Western University
Faculty of Engineering
Department of Electrical and Computer Engineering

ECE 4438B: Advanced Image Processing and Analysis
Course Outline 2023-24

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 a primary emphasis on recent deep learning technology. Topics covered include image segmentation, image registration, and other image processing operations using the Image Processing Toolbox in MATLAB, as well as in Python environment. Examples will be presented to give students exposure to real-world applications.

Instructor: Dr. Yimin Yang
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Consultation hours: Friday from 10:00 am to 11:30 am at TEB 245

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

Contact Hours: 3 lecture hours/week, 0.5 course.

Prerequisites: ECE 4445A/B or MBP 4445A/B

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: Engineering Science 75%, Engineering Design 25%

Required Textbook:
Gonzalez, R.C., & Woods, R.E. (2018). *Digital Image Processing*, 4th ed. Pearson.

Other Required References:
1. Class notes
2. Documentation on Matlab and the Image Processing Toolbox can be found on the Mathworks' Web site at https://www.mathworks.com/help/
3. Pytorch tutorials at https://pytorch.org/tutorials/

General Learning Objectives (CEAB Graduate Attributes)

Knowledge Base (KB)	A	Use of Engineering Tools (ET)	A	Impact on Society and the Environment (IESE)	
Problem Analysis (PA)		Individual and Team Work (ITW)		Ethics and Equity (EE)	A
Investigation (IN)		Communication Skills (CS)		Economics and Project Management (EPM)	
Design (DE)	D	Professionalism (PR)		Life-Long Learning (LL)	

Notation*: where x be I: Introductory, D: Intermediate, A: Advanced, or empty*. I – The instructor will introduce the topic at the level required. It is not necessary for the student to have seen the material before. D – There may be a reminder or review, but the student is expected to have seen and been tested on the material before taking the course. A – It is expected that the student can apply the knowledge without prompting (e.g. no review).

Course Topics and Specific Learning Outcomes	CEAB Graduate Attributes Indicators
1. Object recognition At the end of this section, students will be able to: a. describe and compute boundary and region-based object features discussed in class b. classify objects via prototype matching c. classify objects via deep convolutional neural networks d. write a program in MATLAB to implement algorithms taught in class for feature extraction and matching e. understanding the limitation of the methods, having a critical thinking about the deep learning technology.	KB4, ET1, D3, EE2
2. Morphological image processing At the end of this section, students will be able to: a. understand fundamental concepts of mathematical morphology and how to apply them to pre/post processing tools in image processing b. be familiar with the tools used for binary image morphology, including erosion, dilation, opening, and closing	KB4, ET1, D3

c. develop algorithms based on binary image morphology for performing tasks such as smoothing, edge detection, and boundary extraction d. write a program in MATLAB to implement algorithms taught in class	
3. Image analysis with large language models At the end of this section, students will be able to: a. identify broad categories of image processing methods with recent AI models include CLIP, Stable Diffusion, and Vision Transformer. b. describe in detail the specific the algorithms taught in class. c. Image recognition via Vision Transformer d. Image segmentation via Deep Autoencoder e. Image generation via Stable Diffusion f. Image and text processing with CLIP for scene understanding g. write a program in python to implement algorithms taught in class. h. understanding the limitation of the methods, having a critical thinking about the deep learning technology.	KB4, ET1, D3, EE2, EE4
4. Image registration At the end of this section, students will be able to: i. identify broad categories of registration algorithms j. describe in detail the specific registration algorithms taught in class k. identify an appropriate registration algorithm for a defined task l. appropriately configure the algorithm according to the task m. implement a registration algorithm taught in class	KB4, ET1, D3

5. image processing with Nvidia Jetson
At the end of this section, students will be able to:
    a. describe how to use Jetson
    b. apply pretrained AI model in Jetson for image recognition algorithms as taught in class
	Taught but not evaluated

Evaluation

Course Component	Weight
Assignments	25%
Quizzes	30%
Final Examination	45%

Assignments:

Assignment	Distribution date	Due date	Point
#1	Mon., Jan. 25, 2024	Mon., Feb. 5, 2024	5
#2	Mon., Feb. 5, 2024	Mon., Feb. 29, 2024	8
#3	Mon., Feb. 26, 2024	Mon., Mar. 11, 2024	7
#4	Mon., Mar. 11, 2024	Mon., Mar. 25, 2024	5

Students will work in groups of two (2). One report can be submitted by each group. Most of the assignments will involve programming in MATLAB or Python. All assignments will be distributed via OWL. All assignments are expected to be submitted via OWL by 11:55 pm on the due date. Each assignment is worth 5% of your overall grade.

Quizzes: There will be 2 quizzes to ensure that you are keeping up with the material being taught. They will each take place during the normal lecture hour. Each quiz will last 45 minutes. Quiz dates are as follows:

- **Quiz #1:** Thursday, Feb. 15, 2024
- **Quiz #2:** Thursday, Mar. 14, 2024

All quizzes will be closed book. Only non-programmable calculators will be allowed.

Final Examination: The final examination will be take place during the regular examination period. The final examination will be closed book. Only non-programmable calculators will be allowed.

Late Submission Policy: Late assignments will be accepted up to 2 days past the stated due date, but a late penalty of 5% per day will be applied. Assignments will not be accepted more than 2 days past the due date.

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 Quizzes: If a student misses a quiz, she or he must follow the Instructions for Students Unable to Write Tests and provide documentation to Undergraduate Services Office within 24 hours of the missed quiz. If accommodation is granted, the department will decide whether to provide a make-up quiz or allow reweighting of the quiz, where reweighting means the marks normally allotted for the quiz will be added to the final exam. If no reasonable justification for missing the quiz can be found, then the student will receive a mark of zero for the quiz.

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

Missed Assignments for Academic Consideration: If a student misses an assignment, they must contact the instructor within 48 hours of the deadline of the assignment. Medical documentation must be submitted directly to the appropriate Dean's office for consideration. The instructor will not collect medical documentation. If accommodation is granted, the instructor will decide whether to provide a make-up assignment or extend the deadline. If no justification is found, the student will receive a zero on the assignment.

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 quizzes and examinations. No other electronic devices may be used at any time during lectures, tutorials, or examinations.

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.

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/

Students who are in emotional/mental distress should refer to Mental Health @ Western, http://www.health.uwo.ca/mental_health/, for a complete list of options about how to obtain

help.