University of Ljubljana Faculty of Computer and Information Science



#### BIOMEDICAL SIGNAL AND IMAGE PROCESSING

Master degree, 1st / 2nd year

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Course: 63514



### Course description

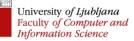
- The course introduces techniques and procedures for analysis of biomedical signals and images like:
  - Cardiology signals
    - \* electrocardiogram ECG
  - Neurophysiology signals
    - \* electromyogram EMG (electrohysterogram EHG)
    - \* (electroencephalogram EEG; See course: Human-Computer Interaction)
  - Medical images
    - \* computed tomography images CT images

with the emphasis on problems of biomedical researches.



#### Course description

- We will recognize how we can automatically detect and classify heart beats and then, non-invasive and punctually, within 24-hour electrocardiogram signals, detect transient ischaemic disease, which is one of the most terrible heart diseases, and if we do not discover it punctually, it may lead to heart infarct.
- We will recognize how we can, using some non-linear signal processing techniques, analyze electromyograms recorded from the abdomen of a pregnant women early during pregnancy (23 week), estimate, or try to predict, danger of pre-term birth.
- We will also recognize techniques of analysis of 2- and 3-dimensional tomographic images with the aim of extraction and visualization of anatomic structures of human body organs.



## Course syllabus

- Introduction to Biomedical Signal and Image Processing
- Data Acquisition
- Digital Filters
- Fourier Transform
- The Z Transform
- Frequency-Domain Analysis of Digital Filters
- Electrocardiogram (ECG) and Detecting Transient Ischaemia
- Feature Extraction, Shape Representation and Processing of the ECG
- Spectral Analysis
- Electromyogram (EMG) and Predicting Pre-Term Delivery
- Non-Linear Signal Processing Techniques



## Course syllabus

- Image Filtering and Enhancement
- Edge Detection and Segmentation of Images
- Computed Tomography (CT) and Visualization of Human Organs
- Algorithms to Detect Transient ST Segment Episodes
- Performance Measures and Evaluation
- (Semi-Automatic Graphic Editing Tools to Annotate Ambulatory ECG Records)
- (Selected topics)



#### Topics

- The topics cover:
  - Representation of international standardized databases of signals and images (*MIT/BIH DB*, *LTST DB*, *TPEHG DB*, *TPEHGT DS*, *CTIMG DB*)
  - Techniques for noise extraction
  - Spectral analysis, modeling
  - Techniques for feature extraction from signals and images (filtering techniques, principal components, Karhunen-Loeve transform, sample entropy, edge detection, contour extraction)
  - Analysis and visualization of diagnostic and morphology feature-vector time series, and anatomic structures
  - Event detection, clustering, classifications
  - Metrics, techniques and protocols for performance and robustness evaluation of biomedical computer systems

# Environments, sites, and tools for laboratory sessions

#### • Web classroom

- PhysioNet site, *http://www.physionet.org* (source of resources in the field of biomedical signal and image processing)
  - Databases: MIT/BIH DB, LTST DB, TPEHG DB, TPEHGT DS
  - Software: ATM tools, wfdb library, lightWAVE, gnuplot
- Home pages of Laboratory for Biomedical Computer Systems and Imaging (LBCSI), http://lbcsi.fri.uni-lj.si
  - Databases: LTST DB, TPEHG DB, TPEHGT DS, CTIMG DB
- Ubuntu 22.04 (LTS), Linux
- Matlab



#### Literature

- Sornmo Leif, Laguna Pablo, Bioelectrical Signal Processing in Cardic and Neurological Applications, 2005, Elsevier Inc.
- Clifford Gari D, Azuaje F, McSharry Patrick E (Editors), Advanced Methods and Tools for ECG Data Analysis, 2006, Artech House Inc.
- Proakis J G, Manolakis D G, Digital Signal Processing, 2014, Prentice Hall Inc. (in our library)
- Gonzales Rafael C, Woods Richard E, Digital Image Processing, 3<sup>rd</sup> Edition, 2008, Pearson Prentice Hall.

Gonzales Rafael C, Woods Richard E, Digital Image Processing, 4<sup>th</sup> Edition, 2018, Pearson Prentice Hall.

- Oppenheim Alan V, Schafer Ronald W, Discrete-Time Signal Processing, Third Edition, 2014, Pearson Education Limited. (in our library)
- Lyons Richard G, Understanding Digital Signal Processing, Third Edition, 2011, Pearson Education, Inc. (in our library)

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Biomedical Signal and Image Processing

#### Laboratory sessions, exam, grading

- Laboratory assignments (each assignment has to be submitted and explained ongoing):
  - 1. Analysis of electrocardiogram (ECG) signals
  - 2. Analysis of electrocardiogram (ECG) signals Analysis of electromyogram (EMG) signals Analysis of computed tomography (CT) images
    - → Obligatory: 50 points; Max: 120 points
- Exam at the end of semester:

→ Obligatory: 50 points; Max: 100 points

(Max: 45 - 55 points)

(Max: 55 - 65 points)

(Max: 55 - 65 points), or

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• How the preliminary grade (5 – 10) will be composed?

Total score = round ((Laboratory points + Exam)/2)

- Total score  $\leq 49 \rightarrow 5$
- $50 \leq Total score \leq 59 \rightarrow 6$
- $60 \leq \text{Total score} \leq 69 \rightarrow 7$
- $70 \leq \text{Total score} \leq 79 \rightarrow 8$
- $80 \leq \text{Total score} \leq 89 \rightarrow 9$
- $90 \leq \text{Total score} \rightarrow 10$
- To decide the final grade, oral exam follows