Introduction to biomedical image

Academic Year: (2023 / 2024) **Review date: 17-05-2023**

Department assigned to the subject: Bioengineering Department

Coordinating teacher: RIPOLL LORENZO, JORGE

Type: Electives ECTS Credits : 6.0

Year : 4 Semester :

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

It is strongly advised to have completed Physics I and II. It is also very beneficial, but not compulsory, if Differential equations and Numerical Methods in Biomedicine have been completed. No prior knowledge on optics or image formation is required.

OBJECTIVES

The student that successfully finishes this course will have an advanced understanding of image formation and how contrast, resolution and signal to noise ratio affects image quality, the quantitative information it may deliver and its interpretation. These main aspects of imaging (resolution, contrast, and quantification) will be studied within different imaging modalities, either currently used in medical imaging or under development for their future implementation in the clinic. Once this course has been completed the student should be able to discuss and defend which imaging modalities are more appropriate for a specific instance, and why. In particular, it is expected that each student will have a good understanding of what each imaging approach can deliver in terms of sensitivity, resolution and quantitation; within the skills acquired the student should be able to second an imaging or combined set of imaging approaches for current medical imaging scenarios.

DESCRIPTION OF CONTENTS: PROGRAMME

1. Physical Principles of Image Acquisition and Formation. Sensors.
2. Resolution, Contrast and Noise in Image Formation
3. Current Laser Technology and Biomedical Applications
4. Interaction of Light with Cells and Tissues
5. Principles of Optical Microscopy and Spectroscopy
6. Functional Imaging: Ultrasound and Optics combined
7. Nonlinear Optical Imaging
8. Deep tissue imaging
9. Other Imaging Modalities and Imaging Displays

Transversal content: The structure of a business plan, the canvas and SWOT matrix. The structure of a research proposal. Matlab/Octave programming.

LEARNING ACTIVITIES AND METHODOLOGY

LECTURES:
Due to the large amount of topics covered and their multidisciplinary nature, it is strongly advised that the student reads the recommended chapters or sections before the class. These will be provided at least one week in advance.
1) Lectures: During the lectures the proposed topic will be presented, always encouraging discussion.
2) Discussion Sessions: When the topic allows it, discussion sessions will be held to solve particular problems related to the current topic with the main idea of understanding the system and developing different strategies to solve it, underlining the fact that there are almost always different approaches to the same problem.
3) Biomedical Project. In individual groups the students will develop the project for a technology based company for biomedical applications which makes use of biomedical imaging approaches.
4) Oral Presentations: At least once during the course each student will have the chance to do a short oral presentation on a topic related to the Biomedical Project chosen. These oral presentations will have a duration of approx. 10-20 minutes per student.

HOMEWORK:

Recommended research papers will have to be studied prior to each other's student oral presentation. Data analysis and representation for the laboratory sessions will need good skills in matlab/octave.

LABORATORY SESSIONS:
Each experiment will be performed in individual groups. During these sessions simple experiments will be done to understand the basics of light transport in tissues, and how scattering affects image quality in microscopy, with emphasis on 3D microscopy. The main goal during these sessions is to understand the physics behind the experiment and how it relates to the theory we presented during the lectures, to obtain rigorous experimental data, and to have a clear understanding on the basis of image formation. Different software for 3D data analysis will be used, mostly Matlab (or Octave) and ImageJ.

ASSESSMENT SYSTEM

The final grade will be a combination of Laboratory Sessions (20%), Continuous Assessment (40%) (note that 20%+40%=60%) and Final Exam (40%), in particular:

1) LABORATORY SESSIONS (20%): Grades will be given for the effort, not for how accurate the final result is. What is important is demonstrate that a clear understanding of the technique used was achieved. The grade will be shared in case the experiment was done by more than one student.

2) CONTINUOUS ASSESSMENT (40%): Within this category we will have grades for one mid-term exam (20%) and the Biomedical Project (20%) which includes an oral presentation of each student.

3) FINAL EXAM (40%): The final exam will be a written exam and take place at the end of the course, being common for all students. It will include problems and multiple choice questions to be solved covering the main topics of the course. The MINIMUM SCORE in order for the result to count in the overall grade of the course is 4.0 over 10, irrespective of the grades obtained in the continuous evaluation.

EXTRAORDINARY EXAM
The continuous evaluation grade is maintained for the extraordinary exam. The final grade for the extraordinary exam will be the maximum between a 100% of the extraordinary exam and 60% continuous evaluation + 40% exam.

EXCHANGE STUDENTS ABROAD
Students following the course from abroad will thus miss all activities which require physical presence (experiments, biomedical project and oral presentation). In this case they will only have access to 60% of the grade after the final exam (60% final exam, and 20% mid term done via internet). In order to access 100% of the grade they will have to take the extraordinary exam at the end of the school year.

DISHONEST CONDUCT
Copying and otherwise dishonest conduct is not allowed in any the activities of this course and will be punished with severities which may range between a zero in that particular activity and a disciplinary hearing by the council of the university.

% end-of-term-examination:	40
% of continuous assessment (assigments, laboratory, practicals…):	60

BASIC BIBLIOGRAPHY

- David Boas, Constantinos Pitris and Nimmi Ramanujam Handbook of Biomedical Optics, CRC press, 2011

- Markus Rudin Molecular Imaging: Principles And Applications In Biomedical Research, Imperial College Press, 2005

ADDITIONAL BIBLIOGRAPHY

- Douglas B. Murphy and Michael W. Davidson Fundamentals of Light Microscopy and Electronic Imaging, Wiley-Blackwell, 2012
- Paras N. Prasad Introduction to Biophotonics, Wiley, 2003