EE-511

Sensors in medical instrumentation

Chételat Olivier Pierre, Ionescu Anisoara

Cursus	Sem.	Type
Biomedical technologies minor	E	Opt.
Electrical and Electronical Engineering	MA2, MA4	Opt.
Life Sciences Engineering	MA2, MA4	Opt.
Mechanical engineering	MA2, MA4	Opt.
Microtechnics	MA2, MA4	Opt.
Neuro-X minor	E	Opt.
Neuro-X	MA2, MA4	Opt.
Robotics, Control and Intelligent Systems		Opt.
Robotics	MA2, MA4	Opt.

Language of teaching	English
Credits	3
Session	Summer
Semester	Spring
Exam	Written
Workload	90h
Weeks	14
Hours	**3 weekly**
Courses	2 weekly
Exercises	1 weekly
Number of positions	

Summary

Fundamental principles and methods used for physiological signal conditioning. Electrode, optical, resistive, capacitive, inductive, and piezoelectric sensor techniques used to detect and convert physiological information to electrical signals. Medical devices for physiological signal monitoring.

Content

1. Electrode sensors

- **Action potentials**
  Nernst equation, Hodgkin-Huxley model, action potential, voltage clamp
- **Biopotentials**
  ECG (electrocardiogram), EEG (electroencephalogram), ExG (other electrogram), ECGi (ECG imaging)
- **Bioimpedances**
  Impedance model, impedance plethysmography, impedance spectroscopy, EIT (electrical impedance tomography), PAP (pulmonary artery pressure)
- **Basic safety of ME equipment**
  Regulations, 60601-1, MOP, applied part and patient connections, leakage and auxiliary currents, defibrillator-proof
- **Electrodes**
  Electrode model, motion artefacts, noise, dry electrodes, potential and current electrodes
- **Metrology of biopotentials**
  EM interferences, shielding, neutral electrode, common mode, defibrillation and ESD protections
- **Metrology of bioimpedances**
  Bipolar and tetrapolar methods, bi-electrodes, AM, IQ demodulation, leakage, shielding

2. Optical sensors

- **Photo-plethysmography**
  PPG, oHRM, ambient light, volume clamp blood pressure, optical blood pressure, SpO2
- **NIRS (near infrared spectroscopy)**
  Basic NIRS, differential NIRS

3. Resistive sensors
Thermistor and its biomedical applications; strain gage for the measurement of blood pressure; force and accelerations of the body
4. Inductive sensors
Simple and mutual inductance and its medical applications
5. Capacitive sensors
Respiratory flow measurement by the gradient of pressure
6. Piezoelectric sensors
Force platform, accelerometer, angular rate sensor for the measurement of tremors and body movements, ultrasound

transducer : measurement of pressure and flow rate

Keywords

Sensors, instrumentation, medical devices, physiological signals, electronic circuits, metrology, monitoring

Learning Prerequisites

Required courses

basic signal and control theory, basic electronics (Kirchhoff, OPA, INA)

Recommended courses

systems, sensors, electronics

Important concepts to start the course

basic electronics, basic physics

Learning Outcomes

By the end of the course, the student must be able to:

- Choose techniques detecting and convert physiological information's to electrical signals
- Exploit fundamental principles and methods used for physiological signal conditioning
- Design measuring devices
- Interpret error, noise in biomedical measuring systems
- Work out / Determine what sensors to choose and how to place them to measure a given physiologica signal.
- Work out / Determine what electronic circuits to use.
- Dimension the electronic circuit.
- Analyze the sources of noise.

Transversal skills

- Use a work methodology appropriate to the task.
- Communicate effectively with professionals from other disciplines.
- Take account of the social and human dimensions of the engineering profession.

Teaching methods

Ex cathedra (including examples) with textbook and exercises

Expected student activities

read textbook, exercises, quizzes and problems

Assessment methods

three quizzes/problems sessions during semester (each worth 5%)
final written exam (worth 85%)

Supervision

Office hours	Yes
Assistant.e.s	Yes
Forum	Yes

Resources

Virtual desktop infrastructure (VDI)

No

Bibliography

Medical Instrumentation, application and design, Webster, 4th edition

Ressources en bibliothèque

- Medical Instrumentation, application and design, Webster, 5th edition

Notes/Handbook

Sensors in medical instrumentation (textbook)
Slides

Moodle Link

- https://go.epfl.ch/EE-511

Prerequisite for

Semester project and Master project