EE-512

Applied biomedical signal processing

Lemay Mathieu

Cursus	Sem.	Type
Biomedical technologies minor	H	Opt.
Computer science	MA1, MA3	Opt.
Cybersecurity	MA1, MA3	Opt.
Electrical and Electronical Engineering	MA1, MA3	Opt.
Life Sciences Engineering	MA1, MA3	Opt.
Microtechnics	MA1, MA3	Opt.
SC master EPFL	MA1, MA3	Opt.

Language of teaching	English
Credits	4
Session	Winter
Semester	Fall
Exam	Written
Workload	120h
Weeks	14
Hours	**4 weekly**
Courses	2 weekly
Project	2 weekly
Number of positions	

Summary

The goal of this course is twofold: (1) to introduce physiological basis, signal acquisition solutions (sensors) and state-of-the-art signal processing techniques, and (2) to propose concrete examples of applications for vital sign monitoring and diagnosis purposes.

Content

• Introduction on the basics in anatomy and physiology of autonomous nervous system, electrical cardiac system, hemodynamic basis, brain and respiratory activities as well as location.

• Digital signal processing basics including sampling, Fourier transform, filtering, stochastic signal correlation and power spectral density. Time-frequency analysis including short-term Fourier and wavelet transforms. Linear modelling including autoregressive models, linear prediction, parametric spectral estimation, and criteria for model selection. Adaptive filtering including adaptive prediction and estimations of transfer functions as well as adaptive interference cancellation.

• Digital signal processing miscellaneous techniques including polynomial models, singular value decomposition and principal component analysis, phase-rectified signal averaging, source separation, support vector regression, and neural network structures such as CNN and RNN.

• Applications and exercises related to cardiac arrythmia detection and classification, central blood pressure estimation, sleep phase classification, heart rate tracking robust against motion artefacts, epilepsy event detection, fall detection, apnoea detection, SpO2 estimation, and respiration tracking and volume estimation. These exercises will be based on biomedical signals such as bio-impedance, electrocardiogram, electroencephalogram, hypnogram, movement (accelerometer, gyroscope, and barometer), photoplethysmography, vocal/audio.

Keywords

signal processing, biomedical engineering, signal modelling, spectral analysis, adaptive filtering, algorithm design

Learning Prerequisites

Recommended courses

Signal processing for telecommunications COM-303
Signal processing EE-350

Important concepts to start the course

basics of discrete-time signal analysis
basics in signal processing programming

Teaching methods

Ex cathedra lectures (approx.. 2h per module) and practical work using Matlab/Python (approx.. 2h per module). The student should provide a separate report for each of the practical work session for evaluation. Grades are based on the practicals and a final exam.

Expected student activities

- Attending lectures
- Processing and analysing human data
- Testing signal processing techniques

Assessment methods

1.75 points in total for the lab/exercise sessions reports during the semester (35% of the final total grade)
3.25 points for the final exam during the examination period (65% of the final total grade)

Supervision

Assistants	Yes

Resources

Moodle Link

- https://go.epfl.ch/EE-512