UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Imaging

2627-1-H4104D053-H4104D05303

Aims

The aim of the course is to provide students with the theoretical and practical knowledge necessary to **understand and analyze the characteristics of medical images**. In particular, the course aims to:

- provide basic knowledge related to medical image generation technologies and their working principles;
- provide an understanding of the characteristics and main formats of digital images, with particular reference to the DICOM format;
- illustrate the main techniques for image processing, aimed at enhancing image features;
- present some tools for visualization and pre-processing of medical images;
- introduce the fundamentals of machine learning and deep learning applied to image analysis, with a focus on the segmentation and classification of biological structures;
- introduce the concept of image rendering and present its main application contexts.

Expected Learning Outcomes (Dublin Descriptors)
1. Knowledge and understanding
At the end of the course, students will have acquired knowledge regarding:

- The physical and operating principles of the main medical imaging modalities (X-ray, CT, MRI, and ultrasound).
- The characteristics, mathematical properties, and standard formats of digital medical images (with a focus on the DICOM standard).
- The theoretical principles of visual perception and basic image processing algorithms.
- The foundational concepts of Artificial Intelligence (Machine Learning and Deep Learning) applied to medical image segmentation and classification.

2. Applying knowledge and understanding
Students will be able to:

- Utilize open-source software applications to visualize, manipulate, and performing basic pre-processing of

digital medical images.
- Correctly interpret the characteristics of a medical image.
- Formulate basic quantitative solutions for simple medical image processing and 3D visualization/rendering problems.

3. Making judgements
Students will develop the ability to:

- Critically evaluate the quality of a medical image and identify potential artifacts or limitations related to the image quality and acquisition technology.
- Independently choose the most suitable group/class of image processing techniques or visualization method based on the clinical or research goal.
- Critically assess the reliability and limitations of artificial intelligence tools when applied to anatomical segmentation and classification.

4. Communication skills
Students will be able to:

- Communicate clearly and with appropriate technical terminology the characteristics, formats, and processing pipelines of medical images.
- Discuss imaging data findings and technical specifications effectively within interdisciplinary teams.

5. Learning skills
Students will acquire the skills to:

- Autonomously explore and learn to use open source software tools in the field of digital medical imaging.
- Keep up to date with technological advancements in medical image analysis and AI applications by consulting scientific literature and technical manuals.

Contents

The course introduces principles of visual perception, the working principles of medical imaging systems, the characteristics of medical images, image processing techniques and software use, with an overview of artificial intelligence, rendering, and visualization.

Detailed program

- Eye, visual system, perception of shapes and colors, image.
- Characteristics (brightness, optical density, contrast, resolution) and standards (JPG, … DICOM) of digital medical images.
- Operating principles of medical image generation devices (X-ray, computed tomography, magnetic resonance imaging, and ultrasound instruments).
- Image processing: main operations for improving image quality.
- Use of software applications for solving practical problems and for 3D representation.
- Fundamentals of artificial intelligence techniques applied to medical images: segmentation and classification.
- Rendering and visualization.

Prerequisites

Basic knowledge in mathematics, algebra and physics.

Teaching form

Lessons in class and asynchronously online, demonstrations by the use of digital image processing software and quantitative solution of simple problems.
In particular, the 36 teaching hours will be allocated as follows: 32 hours delivered in person and 4 hours (equivalent to 10% of the total teaching hours) delivered asynchronously online.

Textbook and teaching resource

- Suggested textbook: The Image Processing Handbook, Seventh Edition, John C. Russ,? F. Brent Neal, CRC Press ISBN-10: 149874026X.
- Open-source software for DICOM image visualization and processing.
- Course slides and any additional teaching materials will be shared with students via the e-learning platform.

Semester

First semester

Assessment method

The assessment consists of a written exam designed to evaluate both theoretical knowledge and practical skills.
The exam includes open questions structured into two main components:

- *Theoretical Knowledge*: questions aimed at verifying the understanding of the physical principles of imaging modalities, digital standards, fundamental image processing algorithms, and rendering techniques.
- *Practical and problem-solving skills*: case studies aimed at assessing the student's ability to interpret medical images, identify artifacts, and select or evaluate appropriate processing strategies discussed during the course.

Office hours

The course professor's office hours and contact details can be found at the following link in the "Ricevimento" panel:
https://unibg.unifind.cineca.it/individual?uri=http%3A%2F%2Firises.unibg.it%2Fresource%2Fperson%2F160451

Sustainable Development Goals

GOOD HEALTH AND WELL-BEING | QUALITY EDUCATION | GENDER EQUALITY