ACQUISITION, RECONSTRUCTION AND MEDICAL IMAGING

1. SYLLABUS INFORMATION

1.1. Course title
Acquisition, Reconstruction and Medical Imaging

1.2. University
University of Bordeaux

1.3. Semester
2nd Year, 1st semester

2. COURSE DETAILS

2.1. Course nature
Compulsory

2.2. ECTS Credit allotment
6

2.3. Recommendations
This course requires previous knowledge in several aspects: image processing, Python and MatLab programming, linear/matrix algebra, basics about probability.

2.4. Faculty data
Prof. Pascal Desbarats – University of Bordeaux / LaBRI
Prof. Jean-François Giovannelli – University of Bordeaux / IMS

3. COMPETENCES AND LEARNING OUTCOMES

3.1. Course objectives
The goal of this course is to understand the principles of 2D/3D imaging, from physics and acquisition to image reconstruction, analysis, and visualization. It gives an overview of several imaging modalities and it is exemplified through a variety of application fields (medical, astrophysical, remote-sensing,...). The students will learn how to implement a processing chain from the physical acquisition of data to the visualisation and analysis of images. They will also understand the specificities of stereoscopic, volumetric and surfacic 3D images.

The goal is also to learn to design regularised methods and implement stable and guaranteed algorithms for imaging, inverse problems and deconvolution in particular. Familiarize with statistical learning approaches, particularly those based on diffusion models. Develop knowledge of the context of imaging for industrial control, physics, astronomy, medicine, etc. On completion, students are to be able to develop innovative solutions in these domains, using traditional and modern AI approaches in a sustainable and controlled manner. They are able to use these standard tools but have sufficiently in-depth knowledge to be able to upgrade these tools further.

3.2. Course contents

1. Volumetric Imaging (voxel images). From Radiography to CT scan-MRI and its different modalities, Nuclear medicine imaging (SPECT, PET).

2. Surface and Depth Imaging (point clouds, meshes, depth maps). Laser scan, Stereo and depth camera, Mono camera.

3. Overview of imaging modalities (optical systems, tomography, Fourier synthesis,...) and exemplification through a variety of fields (medicine, astrophysics, remote-sensing, computer vision,...).

4. Theoretical and practical tools for image resolution enhancement, deconvolution and inverse problems. The course relies on variational techniques and numerical optimization (including robust penalties and constraints), Bayesian strategies and sampling,... and the most recent machine learning standpoint especially those founded on diffusion models.

3.3. Course bibliography

- N. Barrie Smith and A. Smith (2010), "Introduction to Medical Imaging: Physics, Engineering and Clinical Applications", Cambridge University Press.
- T. Luhmann, S. Robson, S. Kyle, J. Boehm. (2014), "Close-Range Photogrammetry and 3D Imaging", De Gruyter Editions.
- J.-F. Giovannelli, and J. Idier (2015), "Regularization and Bayesian Methods for Inverse Problems in Signal and Image Processing", ISTE Ltd and John Wiley & Sons Inc.
- M. T. McCann and M. Unser (2019), "Biomedical Image Reconstruction: From the Foundations to Deep Neural Networks", Foundations and Trends® in Signal Processing: Vol. 13: No. 3, pp 283-359.
- Stanley Chan (2024), "Tutorial on Diffusion Models for Imaging and Vision", Foundations and Trends in Computer Graphics and Vision: Vol. 16, No. 4, pp 322–471.

4. TEACHING-AND-LEARNING METHODOLOGIES AND STUDENT WORKLOAD

4.1. Contact hours

	Hours
Classroom instruction (minimum 33%)	48
Independent study time	48

4.2. List of training activities

Activity	Hours
Lectures	24
Computer lab	24
Assessment activities	

5. EVALUATION PROCEDURES AND WEIGHT OF COMPONENTS IN THE FINAL GRADE

Evaluatory activity	%
Final exam	50
Programming assignments/classroom activities	50