Toronto Metropolitan University

Department of Electrical, Computer, & Biomedical Engineering
Faculty of Engineering & Architectural Science

Course Outline (W2024)

BME872: Biomedical Image Analysis

Instructor(s)	Alice Rueda [Coordinator] Office: EPH 417 Phone: TBA Email: arueda@torontomu.ca Office Hours: Monday 6:00 PM - 7:00 PM
Calendar Description	Introduces the fundamental principles of medical image analysis and visualization. Focuses on the processing and analysis of ultrasound, MR, and X-ray images for the purpose of quantification and visualization to increase the usefulness of modern medical image data. Includes image perception and enhancement, 2-D Fourier transform, spatial filters, segmentation, and pattern recognition.
Prerequisites	BME 229 and BME 772
Antirequisites	None
Corerequisites	None
Compulsory Text(s):	1. R.C. Gonzalez & R.E. Woods, Digital Image Processing, 4th Edition, Pearson, 2018.
Reference Text(s):	1. Medical Image Analysis, second edition, by Atam Dhawan, WILEYISBN: 978-0-470-62205-6. 2. Medical Imaging, Signals and Systems, by J. Prince and J. LinksISBN: 0-13-065353-5.
Learning Objectives (Indicators)	At the end of this course, the successful student will be able to: 1. Students will learn how to formulate an image analysis algorithm from first principles (i.e. block diagrams, mathematics) and learn how to implement, debug and test functionality in Matlab. They will learn how to optimize algorithms for medical imaging. (**1d**), (**1c**), (**4a**), (**4b**), (**5a**) 2. Students will learn to treat digital images as 2D mathematical functions, and to use mathematics to manipulate digital images. Some mathematical methods investigated include convolution, Fourier analysis, filtering, histogram analysis, image enhancement, linear and non-linear systems analysis, and more. (**1b**) 3. Students will learn about sources of noise in medical images (i.e. acquisition noise, low contrast), and how to reduce their impact through denoising and enhancement. (**2a**) 4. Students will learn how to design and implement automated medical analysis algorithms on clinical imaging data using Matlab. They will also learn how to measure success of algorithms, and how to improve designs. (**3a**), (**3b**), (**5b**) 5. Students will perform research on an image analysis algorithm that has practical utility in hospitals. They will identify applications of their technology. (**8b**) 6. Students will learn how to manage their course project. Students will understand the important aspects of the project management, such as time-line, progress report, final delivery of the product, and the deadlines. Since the project works with medical images, the

	students will also be expected to understand the impact of their designs on healthcare. (**11b**) **NOTE:***Numbers in parentheses refer to the graduate attributes required by the Canadian Engineering Accreditation Board (CEAB).*
Course Organization	3.0 hours of lecture per week for 13 weeks 1.0 hours of lab per week for 12 weeks 1.0 hours of tutorial per week for 12 weeks
Teaching Assistants	TBA
Course Evaluation	<table><tr><th colspan="2">Theory</th></tr><tr><td>Midterm Exam</td><td>25 %</td></tr><tr><td>Final Exam</td><td>45 %</td></tr><tr><th colspan="2">Laboratory</th></tr><tr><td>Lab1/Lab2/Lab3</td><td>20 %</td></tr><tr><td>Project</td><td>10 %</td></tr><tr><td>TOTAL:</td><td>100 %</td></tr></table> **Note:** In order for a student to pass a course, a minimum overall course mark of 50% must be obtained. In addition, for courses that have both **"Theory and Laboratory"** components, the student must pass the Laboratory and Theory portions separately by achieving a minimum of 50% in the combined Laboratory components and 50% in the combined Theory components. Please refer to the **"Course Evaluation"** section above for details on the Theory and Laboratory components (if applicable).
Examinations	Midterm exam covers all material covered in class up until the examination. Midterm is scheduled for week 7. The final exam will cover all course material.
Other Evaluation Information	Laboratory: All labs require final write-ups and submission of working code to generate your results. Requested analysis, images and information that will be assessed are included in the lab description. During lab times, the TA will ask you to demo your code, and ask questions about its operation and the results. Labs will be demonstrated to the TA during the last week of the lab and lab reports will be due that same week. Images and experimental details will be given on the course website. You may work in partners for the labs (two maximum). The labs will consist of theoretical and practical parts and will require the use of Matlab. Project: The project details, data and requirements will be uploaded to the course website. There is a four page (conference-style) write up, demo, and presentation that are assessed. During the last weeks in the semester, the TA will ask you to demo your code, and ask questions about its operation and results. You may work in partners (two maximum). The project is design oriented, and will consist of both theoretical and practical components learned from the course, and will require the use of Matlab.
Other Information	Practice problems and their solutions will be provided on the course web page. These assignments will neither be collected nor graded; they are provided only as a study guide. You are strongly recommended to attempt these as well as additional problems without looking at the solutions first.

	Labs/project will be made available on the course web. It is your responsibility to check these and download and submit your work online by the deadlines.

Course Content

Week	Hours	Chapters / Section	Topic, description
1	3	Chapter 1 All Sections	Introduction to Medical Image Analysis
2	3	Chapter 2 All Sections	Digital Image Formation
3-4	4	Chapter 3 Sections 3.1-3.3	Intensity Transforms
4-6	7	Chapter 3 Sections 3.4-3.7	Spatial Filtering
7	2	Midterm	Midterm covering lectures 1-6
8-9	5	Chapter 4	2D Fourier Transform and Sampling
10	3	Chapter 4	Frequency Domain Filtering
11	3	Chapter 5 Sections 5.1-5.3, 5.11	Image Restoration
12	3	Class Notes	Feature Extraction, Segmentation and Classification
13	3		Project Presentations

Laboratory(L)/Tutorials(T)/Activity(A) Schedule

Week	L/T/A	Description
2-4	LAB 1	Medical Image Management, Histograms and Point Operations
5-7	LAB 2	Contrast Adjustment of Mammogram Images
8-10	LAB 3	Vessel Detection in Retinal Images using Edge Detection
2-12	PROJECT	Automated Image Quality Assessment in Medical Images

University Policies & Important Information

Students are reminded that they are required to adhere to all relevant university policies found in their online course shell in D2L and/or on the Senate website

Refer to the Departmental FAQ page for furhter information on common questions.

Important Resources Available at Toronto Metropolitan University

- The Library provides research workshops and individual assistance. If the University is open, there is a Research Help desk on the second floor of the library, or students can use the Library's virtual research help service to speak with a librarian.
- Student Life and Learning Support offers group-based and individual help with writing, math, study skills, and transition support, as well as resources and checklists to support students as online learners.

- You can submit an Academic Consideration Request when an extenuating circumstance has occurred that has significantly impacted your ability to fulfill an academic requirement. You may always visit the Senate website and select the blue radio button on the top right hand side entitled: **Academic Consideration Request (ACR)** to submit this request.

  For Extenuating Circumstances, Policy 167: Academic Consideration allows for a once per semester ACR request without supporting documentation if the absence is less than 3 days in duration and is not for a final exam/final assessment. Absences more than 3 days in duration and those that involve a final exam/final assessment, require documentation. Students must notify their instructor once a request for academic consideration is submitted. See Senate Policy 167: Academic Consideration.

- If a student is requesting accommodation due to a religious, Aboriginal and/or spiritual observance, they must submit their request via the online Academic Consideration Request (ACR) system **within the first two weeks of the class or, for a final examination, within two weeks of the posting of the examination schedule**. If the required absence occurs within the first two weeks of classes, or the dates are not known well in advance as they are linked to other conditions, these requests should be submitted with as much lead time as possible in advance of the required absence.

- If taking a remote course, familiarize yourself with the tools you will need to use for remote learning. The Remote Learning Guide for students includes guides to completing quizzes or exams in D2L Brightspace, with or without Respondus LockDown Browser and Monitor, using D2L Brightspace, joining online meetings or lectures, and collaborating with the Google Suite.
- Information on Copyright for Faculty and students.

Accessibility

- Similar to an accessibility statement, use this section to describe your commitment to making this course accessible to students with disabilities. Improving the accessibility of your course helps minimize the need for accommodation.
- Outline any technologies used in this course and any known accessibility features or barriers (if applicable).
- Describe how a student should contact you if they discover an accessibility barrier with any course materials or technologies.

Academic Accommodation Support

Academic Accommodation Support (AAS) is the university's disability services office. AAS works directly with incoming and returning students looking for help with their academic accommodations. AAS works with any student who requires academic accommodation regardless of program or course load.

- Learn more about Academic Accommodation Support.
- Learn how to register with AAS.

Academic Accommodations (for students with disabilities) and Academic Consideration (for students faced with extenuating circumstances that can include short-term health issues) are governed by two different university policies. Learn more about Academic Accommodations versus Academic Consideration and how to access each.

Wellbeing Support

At Toronto Metropolitan University, we recognize that things can come up throughout the term that may interfere with a student's ability to succeed in their coursework. These circumstances are outside of one's control and can have a serious impact on physical and mental well-being. Seeking help can be a challenge, especially in those times of crisis.

If you are experiencing a mental health crisis, please call 911 and go to the nearest hospital emergency room. You can also access these outside resources at anytime:

- **Distress Line:**24/7 line for if you are in crisis, feeling suicidal or in need of emotional support (phone: 416-408-4357)
- **Good2Talk:**24/7-hour line for postsecondary students (phone: 1-866-925-5454)
- **Keep.meSAFE:** 24/7 access to confidential support through counsellors via My SSP app or 1-844-451-9700

If non-crisis support is needed, you can access these campus resources:

- **Centre for Student Development and Counselling:** 416-979-5195 or email csdc@torontomu.ca
- **Consent Comes First - Office of Sexual Violence Support and Education:** 416-919-5000 ext 3596 or email osvse@torontomu.ca
- **Medical Centre:** call (416) 979-5070 to book an appointment

We encourage all Toronto Metropolitan University community members to access available resources to ensure support is reachable. You can find more resources available through the Toronto Metropolitan University Mental Health and Wellbeing website.