UCLouvain

lgbio2050

2023

Medical Imaging

5.00 credits	30.0 h + 30.0 h	Q1

Teacher(s)	Kerckhofs Greet ;Lee John ;Macq Benoît ;Peeters Frank ;
Language :	English > French-friendly
Place of the course	Louvain-la-Neuve
Prerequisites	Students are expected to master the following skills: basic mathematical notions (derivatives, coordinate systems) and the Fourier transform, as they are covered within the course LFSAB1106
Main themes	The course deals with the basics of medical imaging, including digital image processing, as well as the main modalities of medical imaging (transmission imaging, emission imaging, ultrasound echography, and magnetic resonance imaging).
Learning outcomes	**At the end of this learning unit, the student is able to :** With respect to the AA referring system defined for the Master in Biomedical Engineering, the course contributes to the development, mastery and assessment of the following skills : • AA1.1, AA1.2, AA1.3 • AA2.1, AA2.2, AA2.3, AA2.4 • AA4.1, AA4.2, AA4.4 • AA5.2, AA5.4 a. Domain-related learning outcomes **Upon completion of the course, the student will be able to :** Part 1 (digital image processing) : • Define formally the concept of image and its properties (size, matrix of pixels/voxels, colormap, histogram, color or channel encoding, encoding of the matrix, compression, frequency space representation). (axis 1.1) • List the main classes of problems solved by image processing (denoising, deconvolution, filtering, edge detection, segmentation, registration). (axes 1.1 et 1.2) • List a few typical methods used to solve these different classes of problems. (axis 1.2) • Justify the choice of a method (data representation, criterion to be optimized) with respect to simple problems (segmentation of a slice, registration of two slices, etc.). (axes 1.3 et 2.3) • Solve these simple problems by implementing in Matlab the algorithms corresponding to the methods described in the course. (axes 2.1, 2.2, 2.3, 2.4) Part 2 (MRI and echography) : 1 • Describe the physical principle behind magnetic resonance imaging (MRI) : Nuclear Magnetic Resonance (spin, excitation, reception, relaxation, chemical shift,'). (axe 1.1) • Describe the principle that allows image reconstruction: gradients, slice/volume selection, frequency/phase encoding, k-space, Fourier transform, resolution, ', and describe the possible artifacts. (axes 1.1 et 1.2) • List and describe some sequences used for image acquisition (spin echo and gradient echo, ultrafast sequences and echo planar imaging) and compare their advantages, drawbacks, and application conditions. (axe 1.1) • List and describe the possible contrasts : proton density, T1, T2, T2*, flow, diffusion, perfusion, functional and spectroscopic imaging. (axe 1.1) • Explain the principles of ultrasound imaging : ultrasounds, transducers, image formation and image quality, Doppler imaging,' (axe 1.1) Part 3 (imaging modalities using ionizing radiation) : • List the different imaging modalities described in the course (radiography, computerized tomography, scintigraphy, SPECT, and PET) and explain their underlying principle (mainly from the physics point of view), mention their applications, advantages and limitations. (axis 1.1) • Compare the performances of the different modalities together with the quality of the images (resolution, noise, contrast). (axis 1.2) • Discuss the specificity of each technique and the complementarity of the different modalities. (axis 2.3) b. Transversal learning outcomes **Upon completion of the course, the student will be able to :**

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- Meet the objectives of a course given in English (understanding of the magistral lecture and of the supporting material). (axes 5.2 et 5.4)
- Work in groups of two on small projects (challenges), namely : be able to share and distribute the workload, understand and describe the work of the other student, write a joint report. (axes 4.1, 4.2 et 4.4)

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<tr><td>Evaluation methods</td><td>

<u>Evaluation of the exercises (challenges only)</u>

Each challenge report will be given a note. The global note for all challenges affects the final evaluation (see below). The introductory exercises that preceed the challenges will be evaluated in a formative way with no impact on the final evaluation. The submission of all challenge reports is mandatory to be admitted to the oral examination for part 1 of the course.

<u>Evaluation of the learning outcomes</u>

The students will be evaluated individually and orally on the basis of the contents and learning outcomes mentioned above. The oral examination will address :

Part 1 (10 points out of 20, image processing) : the student must answer two questions dealing with the methods and algorithms used in the challenges (see below). Starting from a simple problem (which can be solved with a pen and paper), the student should be able to justify his choices. On 10 points, one half results from the evaluation of the challenge reports, the other half corresponding to the two questions.

Part 2 (5 points out of 20, IRM and ultrasound imaging) : the student must answer two questions (oral examination with written preparation)

Part 3 (5 pointsout of 20, imaging modalities using ionizing radiation) : the student must answer two questions (oral examination with written preparation).

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<tr><td>Teaching methods</td><td>

The course consists of 13 lectures in English, three sessions of exercises (mostly reminders or introductory exercises), and three small projects (challenges). These challenges are based on the three different parts of lectures. For each challenge, groups of two students must submit a report. These reports are evaluated. During a debriefing session, the most commonly encountered issues will be presented and discussed between the teacher and the students. A visit of medical imaging facilities in Saint-Luc University Hospital (Brussels) completes the program. All activities can switch to comodal or distancial depending on sanitary conditions.

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<tr><td>Content</td><td>

The course is divided in three parts :

Part 1 : digital image processing (definition and properties of an image, histogram, spectrum, segmentation, edge detection, filtering, mathematical morphology, registration)

Part 2 : magnetic resonance imaging and ultrasound imaging (linear systems : convolution, point spread function, Fourier transform, sampling ; image reconstruction : Radon transform, filtered backprojection, algebraic reconstruction)

Part 3 : transmission imaging (radiography and computerized tomography) and emission imaging (scintigraphy, SPECT and PET)

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<tr><td>Inline resources</td><td>

Moodle

https://moodle.uclouvain.be/course/view.php?id=1072

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<tr><td>Bibliography</td><td>

<u>Support de cours :</u>

Partie 1 et 3: transparents.

Parties 2 : transparents et syllabus.

Les documents du cours sont disponibles sur Moodle.

Course material :

Parts 1 and 3: slides.

Part 2: slides and syllabus.

The course documents are available on Moodle.

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<tr><td>Other infos</td><td>The first two sessions of exercise are organized in the computer room</td></tr>
<tr><td>Faculty or entity in charge</td><td>GBIO</td></tr>
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Programmes containing this learning unit (UE)

Program title	Acronym	Credits	Prerequisite	Learning outcomes
Master [120] in Biomedical Engineering	GBIO2M	5		🔍
Master [120] in Statistics: Biostatistics	BSTA2M	5		🔍
Master [120] in Electrical Engineering	ELEC2M	5		🔍
Master [120] in Computer Science and Engineering	INFO2M	5		🔍
Certificat universitaire en physique d'hôpital	RPHY9CE	5		🔍
Master [120] in Computer Science	SINF2M	5		🔍
Master [120] in Mathematical Engineering	MAP2M	5		🔍
Master [120] in Physics [professional focus of Medical Physics : UCLouvain-KULeuven]	PHYS2M	5		🔍
Master [120] in Medical Physics	PHMD2M	5		🔍