
Academic Year of Degree: 2025/26

22130 - Analysis of Biomedical Images

Teaching Guide Information

Academic Course: 2025/26

Academic Center: 337 - Engineering School

Study: 3378 - Bachelor's degree in Biomedical Engineering

Subject: 22130 - Analysis of Biomedical Images

Credits: 5.0

Course: 3

Teaching languages:

Theory: Group 1: English

Practice: Group 101: English

Group 102: English

Seminar: Group 101: English

Teachers: Gema Piella Fenoy

Teaching Period: Second term

Presentation

Biomedical Image Analysis is a compulsory course in the 3rd year of the Biomedical Engineering degree. The course is an introduction to the fundamentals of image processing and analysis of images with special emphasis on its biomedical applications.

The syllabus of the course includes enhancement and restoration techniques, shape analysis and feature extraction, and introduction to segmentation and registration techniques.

The theoretical elements are the basis of the lectures, but an equally relevant part is the implementation of algorithms related to the studied concepts of image processing and analysis. This practical component constitutes a large part of the individual work of students inside and outside the classroom, and it is evaluated in seminars and laboratory classes. Various activities and deliverables in group require students to develop teamwork skills as well as information seeking strategies and oral and written communication skills.

It is highly recommended for students to have a basic knowledge of linear algebra, calculus and numerical methods, signals and systems (in particular, random processes, Fourier transforms, and filters) and biomedical imaging systems. Such prior knowledge is essential for understanding and following the course.

The natural continuation of Biomedical Image Analysis is the optional course Advanced Analysis of Biomedical Images, which delves into the issues of segmentation and quantification, and the use of machine learning for image analysis. Other related (optional) courses: Imaging for Planning and Guidance.

Associated skills | General learning outcomes

Basic

CB2. That the students can apply their knowledge to their work or vocation of a professional form and possess the competences which are usually proved by means of the elaboration and defense of arguments and solving of problems within their study area.

CB3. That the students have the ability of collecting and interpreting relevant data (normally within their study area) to issue judgements which include a reflection about relevant topics of social, scientific, or ethical nature.

CB4. That students can transmit information, ideas, problems and solutions to both specialized and non-specialized audiences.
CB5. That students have developed those learning skills necessary to undertake further studies with a high degree of autonomy.

Transversal

CT1. Work as a team in international and interdisciplinary contexts.

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

CT4. Communicate in academic and professional contexts orally and in writing in English.

Specific

CE1. Solving mathematical problems in engineering and applying knowledge on: linear algebra; differential and integral calculus; numerical methods, numerical algorithms, statistics and optimization.

CE3. Mastering the basic concepts of discrete mathematics, logic, algorithms and computational complexity, and their application to solve engineering problems.

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

CE8. Developing computational methods for the resolution of physical methods both in continuous and discrete formulation.

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

CE10. Designing and implementing computational tools to study biological systems and human physiology with an integrated approach.

Learning outcomes | Specific learning outcomes

RA.CE1.1 Apply knowledge of linear algebra to solve problems that may arise in engineering.

RA.CE1.2 Demonstrate knowledge of differential and integral calculus to solve problems that may arise in engineering.

RA.CE1.3 Use knowledge of numerical methods to solve problems that may arise in engineering.

RA.CE1.4 Demonstrate knowledge of numerical algorithms to solve problems that may arise in engineering.

RA.CE1.5 Use knowledge of statistics to solve problems that may arise in engineering.

RA.CE1.6 Apply knowledge of optimization to solve problems that may arise in engineering.

RA.CE3.1 Apply knowledge of discrete mathematics to solve problems that may arise in engineering.

RA.CE4.6 Compare techniques for image analysis and interpretation.

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

RA.CE8.2 Implement computational methods to solve physical models formulated in a continuous or discrete way.

RA.CE9.1. Develop techniques for computational analysis of signals and multimodal images with applications in diagnosis and monitoring.

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

RA.CE9.3 Compare the various techniques and systems for the acquisition of biomedical signals and images capable of providing structural and / or functional information on the various biological and physiological processes.

RA.CE9.4 Analyze biomedical images using advanced techniques.

RA.CE10.2 Design computational tools to study human physiology.

Contents

Block 1: Fundamentals of digital imaging

- Image processing and related fields
- Image models
- Sampling and quantization
- Interpolation

Block 2: Image enhancement. Intensity transformation and spatial filtering

- Contrast adjustments, histograms, equalization
- Linear filters. Smoothing, sharpening and contours detection. Convolution and correlation.
- Nonlinear filters

Block 3: : Image enhancement. Filtering in the frequency domain.

- Fourier transform. Properties and applications.

- Filtering in the frequency domain
- Multiresolution analysis

Block 4: Image restoration

- Linear degradation models. Deconvolution.
- Noise and noise removal (in the spatial and frequency domain)

Block 5: Geometric transformations

- Basic geometric transformations
- Applications: image registration

Block 6: Mathematical morphology

- Basic morphological operators
- Applications to image processing and analysis

Block 7: Feature extraction

- Point, lines and contour detection
- Thresholding. Otsu's method
- Applications: segmentation

Block 8: Machine learning and image analysis

- Overview of some machine learning concepts
- Examples and applications

Sustainable Development Goals

3 - Good Health and Well-being
9 - Industry, Innovation and Infrastructure

Evaluation and grading system

The assessment elements of the course are included in the following table, which also indicates the weight of each element in the evaluation grade, the conditions required to pass (minimum) and what elements are recoverable (in July).

		JULY?
Final exam (60%)	1 Final individual exam Grade should be ≥ 5	Recoverable
Practical sessions (40%)	60% lab tests + 40% project Average grade should be ≥ 5	Non recoverable

The final individual written exam will be at the end of the quarter (during the examination period). All knowledge (theoretical and practical) acquired in the course will be evaluated. This exam has a weight of 60% in the final grade and it is recoverable in July. It is necessary to have **at least a score of 5 in the final exam** to be able to pass the course.

Participation in the practical sessions/labs is a prerequisite for passing the course. It is necessary to have **at least a score of 5 in the average grade of practical sessions** in order to pass the course. Practices are carried out in teams of 2 persons (exceptionally 1 or 3). They account for 40% of the final grade. They will be evaluated through individual tests (practical or theoretical questions about the lab sessions) and through the development and presentation of the final project. The practices are not recoverable in July. The code will be graded according to the following criteria:

Grade	Criteria
0	Absent or very poor job with serious errors, or text / code copied (from Internet or from another source)
0-4.9	The code does not work as expected and / or there are some major errors in the report, some basic concepts are misunderstood.
5-7.5	The code works as expected but there are some errors in the report, some misunderstood concepts.
7.5-9	The code is well done and the report is well written and without errors
9-10	The code is well done and the report is well written and without error: answers have been reasoned and justified. Additionally, the student has done more than was requested in the lab guide (for example, he/she has implemented some additional filter or has performed a more detailed analysis).

Eventually, an oral defense of some of the contents studied in class can be required. The final grade will be computed according to a weighted average of the different evaluation elements (see Table) as long as the final exam's grade is equal or above 5. Otherwise the final grade will be the final exam's grade.

Very important: there will be a strict policy of zero tolerance towards cheating and plagiarism. Upon suspicion, the ETIC board of directors will be informed to take the corresponding actions.