ELEC447/547: Biomedical Signal Processing (Fall 2021)

Course Description:
Motivations and opportunities regarding current and future applications of biomedical signal processing and wearable devices will be presented. Design principles of the physiological monitoring systems will be discussed. Fundamentals of digital signal processing and statistics will be reviewed. Physiology concepts and physiological signals will be introduced with examples of feature extraction, noise reduction, event detection, and signal modeling approaches. Finally basic data science and machine learning methods used in healthcare applications will be discussed. Students will complete a final project in small groups, including a short proposal, final presentation, and final paper.

Pre-requisites:
ELEC 201 or consent of the instructor.

Day / Time:
MoWe, 1.00 - 2.10 PM
CASE Z25

Instructor:
Beren Semiz, besemiz@ku.edu.tr
Office hours: TBA, my office (SNA Z25) or online via Zoom (link TBA).

KU Credits: 3.00
ECTS Credits: 6.00
Language: English

Teaching Assistants (TAs):
TBA

Suggested Textbooks:
The optional reference textbooks are as follows:

- *Sörnmo and Laguna*, Bioelectrical Signal Processing in Cardiac and Neurological Applications
- *Oppenheim and Schafer*, Digital Signal Processing
- *Hayes*, Statistical Digital Signal Processing and Modeling
- *Guyton and Hall*, Textbook of Medical Physiology
- *Despopoulos*, Color Atlas of Physiology

Course Learning Outcomes (CLOs):

- Understand the types, origins, and properties of the biomedical signals
- Learn how to design and implement pre-processing algorithms for reducing noise and artifacts from biomedical signals
- Learn how to apply multi-modal signal processing and machine learning techniques to extract clinically useful information from biomedical signals

Assessment Method:

- **Homework (25%):** There will tentatively be 4 graded homework assignments. Late homework will not be accepted.
- **Midterms (40%):** There will tentatively be 2 in-class midterms covering material from the lectures or homework.
- **Final Project (35%):** You will be working in small groups (2-3 people) on a research project related to biomedical signal processing and modeling in consultation with the instructor. At the end of the term, you will present your results to the class in a 10-12 minute presentation and provide a project paper (8 pages maximum length, including references). You will be graded based on the depth, correctness, originality and quality of the analysis, and the overall clarity of the paper and presentation. Grade distribution will be as follows:
    - Project Proposal: 8 %
    - Final Presentation: 12%
    - Final Paper: 15%

Tools and Infrastructure:

You will primarily be using Matlab for the homework assignments. For the final project, you will have the chance to use any programming language you choose (Python, Matlab, etc.).

Tentative Outline:

1. Current and future applications of biomedical signal processing and wearable devices
2. Design principles of physiological monitoring systems
3. Signals and systems - *revisited*
    a. Discrete and Continuous Time Signals
    b. Linear Time-Invariant Systems and Convolution
    c. Fourier Series, Fourier Transform and Sampling
4. Signal conditioning and pre-processing
5. Basics of feature extraction and feature importance ranking
6. Physiological monitoring
    a. Cardiovascular and Pulmonary Physiology and Signals
    b. Activity and Exercise Monitoring
    c. Biomechanics: Posture, Balance, and Movement
    d. Nervous System and Neurological Disorders
    e. Sleep Monitoring: Apnea and Sleep Quality Assessment
7. Data visualization techniques
8. Basics of machine learning on healthcare applications
    a. Regression
    b. Classification

All students are expected to comply with the Koç University Student Code of Conduct (https://apdd.ku.edu.tr/en/academic-policies/student-code-of-conduct/). Cheating will not be tolerated. All homework and exam submissions will be checked for similarity and plagiarism.