UNIVERSITY of GUELPH

ENGG*4660 Medical Image Processing

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Winter 2020
Section(s): C01

School of Engineering
Credit Weight: 0.50
Version 1.00 - January 05, 2020

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1 Course Details

1.1 Calendar Description

This course covers the fundamentals of medical imaging from both the processing of digital images and the physics of image formation. Image processing topics covered include: fundamentals of resolution and quantization; linear systems as applied to multi-dimensional continuous and discrete systems including the relationship between the point spread functions and modulation transfer function; point operations such as contrast enhancement, histogram equalization, and H and D curves, geometric operations for distortion correction, including interpolation methods; linear filtering in both the spatial and spatial-frequency domains; and image restoration and inverse filtering. The physics of the following imaging modalities with emphasis on the parameters which effect image quality will be covered: x-ray radiology, MRI, ultrasound, and nuclear medicine.

Pre-Requisites: ENGG*3390

1.2 Course Description

Medical imaging is a rapidly developing field within biomedical engineering. There is a demand both within the research community and in clinical support for people with knowledge of the imaging process for the various modalities and the digital image processing techniques for enhancing, restoring and manipulating digital images.

1.3 Timetable

Lectures:

Tuesday   10:00-11:20 ANNU 306

Thursday   10:00-11:20 ANNU 306

Laboratory:

Monday   11:30-13:20   THRN 2336

1.4 Final Exam

Sat Apr 18, 19:00-21:00, Room TBA on Webadvisor

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2 Instructional Support

2.1 Instructional Support Team

Instructor:	Bob Dony Ph.D., P.Eng
Email:	rdony@uoguelph.ca
Telephone:	+1-519-824-4120 x53458
Office:	THRN 2341
Office Hours:	By appointment

2.2 Teaching Assistants

Teaching Assistant:	Zachary Szentimrey
Email:	zszentim@uoguelph.ca

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3 Learning Resources

3.1 Required Resources

Course Website (Website)
Course material, news, announcements, and grades will be regularly posted to the ENGG*4460 Courselink site. You are responsible for checking the site regularly.

3.2 Additional Resources

Digital Image Processing using MATLAB (Textbook)
Gonzalez, Woods, Eddins, Pearson Prentice Hall, 2004

Digital Image Processing (Textbook)
Gonzalez, Woods, Addison-Wesley, 1992

Digital Image Processing (Textbook)

Castleman, Prenice Hall, 1996

Medical Imaging: Signals and Systems (Textbook)
Prince, Links, Pearson Prentice Hall, 2006

Fundamentals of Medical Imaging (Textbook)
Suetens, Cambridge, 2002

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4 Learning Outcomes

4.1 Course Learning Outcomes

By the end of this course, you should be able to:
1. Relate the point spread function to image resolution both in terms of spatial and spatial-frequency measurements.
2. Perform filtering operations in both the spatial and spatial-frequency domains.
3. Explain the effects and uses of the various image processing techniques on digital images.
4. Given a corrupted image, justify a choice of image processing operators to restore or enhance the image, design and implement the operators, and evaluate both qualitatively and quantitatively the results.
5. Describe the components of pattern recognition and explain their limitations.
6. Justify the choice of segmentation technique given an end-use application.
7. Implement various segmentation techniques as appropriate.

4.2 Engineers Canada - Graduate Attributes (2018)

Successfully completing this course will contribute to the following:

#	Outcome	Learning Outcome
1	Knowledge Base	1, 2, 3, 4, 5, 6, 7
1.4	Recall, describe and apply program-specific engineering principles and concepts	1, 2, 3, 4, 5, 6, 7
2	Problem Analysis	1, 2, 3, 4, 5, 6

#	Outcome	Learning Outcome
2.2	Identify, organize and justify appropriate information, including assumptions	5
2.3	Construct a conceptual framework and select an appropriate solution approach	1
2.4	Execute an engineering solution	2
2.5	Critique and appraise solution approach and results	3, 4, 6
3	Investigation	3, 4, 5, 6, 7
3.1	Propose a working hypothesis	5
3.2	Design and apply an experimental plan/investigative approach (for example, to characterize, test or troubleshoot a system)	7
3.3	Analyze and interpret experimental data	7
3.4	Assess validity of conclusions within limitations of data and methodologies	3, 4, 6, 7
4	Design	4, 6
4.4	Evaluate alternative design solutions based on problem definition	6
4.5	Develop and refine an engineering design solution, through techniques such as iteration, simulation and/or prototyping	4
5	Use of Engineering Tools	2, 4, 5, 7
5.1	Select appropriate engineering tools from various alternatives	4, 5, 7
5.2	Demonstrate proficiency in the application of selected engineering tools	2, 4, 7
5.3	Recognize limitations of selected engineering tools	4, 7

4.3 Relationships with other Courses & Labs

Previous Courses:
ENGG*3390: Provides a background in linear systems theory and signal processing.
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5 Teaching and Learning Activities

5.1 Lecture

Lecture Schedule

Topics:	Day	Lecture Topic

Jan 7	2D Signals and Systems
Jan 9	2D Fourier
Jan 14	Fourier and Sampling
Jan 16	Filtering
Jan 21	Optimal Filtering
Jan 23	Optimal Filtering
Jan 28	Human Visual System
Jan 30	Vision and Resolution
Feb 4	Point Operations The Histogram
Feb 6	Histogram Equalization Algebraic Operations
Feb 11	Geometric Operations
Feb 13	Image Registration
	Reading Week
Feb 25	Segmentation Edge Detection
Feb 27	**Midterm**
Mar 3	*Iron Ring*
Mar 5	Thresholding
Mar 10	Morphology
Mar 12	Pattern Classification
Mar 17	Multi-dimensional Pattern Classification
Mar 19	Learning Systems
Mar 24	Unsupervised Learning Systems
Mar 26	Supervised Learning
Mar 31	Neural Networks
Apr 2	

5.2 Lab

Lab Schedule Topics:

Week	Dates	Activity	Due
Week 2	Jan 13	Introduction to MATLAB	
Week 3-4	Jan 20, 27	Filtering	Feb 3
Week 5-6	Feb 3, 10	Optimal Filtering	Feb 24

Week 7	Feb 24	Greylevel Operations	Mar 2
Week 8-9	Mar 2, 9	Image Registration	Mar 16
Week 10-12	Mar 16, 23, 30	Segmentation	Apr 2

5.3 Other Important Dates

Monday, January 6, 2020: First day of classes

Monday, February 17 - Friday, February 21 2020: Winter Break

Friday, April 3 2020: drop date and last day of classes

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6 Assessments

6.1 Assessment Details

Computer Labs/Assignments (40%)
Learning Outcome: 1, 2, 3, 4, 5, 6, 7
See lab schedule for due dates.

Midterm (25%)
Date: Thu, Feb 27, In Class
Learning Outcome: 1, 2, 3, 4

Final Exam (35%)
Date: Sat, Apr 18, 7:00 PM - 9:00 PM, Room TBA on Webadvisor
Learning Outcome: 1, 2, 3, 4, 5, 6, 7

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7 Course Statements

7.1 Course Grading Policies

Missed Assessments: If you are unable to meet an in-course requirement due to medical, psychological, or compassionate reasons, please email the course instructor. See the undergraduate calendar for information on regulations and procedures for Academic Consideration.

Accommodation of Religious Obligations: If you are unable to meet an in-course requirement due to religious obligations, please email the course instructor within two weeks of the start of the semester to make alternate arrangements. See the undergraduate calendar for information on regulations and procedures for Academic Consideration of Religious Obligations.

Passing grade: As per University policy, the minimum passing grade is 50%.

Missed midterm tests: If you miss a test due to grounds for granting academic consideration or religious accommodation, the weight of any missed test will be added to the final exam weight. There will be no makeup midterm tests.

Late Assignments: Late submission of assignments will not be accepted.

8 School of Engineering Statements

8.1 Instructor's Role and Responsibility to Students

The instructor's role is to develop and deliver course material in ways that facilitate learning for a variety of students. Selected lecture notes will be made available to students on Courselink but these are not intended to be stand-alone course notes. Some written lecture notes will be presented only in class. During lectures, the instructor will expand and explain the content of notes and provide example problems that supplement posted notes. Scheduled classes will be the principal venue to provide information and feedback for tests and labs.

8.2 Students' Learning Responsibilities

Students are expected to take advantage of the learning opportunities provided during lectures and lab sessions. Students, especially those having difficulty with the course content, should also make use of other resources recommended by the instructor. Students who do (or may) fall behind due to illness, work, or extra-curricular activities are advised to keep the instructor informed. This will allow the instructor to recommend extra resources in a timely manner and/or provide consideration if appropriate.

8.3 Lab Safety

Safety is critically important to the School and is the responsibility of all members of the School: faculty, staff and students. As a student in a lab course you are responsible for taking all reasonable safety precautions and following the lab safety rules specific to the lab you are working in. In addition, you are responsible for reporting all safety issues to the laboratory supervisor, GTA or faculty responsible.

9 University Statements

9.1 Email Communication

As per university regulations, all students are required to check their e-mail account regularly: e-mail is the official route of communication between the University and its students.

9.2 When You Cannot Meet a Course Requirement

When you find yourself unable to meet an in-course requirement because of illness or compassionate reasons please advise the course instructor (or designated person, such as a teaching assistant) in writing, with your name, id#, and e-mail contact. The grounds for

Academic Consideration are detailed in the Undergraduate and Graduate Calendars.

Undergraduate Calendar - Academic Consideration and Appeals
https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-ac.shtml

Graduate Calendar - Grounds for Academic Consideration
https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/index.shtml

Associate Diploma Calendar - Academic Consideration, Appeals and Petitions
https://www.uoguelph.ca/registrar/calendars/diploma/current/index.shtml

9.3 Drop Date

Students will have until the last day of classes to drop courses without academic penalty. The deadline to drop two-semester courses will be the last day of classes in the second semester. This applies to all students (undergraduate, graduate and diploma) except for Doctor of Veterinary Medicine and Associate Diploma in Veterinary Technology (conventional and alternative delivery) students. The regulations and procedures for course registration are available in their respective Academic Calendars.

Undergraduate Calendar - Dropping Courses
https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-drop.shtml

Graduate Calendar - Registration Changes
https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/genreg-reg-regchg.shtml

Associate Diploma Calendar - Dropping Courses
https://www.uoguelph.ca/registrar/calendars/diploma/current/c08/c08-drop.shtml

9.4 Copies of Out-of-class Assignments

Keep paper and/or other reliable back-up copies of all out-of-class assignments: you may be asked to resubmit work at any time.

9.5 Accessibility

The University promotes the full participation of students who experience disabilities in their academic programs. To that end, the provision of academic accommodation is a shared responsibility between the University and the student.

When accommodations are needed, the student is required to first register with Student Accessibility Services (SAS). Documentation to substantiate the existence of a disability is required; however, interim accommodations may be possible while that process is underway.

Accommodations are available for both permanent and temporary disabilities. It should be noted that common illnesses such as a cold or the flu do not constitute a disability.

Use of the SAS Exam Centre requires students to book their exams at least 7 days in advance

and not later than the 40th Class Day.

For Guelph students, information can be found on the SAS website
https://www.uoguelph.ca/sas

For Ridgetown students, information can be found on the Ridgetown SAS website
https://www.ridgetownc.com/services/accessibilityservices.cfm

9.6 Academic Integrity

The University of Guelph is committed to upholding the highest standards of academic integrity, and it is the responsibility of all members of the University community-faculty, staff, and students-to be aware of what constitutes academic misconduct and to do as much as possible to prevent academic offences from occurring. University of Guelph students have the responsibility of abiding by the University's policy on academic misconduct regardless of their location of study; faculty, staff, and students have the responsibility of supporting an environment that encourages academic integrity. Students need to remain aware that instructors have access to and the right to use electronic and other means of detection.

Please note: Whether or not a student intended to commit academic misconduct is not relevant for a finding of guilt. Hurried or careless submission of assignments does not excuse students from responsibility for verifying the academic integrity of their work before submitting it. Students who are in any doubt as to whether an action on their part could be construed as an academic offence should consult with a faculty member or faculty advisor.

Undergraduate Calendar - Academic Misconduct
https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-amisconduct.shtml

Graduate Calendar - Academic Misconduct
https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/index.shtml

9.7 Recording of Materials

Presentations that are made in relation to course work - including lectures - cannot be recorded or copied without the permission of the presenter, whether the instructor, a student, or guest lecturer. Material recorded with permission is restricted to use for that course unless further permission is granted.

9.8 Resources

The Academic Calendars are the source of information about the University of Guelph's procedures, policies, and regulations that apply to undergraduate, graduate, and diploma programs.

Academic Calendars
https://www.uoguelph.ca/academics/calendars

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