih tehničnih in relevantnih področjih.	of knowledge transfer and writing skills in the native language as well as a foreign language, The ability to apply acquired knowledge in independent work for solving technical and scientific problems in computer and information science, The ability to upgrade acquired knowledge, The ability to understand and apply computer and information science knowledge to other technical and relevant fields.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Po uspešnem zaključku tega predmeta naj bi bili študenti zmožni:- poznati računalniške tehnologije in avtomatske postopke analize biomedicinskih signalov in slik za razvoj avtomatskih analizatorjev v pomoč pri diagnosticiranju,- analizirati biomedicinske signale (elektrokardiogram,elektromiogram in elektroencefalogram) v frekvenčnem prostoru,- razviti algoritme za odkrivanje in klasifikacijo dogodkov v biomedicinskih signalih,- analizirati biomedicinske 2D in 3D tomografske slike,- razviti algoritme za izločanja kontur ter segmentacijo in vizualizacijo anatomskih struktur v tomografskih slikah,- vrednotiti zmogljivost in robustnost biomedicinskih računalniških sistemov.	After the completion of the course, students should be able to:- know computer technologies and automatic procedures of biomedical signal and image analysis to develop automatic analyzers in help to diagnose,- analyze biomedical signals (electrocardiogram, electromyogram,electroencephalogram) in frequency domain,- develop algorithms for detecting and classifying events inbiomedical signals,- analyze biomedical 2D and 3D tomography images,- develop algorithms for conture extraction, and segmentation andvisualization of anatomic structures in tomographic images,- evaluate performance and robustness of biomedical computersystems.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja, vaje z aktivnim sodelovanjem, seminarski način dela pri individualnih projektih. Poseben poudarek je pri sprotnem študiju in sprotnem delu pri vajah in seminarjih.	Lectures, laboratory work with active cooperation, seminar type of work on individual projects. Special emphasize is given to prompt study and prompt work on laboratory work and seminars.

Delež (v %) /

Načini ocenjevanja:	Weight (in %)	**Assessment:**
Način (pisni izpit, ustno izpraševanje, naloge, projekt):Sprotno preverjanje (domače naloge, kolokviji in projektno delo) Končno preverjanje (pisni in ustni izpit) Ocene: 6-10 pozitivno, 5 negativno (v skladu s Statutom UL).	50% 50%	Type (examination, oral, coursework, project):Continuing (homework, midterm exams, project work)Final (written and oral exam)Grading: 6-10 pass, 5 fail (according to the rules of University of Ljubljana).

Reference nosilca / Lecturer's references:

Franc Jager:

– JAGER, Franc, TADDEI, Alessandro, MOODY, George B., EMDIN, Michele, ANTOLIČ, Gorazd, DORN, Roman, SMRDEL, Aleš, MARCHESI, Carlo, MARK, Roger G. Long-term ST database : a reference for the development and evaluation of automated ischaemia detectors and for the study of the dynamics of myocardial ischaemia. Medical & biological engineering & computing, ISSN 0140-0118. [Print ed.], 2003, vol. 41, str. 172-182 [COBISS.SI-ID 3464532]

– JAGER, Franc. Introduction to feature extraction. V: CLIFFORD, Gari D. (ur.), AZUAJE, Francisco (ur.), MCSHARRY, Patrick E. (ur.). Advanced methods and tools for ECG data analysis, (Artech House engineering in medicine & biology series). Boston; London: Artech House, cop. 2006, str. 245-267. [COBISS.SI-ID 9880916]

– PANGERC, Urška, JAGER, Franc. Robust detection of heart beats in multimodal records using slope- and peak-sensitive band-pass filters. Physiological measurement, ISSN 0967-3334. [Print ed.], Aug. 2015, vol. 36, no. 8, str. 1645-1664, ilustr. [COBISS.SI-ID 1536389571]

– AMON, Miha, JAGER, Franc. Electrocardiogram ST-segment morphology delineation method using orthogonal transformations. PloS one, ISSN 1932-6203, 2016, vol. 11, no. 2, str. 1-18, graf. prikazi. [COBISS.SI-ID 1536764611]

– TROJNER-BREGAR, Andreja, LUČOVNIK, Miha, VERDENIK, Ivan, JAGER, Franc, GERŠAK, Ksenija, GARFIELD, Robert. Uterine electromyography during active phase compared with latent phase of labor at term. Acta obstetricia et gynecologica Scandinavica, ISSN 0001-6349. [Print ed.], Feb. 2016, vol. 95, no. 2, str. 197-202. [COBISS.SI-ID 1536765379]