Carleton University
Department of Systems and Computer Engineering

BIOM 5203 / SYSC 5301 – Fall 2016
Advanced Topics in Biomedical Image Processing

Instructor

Elodie Roullot, PhD

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Office: ME 4490.

Office hours: TBA during first class.

Lectures

Mondays 10:00 am – 11:30 am

Wednesdays 10:00 am – 11:30 am

Classroom: TBA

Prerequisites

- Undergraduate course in Digital Image Processing, Computer Vision, Digital Signal Processing, or equivalent.
- OCIECE/OCIBME graduate student, or permission of the instructor.
- Basic programming skills, preferably with Matlab.

Short description

The course covers state-of-the-art image processing methods (enhancement, registration, segmentation, rendering…) together with their applications to medical images (e.g. brain tumor detection, cardiac functional imaging, and image-guided surgery). It is intended for graduate students from various backgrounds who wish to acquire skills and expertise in image processing applied to medical imaging.

Textbook & References

There is no specific textbook. Lecture slides will be provided online by instructor before or after each lecture. References will also be provided for studying and further reading.

Webpage

All content will be posted on cuLearn. Students are required to check cuLearn on a regular basis for course updates.

University of Ottawa students need to complete a form and submit it to the FGPA (Faculty of Graduate and Postdoctoral Affairs) to gain access to cuLearn for the term.

Grading scheme

The final grade will be assigned as follows:

- Quizzes: 50%
- Assignments & Project: 50%

Quizzes – Assignments - Project

There will be several quizzes that will be announced with one week notice and take place during the classes. Unless otherwise indicated, the quizzes will be closed-book. The chapters covered by each quiz will be indicated by the instructor.

There will be several assignments that will be posted on cuLearn. Assignments will include programming and testing methods mentioned in class, preparing a presentation on a subject related to the course and delivering it in front of the class, studying a research paper, etc.

Each student will also undertake a project that consists in studying and applying one (possibly more for comparison) advanced image processing method to a set of medical images available on public repositories. The main deliverable for the project will take the form of a short scientific paper. The students might also be required to present their project in front of the class and/or make a demonstration of their project.

Attendance and Deadlines

Students are expected to attend all lectures. If a student is absent from a lecture, it is up to the student to obtain missed lecture material from colleagues in the course.

Students who miss a deadline due to illness must provide a valid medical certificate to the instructor not later than 48 hours after returning to campus. The certificate must clearly state the name of the doctor with contact information, the degree of incapacitation, the time & date of onset, the time & date that you were seen, and the expected recovery date. Once the certificate has been verified, alternate arrangements will be negotiated with the instructor.

Academic Accommodation

You may need **special arrangements** to meet your academic obligations during the term because of **disability**, **pregnancy** or **religious obligations**. Please write to the instructor with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist.

The Paul Menton Centre for Students with Disabilities (PMC) provides services to students with Learning Disabilities (LD), psychiatric/mental health disabilities, Attention Deficit Hyperactivity Disorder (ADHD), Autism Spectrum Disorders (ASD), chronic medical conditions, and impairments in mobility, hearing, and vision. If you have a disability requiring academic accommodations in this course, please contact PMC at 613-520-6608 or mailto:pmc@carleton.ca for a formal evaluation. If you are already registered with the PMC, contact your PMC coordinator to send me your Letter of Accommodation at the beginning of the term, and no later than two weeks

before the first in-class scheduled test or exam requiring accommodation (if applicable). Requests made within two weeks will be reviewed on a case-by-case basis. After requesting accommodation from PMC, meet with me to ensure accommodation arrangements are made. Please consult the PMC website (http://www.carleton.ca/pmc) for the deadline to request accommodations for the formally-scheduled exam (if applicable).

Plagiarism and Cheating

Plagiarism and cheating at the graduate level are viewed as being particularly serious and the sanctions imposed are accordingly severe. Students are expected to familiarize themselves with and follow the Carleton University Student Academic Integrity Policy (See http://carleton.ca/senate/wp-content/uploads/Academic-Integrity-Policy1.pdf). The Policy is strictly enforced and is binding on all students. Plagiarism and cheating – presenting another's ideas, arguments, words or images as your own, using unauthorized material, misrepresentation, fabricating or misrepresenting research data, unauthorized co-operation or collaboration or completing work for another student – weaken the quality of the graduate degree. Academic dishonesty in any form will not be tolerated. Students who infringe the Policy may be subject to one of several penalties including: expulsion; suspension from all studies at Carleton; suspension from full-time studies; and/or a reprimand; a refusal of permission to continue or to register in a specific degree program; academic probation; or a grade of Failure in the course.

Health and Safety

Every student should have a copy of the Health and Safety Manual. An electronic version of the manual can be found at: http://www.sce.carleton.ca/courses/health-and-safety.pdf.

Agenda (subject to change)

Chapter 0	**Introduction** ▪ Medical Image Processing: a challenging, active field ▪ Digital Images: Definitions and Representations	1:30
Chapter 1	**Managing Digital Medical Images: Communication and Storage** ▪ The Digital Revolution in Medical Imaging ▪ The DICOM Standard ▪ Picture Archiving and Communication Systems ▪ Review of useful databases and software	1:30
Chapter 2	**Biomedical Imaging Modalities – A Review** ▪ Computed Tomography ▪ Nuclear Medicine (PET & SPECT) ▪ Ultrasound Imaging ▪ Magnetic Resonance Imaging ▪ Optical Microscopic Imaging	4:30
Chapter 3	**Medical Image Enhancement** ▪ Medical Imaging Quality Issues ▪ Image Quality Metrics ▪ Basic Image Enhancement Methods ▪ Medical Image Denoising Methods ▪ Modality Specific Enhancement Methods	3:00
Chapter 4	**Medical Image Registration: Methods** ▪ Search Space and Transformation Models ▪ Feature Space and Similarity Metrics ▪ Search Strategy and Optimization Methods ▪ Image Fusion	3:00
Chapter 5	**Medical Image Registration: Applications** ▪ Case study: Registration for Image-guided Cardiac Interventions ▪ Case study: Automatic Deformable MR-US Registration for Image-Guided Neurosurgery	1:30
Chapter 6	**Medical Image Segmentation – Fundamentals (review)** ▪ Region-based Segmentation: Low level methods ▪ Contour-based Segmentation: Low level methods ▪ Low level Post-Processing Techniques ▪ Pattern Recognition Methods	4:30
Chapter 7	**Medical Image Segmentation Methods: Deformable Models** ▪ Parametric Deformable Models (snakes, balloon forces, Gradient Vector Flow…) ▪ Geometric Deformable Models (Curve evolution theory, Level Set methods…)	4:30
Chapter 8	**Medical Image Segmentation Methods: Graph theory and set theory based methods** ▪ Medical Image Segmentation based on Set Theory (Watersheds…) ▪ Medical Image Segmentation based on Graph Theory (Graph-cuts…) ▪ Recent Advances in graph-based and watershed segmentation (Image Foresting Transform, Watershed Cuts…)	4:30
Chapter 9	**Medical Image Segmentation: Applications** (Presentations by students), e.g. ▪ Case study: Brain Tumor Segmentation ▪ Case Study: Cardiac Segmentation ▪ Case study: Lung Nodules Segmentation	4:30
Chapter 10	**Algorithm Evaluation in Medical Image Processing** ▪ Evaluation Metrics ▪ Ground Truth ▪ Evaluation without a Gold Standard ▪ Evaluation Campaigns and Databases	3:00
Chapter 11	**Medical Image Compression** ▪ Lossless compression methods (RLE, Huffman, LZW…) ▪ Lossy compression methods (JPEG baseline, JPEG-LS, JPEG-2000…)	1:30
Chapter 12	**Surface and Volume Rendering of Medical Images** ▪ 2D visualization (Multiplanar Reformatting, Maximum Intensity Projection) ▪ Surface Rendering (the marching cube algorithm…) ▪ Volume Rendering (sampling, classification, shading, compositing…)	1:30