

**Western University
Faculty of Engineering
Department of Electrical and Computer Engineering
Graduate Program in Biomedical Engineering, AND
Schulich School of Medicine and Dentistry, Department of Medical Biophysics**

ECE 9020B/ECE 9022/BIOMED 9519B/BIOPHYS 9519B/CAMI 9519B

Advanced Image Processing and Analysis

Course Outline, Winter 2018

Description: Digital image processing has various applications ranging from remote sensing and entertainment to medical applications. This course explores a few major areas of digital image processing at an advanced level, with primary emphasis on medical applications. Topics covered include image segmentation, image registration, validation of image processing algorithms, and image processing using the Insight Toolkit (ITK) and Jupyter Notebook. Examples will be presented to give the students exposure to real-world applications.

Instructor: Dr. Elvis C.S. Chen, L.E.L.
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Consultation hours: By appointment

Academic Calendar Copy: This course explores a few major areas of digital image processing at an advanced level, with primary emphasis on medical applications. Topics covered include image filtering and enhancement, visualization, image segmentation and image registration. Examples will be presented to give the students exposure to real-world applications in medicine and other applications.

Contact Hours: 3 lecture hours/week, 0.5 course

Antirequisite:

Prerequisites: ECE 4445A/B or MBP 4445A/B or BIOPHYS 9509 or BME 9509

Unless you have either the requisites for this course or written special permission from your Dean to enroll in it, you will be removed from this course and it will be deleted from your record. This decision may not be appealed. You will receive no adjustment to your fees in the event that you are dropped from a course for failing to have the necessary prerequisites.

Co-requisite:

Unless you have either the requisites for this course or written special permission from your Dean to enroll in it, you will be removed from this course and it will be deleted from your record. This decision may not be appealed. You will receive no adjustment to your fees in the event that you are dropped from a course for failing to have the necessary prerequisites.

CEAB Academic Units: Mathematics 33%, Science 33%, Complementary Studies 34%.

Required Textbook: None

Other Required References:

Recommended References:

General Learning Objectives (CEAB Graduate Attributes)

| | | | | | |
|------------------|-----|--------------------------|-----|---------------------------------------|--|
| Knowledge Base | 3/3 | Use of Engineering Tools | 3/3 | Impact on Society and the Environment | |
| Problem Analysis | 3/3 | Individual and Team Work | | Ethics and Equity | |
| Investigation | | Communication Skills | 3/2 | Economics and Project Management | |
| Design | | Professionalism | | Life-Long Learning | |

Notation: x/y , where x is the cognitive level (1: Remember, 2: Understand, 3: Apply) at which the attribute is assessed and y is the academic level (1: Beginner, 2: Intermediate, 3: Advanced) at which the attribute is assessed.

Topics and Specific Learning Objectives

1. Jupyter Notebook

At the end of this section, students will be able to:

- describe how to load and visualize 3D volumetric images in Jupyter Notebook
- Apply segmentation and registration algorithms as taught in class
- successfully apply segmentation and registration algorithms beyond those taught in class

2. Segmentation algorithms

At the end of this section, students will be able to:

- identify broad categories of segmentation algorithms
- describe in detail the specific segmentation algorithms taught in class
- describe at a high level related segmentation algorithms not covered during lectures
- identify appropriate segmentation algorithms for a defined task
- appropriately configure/task the algorithm according to the task
- write an ITK/Python program to load a 3D volumetric image
- implement an ITK-based segmentation algorithm taught in class
- implement an ITK-based segmentation algorithm beyond those taught in class

3. Registration algorithms

At the end of this section, students will be able to:

- identify broad categories of registration algorithms
- describe in detail the specific registration algorithms taught in class
- describe at a high level related registration algorithms not covered during lectures

- d. to identify appropriate registration algorithm for a define task
- e. appropriately configure/task the algorithm according to the task
- f. write an ITK/Python program to load a 3D volumetric image
- g. implement an ITK-based registration algorithm taught in class
- h. implement an ITK-based registration algorithms beyond those taught in class

4. Validation metrics

At the end of this section, students will be able to:

- a. identify broad categories of validation metrics used for image segmentation and registration
- b. describe in detail the specific validation metrics taught in class
- c. describe at a high level validation metrics not covered during lectures
- d. identify appropriate specific segmentation and registration algorithm validation metrics for a given task
- e. elucidate relative merits of different metrics for a given task
- f. calculate appropriate segmentation and registration algorithm validation metrics for a given task
- g. perform the necessary calculations to compute the metrics in ITK/Python

Evaluation (MSc/PhD students – ECE 9202B/BME 9519B/BIOPHY 9519B/CAMI 9519B):

| Course Component | Weight |
|----------------------|--------|
| Homework Assignments | 20% |
| Midterm Test | 20% |
| Final Examination | 25% |
| Course Project | 35% |

The project topic and scope (MSc and PhD students only) will be selected in consultation with the instructor and will involve algorithm implementation. The deliverables will consist of a written report, an oral presentation, and the software implementation.

Evaluation (MEng students – ECE 9022B):

| Course Component | Weight |
|----------------------|--------|
| Homework Assignments | 20% |
| Midterm Test | 30% |
| Final Examination | 50% |

For MSc and PhD students to obtain a passing grade in the course, a mark of 50% or more must be achieved on the course project; such as mark < 50% will result in a final course grade of 48% or less.

For all students, to obtain a passing grade in the course, a mark of 50% or more must be achieved on the final examination as well as on the laboratory. A final examination mark < 50% will result in a final course grade of 48% or less.

Homework Assignments: The course will include up to four (4) homework assignments, submitted online through the OWL system.

Midterm Test: There will be one closed-book midterm test during a 110-minute scheduled lecture time slot. Only non-programmable calculators will be permitted; no other materials or electronic devices will be allowed.

Final Examination: The 180-minute closed-book final examination will be take place during the regular examination period. Only non-programmable calculators will be permitted; no other materials or electronic devices will be allowed.

Late Submission Policy: Policy: Late assignments will be penalized at a rate of 20% per 24 hours overdue, with NO EXCEPTIONS.

Any reason for late submission of an assignment must be brought to the attention of the instructor for consideration prior to the assignment deadline. Documented evidence of the reason for such requests must be provided for such requests to be considered. No requests for accommodation of late submission of assignments will be considered by the instructor after assignment deadlines.

Use of English: In accordance with Senate and Faculty Policy, students may be penalized up to 10% of the marks on all assignments, tests, and examinations for improper use of English. Additionally, poorly written work with the exception of the final examination may be returned without grading. If resubmission of the work is permitted, it may be graded with marks deducted for poor English and/or late submission.

Attendance: Any student who, in the opinion of the instructor, is absent too frequently from class, laboratory, or tutorial periods will be reported to the Dean (after due warning has been given). On the recommendation of the department, and with the permission of the Dean, the student will be debarred from taking the regular final examination in the course.

Absence Due to Illness or Other Circumstances: Students should immediately consult with the instructor or department Chair if they have any problems that could affect their performance in the course. Where appropriate, the problems should be documented (see the attached “Instructions for Students Unable to Write Tests or Examinations or Submit Assignments as Scheduled”). The student should seek advice from the instructor or department Chair regarding how best to deal with the problem. Failure to notify the instructor or department Chair immediately (or as soon as possible thereafter) will have a negative effect on any appeal.

For more information concerning medical accommodations, see the relevant section of the Academic Handbook:

http://www.uwo.ca/univsec/pdf/academic_policies/appeals/accommodation_medical.pdf

For more information concerning accommodations for religious holidays, see the relevant section of the Academic Handbook:

http://www.uwo.ca/univsec/pdf/academic_policies/appeals/accommodation_religious.pdf

Missed Midterm Examinations: If a student misses a midterm examination, the exam will not be rescheduled. The student must follow the Instructions for Students Unable to Write Tests and provide documentation to their department within 24 hours of the missed test. The department will decide whether to allow the reweighting of the test, where reweighting means the marks normally allotted for the midterm will be added to the final exam. If no reasonable justification for missing the test can be found, then the student will receive a mark of zero for the test.

If a student is going to miss the midterm examination for religious reasons, they must inform the instructor in writing within 48 hours of the announcement of the exam date or they will be required to write the exam.

Cheating and Plagiarism: Students must write their essays and assignments in their own words. Whenever students take an idea or a passage from another author, they must acknowledge their debt both by using quotation marks where appropriate and by proper referencing such as footnotes or citations. University policy states that cheating, including plagiarism, is a scholastic offence. The commission of a scholastic offence is attended by academic penalties, which might include expulsion from the program. If you are caught cheating, there will be no second warning.

All required papers may be subject to submission for textual similarity review to commercial plagiarism-detection software under license to the University for the detection of plagiarism. All papers submitted will be included as source documents on the reference database for the purpose of detecting plagiarism of papers subsequently submitted to the system. Use of the service is subject to the licensing agreement, currently between the University of Western Ontario and Turnitin.com (<http://www.turnitin.com>).

Scholastic offences are taken seriously and students are directed to read the appropriate policy, specifically, the definition of what constitutes a Scholastic Offence, in the relevant section of the Academic Handbook:

http://www.uwo.ca/univsec/pdf/academic_policies/appeals/scholastic_discipline_undergrad.pdf

Use of Electronic Devices: Students may use laptops, tablet computers, or smart phones only to access the course OWL site during lectures and tutorials. Use of nonprogrammable calculators only is permitted during the midterm and the final examination. No other electronic devices may be used at any time during lectures, midterm, or the final examination.

Use of Personal Response Devices (“Clickers”): n/a

Policy on Repeating All Components of a Course: Students who are required to repeat an Engineering course must repeat all components of the course. No special permissions will be granted enabling a student to retain laboratory, assignment, or test marks from previous years. Previously completed assignments and laboratories cannot be resubmitted by the student for grading in subsequent years.

Internet and Electronic Mail: Students are responsible for regularly checking their Western e-mail and the course web site (<https://owl.uwo.ca/portal/>) and making themselves aware of any information that is posted about the course. It is the student’s responsibility to read the course

website posted on Western's on-line learning management system, OWL (<https://owl.uwo.ca/portal/>) This includes the course bulletin board and all information and/or assignments posted about the course. If the student fails to act on information that has been posted on the course site and does so without a legitimate explanation (i.e., those covered under the illness/compassionate form), then there are NO grounds for an appeal.

Accessibility: Please contact the course instructor if you require material in an alternate format or if any other arrangements can make this course more accessible to you. You may also wish to contact Services for Students with Disabilities (SSD) at 519-661-2111 ext. 82147 for any specific question regarding an accommodation.

Support Services: Office of the Registrar, <http://www.registrar.uwo.ca/>
Student Development Centre, <http://www.sdc.uwo.ca/>
Engineering Undergraduate Services, <http://www.eng.uwo.ca/undergraduate/>
USC Student Support Services, <http://westernusc.ca/services/>

As part of a successful graduate student experience at Western, students are encouraged to make their health and wellness a priority. Western provides several on campus health-related services to help you achieve optimum health and engage in healthy living while pursuing your graduate degree. For example, to support physical activity, all students, as part of their registration, receive membership in Western's Campus Recreation Centre:

http://www.uwo.ca/campus_life/athletics.html

All facets of extracurricular campus life in which graduate students can participate are available on this URL: http://www.uwo.ca/campus_life/arts_culture.html

Information regarding health and wellness-related services available to students may be found at <http://www.health.uwo.ca>. Students seeking help regarding mental health concerns are advised to speak to someone in whom they feel comfortable confiding, such as their graduate supervisor, their program director (Graduate Chair), or other relevant administrators in their unit. Campus mental health resources may be found at:

http://www.health.uwo.ca/mental_health/resources.html