

Academic Year of Degree: 2025/26

24049 - Biomedical Imaging Systems

Teaching Guide Information

Academic Course: 2025/26

Academic Center: 337 - Engineering School

Study: 3378 - Bachelor's degree in Biomedical Engineering

Subject: 24049 - Biomedical Imaging Systems

Credits: 5.0

Course: 3

Teaching languages:

Theory: Group 1: English

Practice: Group 101: English

Group 102: English

Seminar: Group 101: English

Group 102: English

Teachers: Bart H Bijmens

Teaching Period: Second term

Presentation

This subject provides the basics of the different modalities for medical imaging that are predominantly used in clinical practice. The consist of ultrasonic imaging; X-ray projection imaging and computed tomography; nuclear medicine and magnetic resonance imaging. Emphasis is placed on the basic physical principles and image formation. Additionally, illustrative examples are provided highlighting the complementarity of the modalities and their use in clinical practice.

Associated skills | General learning outcomes

Learning to interpret medical images from a physical point of view, distinguishing artefacts from information.

This aligns with the following skills associated with the degree:

Transversal skills:

CT3. Applying with flexibility and creativity the acquired knowledge and adapting it to new contexts and situations.

CT4. Communicating in academic and professional contexts in English, both orally and in writing

Specific skills:

CE4. Mastering the use and programming of computers, operating systems, databases and computer programs with application in engineering.

CE7. Master physical and chemical laws which regulate energy-matter interaction, mechanics and thermodynamic general laws and apply them in the context of typical problems in engineering

CE8. Developing computational methods for the solution of physical methods formulated in a continuous or discrete way.

CE9. Designing and implementing technological solutions related to the acquisition, processing, modelling, visualization and interpretation of biological, physiological and clinical variables and signals that contribute in the processes of prevention, diagnosis, treatment and rehabilitation.

Learning outcomes | Specific learning outcomes

Basic concepts of energy-matter interaction. The atom and the spectrum of electromagnetic radiation. Factors that determine the diagnostic quality of the image. X-ray - generation, projection radiography, fluoroscopy, computed tomography, tomographic reconstruction. Magnetic resonance - Magnetic resonance principle, positioning systems using gradients and excitation and reading sequences. Flow measurement and other advanced properties by magnetic resonance. Ultrasonography - operating principle and operation modes, Doppler effect. Nuclear Medicine - Radioactivity and nuclear transformations, production of radiators. Tomography emission of positrons and tomography by emission of a single photon.

This aligns with the following learning outcomes associated with the degree:

RA.CE4.6 Comparing techniques of analysis and interpretation of images.

RA.CE7.1 Apply knowledge of physical and chemical laws which regulate energy-matter interaction to solve problems in engineering.

RA.CE8.1 Understand the principles of computational methods used in physical models.

RA.CE9.2 Design technological solutions related to the acquisition, processing, modelling, visualization and interpretation of biological, physiological and clinical variables and signals that contribute in the processes of prevention, diagnosis, treatment and rehabilitation.

RA.CE9.3 Compare the several techniques and systems of acquisitions of biomedical signals and images capable of providing information and/or functional information of the several biological and physiological processes.

RA.CE9.7 Identifying the different devices used in the diagnosis and treatment of the main medical pathologies.

RA.CE10.4 Recognizing the fundamental engineering elements and tools related to biological elements at different scale.

Contents

Theoretical classes (22h). These include:

1. Introduction to the medical image + X-ray image.
2. Computed tomography, electronic microscopy and Soft X-ray synchrotron image.
3. Ultrasonography.
4. Nuclear Medicine.
5. Magnetic Resonance.
6. Integrated Heart Imaging.
7. Radiological protection.

Practices (14.5h). The practical sessions consist of 3 parts:

1. Simulating and reconstructing ultrasound images. This includes for example:
 - Generation of "sector scan RF lines" by a given geometry (in movement) and reconstruct the M-mode images.
 - Rebuilding images (in movement) of the sector.
 - Estimating velocities using "Pulsed and Continuous Doppler" models.
 - Reconstructing the "Pulsed and Continuous Doppler" spectrum.
 - Estimating velocities using a "Color Doppler" model.
 - Rebuilding images (in movement) of "Color Doppler".
2. Radioprotection - Measurements of ionising radiation.
3. A visit of clinical imaging modalities.

Seminars (10h)

The seminars envisage a deeper understanding of the foundations and applications of reconstruction from projections. This includes for example:

- Acquisition of projections - foundations.
- Generation of simple projections of objects.

- Reconstructions ("Filtered back projection / Iterative") - foundations.
- Reconstruction of an object using "filtered back projection".
- Iterative reconstruction of an object.

Sustainable Development Goals

3 - Good Health and Well-being

9 - Industry, Innovation and Infrastructure

Evaluation and grading system

The evaluation of the academic performance will be carried out in the following way (on a total of 10 points):

- Oral exam (with written preparation) covering the whole content of the course (recoverable): 60%
- Written or oral report on the ultrasound simulations (not recoverable): 20%
- Written or oral report on image reconstruction (non-recoverable): 20%

To pass the subject, each of the following requirements must be fulfilled:

- Obtain a mark equal to or greater than 50% in the exam.
- Obtain a mark equal to or greater than 50% in the practices as well as the seminars.
- Attend the practices and seminars.

Requirements

- The attendance to the practices and seminars is obligatory and absence requires an official justification.
- The students of seminars and practices can only change group when explicitly approved by the teacher.