Advanced topics in medical image

Academic Year: (2023 / 2024) **Review date: 11-01-2024**

Department assigned to the subject: Bioengineering Department

Coordinating teacher: PASCAU GONZALEZ GARZON, JAVIER

Type: Electives ECTS Credits : 6.0

Year : 4 Semester :

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

Signals and Systems
Medical Image processing

SKILLS AND LEARNING OUTCOMES

RA3: Be able to carry out conceptual designs for bioengineering applications according to their level of knowledge and understanding, working in a team. Design encompasses devices, processes, protocols, strategies, objects and specifications broader than strictly technical, including social awareness, health and safety, environmental and commercial considerations.
RA4: Be able to use appropriate methods to carry out studies and solve problems in the biomedical field, commensurate with their level of knowledge. Research involves conducting literature searches, designing and carrying out experimental practices, interpreting data, selecting the best approach and communicating knowledge, ideas and solutions within their field of study. May require consultation of databases, safety standards and procedures.
RA5: Acquire intermediate/advanced knowledge of engineering and biomedical sciences and demonstrate an understanding of the theoretical and practical aspects and methodology of work in their field of study.
CB1: Students have demonstrated possession and understanding of knowledge in an area of study that builds on the foundation of general secondary education, and is usually at a level that, while relying on advanced textbooks, also includes some aspects that involve knowledge from the cutting edge of their field of study.
CB2: Students are able to apply their knowledge to their work or vocation in a professional manner and possess the competences usually demonstrated through the development and defence of arguments and problem solving within their field of study.
CB3: Students have the ability to gather and interpret relevant data (usually within their field of study) in order to make judgements which include reflection on relevant social, scientific or ethical issues.
CB4: Students should be able to communicate information, ideas, problems and solutions to both specialist and non-specialist audiences.
CB5: Students will have developed the learning skills necessary to undertake further study with a high degree of autonomy.
CG2: Ability to design, draft and develop scientific-technical projects in the field of biomedical engineering.
CG4: Ability to solve problems with initiative, decision-making, creativity, and to communicate and transmit knowledge, skills and abilities, understanding the ethical, social and professional responsibility of the biomedical engineer's activity. Capacity for leadership, innovation and entrepreneurial spirit.
CG6: Knowledge of current standards, regulations and legislation and ability to apply them to bioengineering projects. Bioethics applied to biomedical engineering.
CG7: Drafting, representing and interpreting scientific-technical documentation.
CG8: Ability to solve mathematical, physical, chemical and biochemical problems that may arise in biomedical engineering.
CG12: Ability to solve mathematically formulated problems applied to biology, physics and chemistry, using numerical algorithms and computational techniques.
CG19: Ability to apply different image analysis and processing techniques, as well as artificial vision to the resolution of problems of biological and medical interest. In particular, the problems of diagnosis by Medical Imaging stand out.
CG21: Ability to analyse complex and multidisciplinary problems from the global point of view of Biomedical Instrumentation.
CT1: Ability to communicate knowledge orally and in writing to both specialised and non-specialised audiences.
CT2: Ability to establish good interpersonal communication and to work in multidisciplinary and

international teams.
CT3: Ability to organise and plan their work, making the right decisions based on the information available, gathering and interpreting relevant data in order to make judgements within their area of study.

OBJECTIVES

The goal of this course is to provide the students with a complete understanding of advanced techniques for image processing in the field of medical imaging. Using the concepts already learn in Image Processing, the student will be able to process images with techniques such as automatic segmentation, machine learning methods or pattern recognition.
After completion of the course, the student should be able to select the proper approach to process medical image data depending on the modality and the desired output, to write the necessary program and to evaluate the results.

DESCRIPTION OF CONTENTS: PROGRAMME

1. Review of basic concepts in image processing
2. Information Systems in the Medical Environment: DICOM, RIS and PACS.
3. 3D and 4D image visualization. Software tools for medical image analysis.
4. Wavelets and multi-resolution processing.
5. Advanced Segmentation I: detecting lines and shapes with Hough transform and active contours.
6. Advanced Segmentation II:Adaptive filters.
7. Advanced Segmentation III: Morphological processing.
8. Image registration.
9. Image processing for feature extraction.
10. Dimensionality reduction and machine learning methods.
11. Beyond classical methods: deep learning and convolutional networks.

LEARNING ACTIVITIES AND METHODOLOGY

Teaching methodology will be mainly based on lectures, seminars and practical sessions.
Students are required to read assigned documentation before lectures and seminars. Lectures will be used by the teachers to stress and clarify some difficult or interesting points from the corresponding lesson, previously prepared by the student. Seminars will be mainly dedicated to interactive discussion with the students, present and evaluate homework.

Grading will be based on continuous evaluation (including short-exams, homework, group essays, practical sessions, and student participation in class and Aula Global) and a final exam covering the whole subject. Help sessions and tutorial classes will be held prior to the final exam.

Attendance to lectures, practical sessions, short-exams or submission of possible homework is not compulsory. However, failure to attend any exam or submit the exercises before the deadline will result in a mark of 0 in the corresponding continuous evaluation block.
The practical sessions may consist on laboratory work or visits to research or clinical centers. A laboratory report will be required for each of them. Homework exercises will also be a very important contribution, since they will imply solving a specific problem, proposing an algorithm and implement it using computer tools. The attendance to 80% of practical sessions is mandatory. Failure to hand in the laboratory reports on time or unjustified lack of attendance will result in 0 marking for that continuous evaluation block.
Some activities could reduce the total weight of the final exam, such as projects or open essays to be presented at the exam.

ASSESSMENT SYSTEM

Continuous evaluation
It accounts for up to 50% of the final score of the subject, and includes three components:
1) Practical sessions and homework exercises: They will be assessed through quizzes or exercises to be solved in groups or individually or a laboratory notebook or report in that will be handed in at the end of each practical session. Attendance to at least 80% of the practical sessions is mandatory; otherwise the score will be 0 in this item.
2) Final project
3) Student participation: It includes contribution to seminars, forum in Aula Global, attitude, or other activities.

Final exam
The final exam will cover the whole subject and will account 50 % of the final score. The minimum score in the final exam to pass the subject is 4.0 over 10, notwithstanding the mark obtained in continuous

evaluation. This exam could include an open topic that the student will choose on his own with a weight of 30% of the total grade for this exam.

Extraordinary exams
The mark for students attending any extraordinary examination will be the maximum between:
a) 100% extraordinary exam mark, or
b) 50% extraordinary exam mark and 50% continuous evaluation if it is available in the same course.

Academic conduct
All exams will be closed-book, closed-notes, no PC or mobile phone, or anything else other than a writing implement and the exam itself. Plagiarism, cheating or other acts of academic dishonesty will not be tolerated. Any infractions whatsoever will result in a failing grade.

% end-of-term-examination:	50
% of continuous assessment (assigments, laboratory, practicals…):	50

BASIC BIBLIOGRAPHY

- Javier Pascau; José María Mateos Pérez Image Processing with ImageJ, Packt Publishing, 2013
- G. Dougherty Digital Image Processing for Medical Applications, Cambridge Univ Press, 2009. ISBN-13: 978-0521860857
- Mark A. Haidekker Advanced Biomedical Image Analysis, John Willey and Sons, 2011. ISBN 978-0-470-62458-6
- R. C. Gonzalez, R. E. Woods. Digital Image Processing, Pearson Education. 3rd edition. , 2008. ISBN-13: 978-0135052679

ADDITIONAL BIBLIOGRAPHY

- Isaac Bankman Handbook of Medical Image Processing and Analysis, Academic Press Inc. 2nd Ed., 2008. ISBN-13: 978-0123739049
- Jiri Jan Medical Image Processing, Reconstruction, and Restoration: Concepts and Methods, Taylor & Francis Ltd, 2005. ISBN-13: 978-0824758493
- Terry S. Yoo. Insight into Images: Principles and Practice for Segmentation, Registration, and Image Analysis, A K Peters, 2004. ISBN-13: 978-1568812175

BASIC ELECTRONIC RESOURCES

- . ImageJ: Biomedical Image Analysis Software: https://imagej.net/ij/index.html
- . 3DSlicer Image Computing Platform: https://www.slicer.org/