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| **UČNI NAČRT PREDMETA / COURSE SYLLABUS** | | | | | | | | | | | | | | | | | |
| **Predmet:** | | | Obdelava biomedicinskih signalov | | | | | | | | | | | | | | |
| **Course title:** | | | Biomedical signal processing | | | | | | | | | | | | | | |
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| **Študijski program in stopnja**  **Study programme and level** | | | | | **Študijska smer**  **Study field** | | | | | | | | **Letnik**  **Academic year** | | **Semester**  **Semester** | | |
| Podiplomski magistrski študijski program druge stopnje Elektrotehnika | | | | | Biomedicinska tehnika | | | | | | | | 1 | | 2 | | |
| 2nd cycle masters study programme in Electrical Engineering | | | | | Biomedical Engineering | | | | | | | | 1 | | 2 | | |
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| **Vrsta predmeta / Course type** | | | | | | | | | | | | Obvezni-strokovni / Compulsory professional | | | | | |
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| **Univerzitetna koda predmeta / University course code:** | | | | | | | | | | | | 64213 | | | | | |
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| **Predavanja**  **Lectures** | **Seminar**  **Seminar** | | | **Vaje**  **Tutorial** | | | **Klinične vaje**  **work** | | | | **Druge oblike študija** | | | **Samost. delo**  **Individ. work** | |  | **ECTS** |
| **45** |  | | | **30** | | |  | | | |  | | | **75** | |  | **6** |
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| **Nosilec predmeta / Lecturer:** | | | | | Tomaž Jarm | | | | | | | | | | | | |
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| **Jeziki /**  **Languages:** | | **Predavanja / Lectures:** | | | | slovensko (možna navodila v angleščini) /  Slovene (instructions in English can be provided) | | | | | | | | | | | |
| **Vaje / Tutorial:** | | | | slovensko (možna navodila v angleščini) /  Slovene (instructions in English can be provided) | | | | | | | | | | | |
| **Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:** | | | | | | | | |  | **Prerequisits:** | | | | | | | |
| Vpis v letnik. | | | | | | | | |  | Enrolment in the year of the course. | | | | | | | |
| **Vsebina:** | | | | | | | |  | | **Content (Syllabus outline):** | | | | | | | |
| Izvor in vrste biomedicinskih signalov ter cilji obdelave. Slučajna spremenljivka, verjetnostne funkcije, funkcije slučajnih spremenljivk. Slučajni procesi in momentne funkcije. Korelacija, konvolucija, koherenca. Ocenjevanje statističnih veličin iz časovno omejenih signalov. Ocenjevanje stacionarnosti in ponovljivosti. Spekter močnostne gostote. Klasične na Fourierjevi transformaciji temelječe in moderne (parametrične) metode za spektralno analizo slučajnih signalov. Podatkovna okna. Modeliranje slučajnih signalov. Linearna predikcija. Lastnosti in tipični postopki za obdelavo elektrofizioloških signalov (EKG, EMG, EEG). Motnje v biomedicinskih signalih in njihovo filtriranje. Optimalno in adaptivno filtriranje. Detekcija dogodkov in valovnih oblik v biomedicinskih signalih. Cepstrum in homomorfna dekonvolucija. Časovno-frekvenčna analiza nestacionarnih signalov. Zvezna in diskretna valčna transformacija (multiresolucijska analiza). Metodi PCA in PCI. | | | | | | | |  | | Sources and types of biomedical signals, goals of signal processing. Random variable, probability functions, functions of random variables. Random processes, moment functions. Correlation, convolution, coherence. Parameter estimation based on time-limited random signals. Stationarity and nonstationarity of random signals, assessment of stationarity. Power spectral density and its estimates based on classical (Fourier-based) and modern approaches (based on parametric modeling of random signals). Data windows. Parametric modeling of random processes and linear prediction. Common electrophysiological signals, their properties and common signal processing approaches (EKG, EMG, EEG). Noise in biomedical signals and filtering. Optimal and adaptive filtering. Event and wavelet detection. Cepstrum and homomorphic deconvolution. Time-frequency analysis of non-stationary signals (using short-time Fourier transform and wavelet transform). | | | | | | | |

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| **Temeljni literatura in viri / Readings:** | | | | | |
| 1. E.N. Bruce: Biomedical signal processing and signal modeling. Wiley-Interscience, 2001. 2. R.M. Rangayyan: Biomedical signal analysis: a case-study approach. Wiley-IEEE Press, 2001. 3. L. Soernmo, P. Laguna: Bioelectrical signal processing in cardiac and neurological applications. Academic Press, 2005. 4. H. Stark, J.W. Woods: Probability and random processes with applications to signal processing (3rd ed.). Prentice Hall, 2002. 5. J.L. Semmlow: Biosignal and biomedical image processing: MATLAB-based applications. CRC Press, 2004. 6. T. Jarm, S. Reberšek: Obdelava biomedicinskih signalov. Založba FE in FRI, 2005. | | | | | |
| **Cilji in kompetence:** | |  | | **Objectives and competences:** | |
| Spoznati in razumeti koncept slučajnih procesov, ki je temelj za razumevanje metod za obdelavo slučajnih signalov. Razumeti delovanje različnih metod za obdelavo biomedicinskih signalov ter prepoznati njihovo praktično uporabnost na praktičnih primerih biomedicinskih signalov različnega izvora. Pridobiti sposobnost samostojno izbrati in utemeljiti ustrezen način obdelave različnih biomedicinskih in drugih signalov slučajne narave. | |  | | To get insight into principles of random processes in relation to signal processing applications. Understanding of theoretical background of various methods for biomedical signal processing and to recognize practical usefulness of these methods for extraction of information from common electrophysiological and other signals of biomedical origin. | |
| **Predvideni študijski rezultati:** | | |  | **Intended learning outcomes:** | |
| Znanje in razumevanje:  Razširiti znanje in razumevanje področja obdelave signalov z determinističnih signalov na signale slučajne narave (večina biomedicinskih signalov). Spoznati glavne vrste signalov biomedicinskega izvora in področja uporabe obdelave biomedicinskih signalov. Osvojiti teoretično razumevanje matematičnih postopkov za obdelavo slučajnih signalov.  Uporaba: Praktična uporaba obravnavanih metod za obdelavo biomedicinskih in drugih slučajnih signalov. Reševanje problemov obdelave biomedicinskih in drugih slučajnih signalov z izbranim programskim orodjem (MATLAB).  Refleksija: Analizirati (samostojno in z izmenjavo mnenj v skupini) zadani problem. Izbrati ustrezne postopke za obdelavo glavnih oblik signalov glede na zastavljeni cilj obdelave ter svojo izbiro utemeljiti.  Prenosljive spretnosti: Samostojno ali v skupini poiskati dodatne ustrezne vire informacij potrebnih za reševanje zadanega problema. Sodelovati v teamu s kolegi pri analizi problema, razdelitvi nalog in sintezi rezultatov v skupno rešitev. Kritično ovrednotiti rezultate lastnega dela in dela kolegov ali drugih avtorjev. | | |  | Knowledge and understanding: To expand knowledge about signal processing approaches from deterministic to random signals; to learn about typical biomedical signals; to gain theoretical understanding of mathematical methods used in processing of such signals.  Practical use: Application of signal processing methods to solve problems related to extraction of clinically relevant information from medical signals (using Matlab); to be able to select and justify an appropriate method based on the purpose of signal processing.  Refelxion and transferable skills: Ability to investigate the problem at hand individually or as a member of a team, to search for new sources of information, to be able to evaluate critically the results of oneself or others. | |
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| **Metode poučevanja in učenja:** | | |  | **Learning and teaching methods:** | |
| Metode poučevanja vključujejo predavanja in praktične laboratorijske vaje. Predavanja: formalno podajanje ključnih elementov snovi podprto s projekcijo slikovnega gradiva ter demonstracijo delovanja posameznih metod. Primeri analitičnega reševanja nekaterih računskih nalog. Laboratorijske vaje: uporaba obravnavanih metod na krajših nalogah na signalih biomedicinskega izvora, ki vsaj delno izvirajo iz praktičnega izvajanja meritev pri drugih predmetih. Del laboratorijskih vaj se lahko nadomesti z obsežnejšo projektno nalogo, kjer študenti zastavljeni problem analizirajo, poiščejo dodatno literaturo, in predlagajo rešitev. Pri reševanju problema morajo integrirati različne dele obravnavane snovi. | | |  | Lectures, individual practical lab work, self study. One part of lab work can be replaced by project work (individual or team assignment). Practical work involves application of methods for signal processing on real signals of biomedical origin (signals from clinical environment or students' own signals recorded during lab assignments from other courses). | |
| **Načini ocenjevanja:** | Delež (v %) /  Weight (in %) | | | | **Assessment:** |
| Način: laboratorijske vaje (lahko delno izvedeno kot projekt), izpit (pisni in/ali ustni).  Ocene od 1 do vključno 5 so negativne, ocene od vključno 6 do 10 so pozitivne.  Pozitivna ocena laboratorijskih vaj je pogoj za pristop k izpitu.  Prispevki k oceni:   * laboratorijske vaje * izpit | 40%  60% | | | | Type: laboratory exercises (can be partially realized as a project), exam (written or oral).  Negative grades: from 1 to 5, positive grades: from 6 to 10.  Positive evaluation of laboratory exercises is a prerequisite for the exam.  Contributions to final grade:   * laboratory exercises * exam |
| **Reference nosilca / Lecturer's references:** | | | | | |
| 1. JARM, Tomaž, REBERŠEK, Stanislav. Obdelava biomedicinskih signalov. 1. izd. Ljubljana: Fakulteta za elektrotehniko, 2005. 2. JARM, Tomaž, ČEMAŽAR, Maja, MIKLAVČIČ, Damijan, SERŠA, Gregor. Antivascular effects of electrochemotherapy: implications in treatment of bleeding metastases. Expert rev. anticancer ther., 2010, vol. 10, no. 5, str. 729-746. 3. ŠTIRN, Igor, JARM, Tomaž, KAPUS, Venceslav, STROJNIK, Vojko. Evaluation of muscle fatigue during 100-m front crawl. European journal of applied physiology. [Online izd.], 2011, vol. 111, no. 1, str. 101-113. 4. Mali B, Žulj S, Magjarević R, Miklavčič D, Jarm T. Matlab-based tool for ECG and HRV analysis. Biomed. Signal Process. Control 10: 108-116, 2014. 5. 5. MALI, Barbara, GORJUP, Vojka, EDHEMOVIĆ, Ibrahim, BRECELJ, Erik, ČEMAŽAR, Maja, SERŠA, Gregor, STRAŽIŠAR, Branka, MIKLAVČIČ, Damijan, JARM, Tomaž. Electrochemotherapy of colorectal liver metastases - an observational study of its effects on the electrocardiogram. BioMedical engineering online, vol. 14, suppl. 3, 2015. | | | | | |