ECE 736
3D Image Processing and Computer Vision

COURSE OUTLINE

Please refer to course website for updated information.

CALENDAR DESCRIPTION

The goal of computer vision is to use acquired image data to infer something about the world. Central to computer vision are the mathematical models governing image formation and methods for processing and recovering information based on the model and the image data. In this course we concentrate on geometrical and learning models of visual data. In the first part of this course, we take a geometrical approach to image formation and look at problems such as image blending and 3D reconstruction. In our discussion of 3D computer vision, we focus on how to make use of the spatial and temporal coherence imposed by camera geometry to reconstruct a 3D scene or stich several 2D images. These images are from a moving video camera, stereo camera rig or multiple views from a single camera. We will also look at computational photography where image analysis and processing algorithms are applied to one or more images to create images that go beyond the capabilities of traditional imaging systems. Assuming a learning model for the visual data, we talk about prediction and inference. We cover regression, and classification methods. We will also look at applications of convolutional neural networks in classification, regression, and several other computer vision applications.

SCHEDULE And MODE OF DELIVERY

The material for this course will be delivered in person. Course notes and supplementary material will be posted online on Avenue to Learn.

INSTRUCTOR

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Phone: 905-525-9140 ext.
Office Hours**:** by appointment

COURSE WEBSITE/S

Primarily the class Teams website. Also http://avenue.mcmaster.ca

COURSE OBJECTIVES

Learning Objectives:

- Model image formation in single camera and multi-camera setups
- Mathematically understand the relation between the 3D world and its projection in 2D images and learn how to reconstruct a 3D scene model from several 2D images.
- Extract features from images and match/track them.
- Choose the right regression model for a vision problem.
- Choose the right classifier for a vision problem.
- Employ the RANSAC algorithm to remove the effects of outliers.
- Be able to apply computational photography techniques to solve image processing and computer vision problems.
- Be able to devise a neural network-based solution to typical computer vision problems.

ASSUMED KNOWLEDGE

- Undergraduate level DSP, undergraduate level probability, undergraduate level image processing

COURSE MATERIALS

Textbooks:

- Richard Szeliski, "Computer Vision: Algorithms and Applications, 2nd edition", 2021. Electronic version of the book is available free at: http://szeliski.org/Book/
- Richard Hartley, Andrew Zisserman, "Multiple View Geometry in Computer Vision" Second Edition, Cambridge University Press, 2004. Electronic version available online.
- Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani, "An Introduction to Statistical Learning", Springer Science, Business Media, New York 2017, available online.
- C. M. Bishop, "Pattern Recognition and Machine Learning", Springer, 2006. Available online.

Reference Books:

- Simon J.D. Prince, "Computer vision: models, learning and inference", Cambridge University Press, 2012. Electronic version of the book is available free at: http://www.computervisionmodels.com

COURSE OVERVIEW

Week	Topic
1	Pinhole camera model Camera calibration Pose estimation 3D reconstruction Structure from motion
2	Epipolar geometry Stereo correspondence Edge detection Interest points, corners and local image features
3	Feature matching and tracking Model fitting and RANSAC
4	Optical Flow
5	Regression models
6	Classification models Support Vector Machine (SVM)
7	Deep learning
8	Applications of deep learning in computer vision
9	Image completion / inpainting High dynamic range imaging
10	Deformable contours
11	Image retargeting Seam carving

At certain points in the course it may make good sense to modify the schedule. The instructor may modify elements of the course and will notify students accordingly (in class, on the course website).

Course Evaluation

- Homework: 80%
- Project: 20%

CONDUCT EXPECTATIONS

As a McMaster graduate student, you have the right to experience, and the responsibility to demonstrate, respectful and dignified interactions within all of our living, learning and working communities. These expectations are described in the *Code of Student Rights & Responsibilities* (the "Code"). All students share the responsibility of maintaining a positive environment for the academic and personal growth of all McMaster community members, **whether in person or online**.

It is essential that students be mindful of their interactions online, as the Code remains in effect in virtual learning environments. The Code applies to any interactions that adversely affect, disrupt, or interfere with reasonable participation in University activities. Student disruptions or behaviours that interfere with university functions on online platforms (e.g. use of Avenue 2 Learn, WebEx or Zoom for delivery), will be taken very seriously and will be investigated. Outcomes may include restriction or removal of the involved students' access to these platforms.

COPYRIGHT AND RECORDING

Students are advised that lectures, demonstrations, performances, and any other course material provided by an instructor include copyright protected works. The Copyright Act and copyright law protect every original literary, dramatic, musical and artistic work, **including lectures** by University instructors.

The recording of lectures, tutorials, or other methods of instruction may occur during a course. Recording may be done by either the instructor for the purpose of authorized distribution, or by a student for the purpose of personal study. Students should be aware that their voice and/or image may be recorded by others during the class. Please speak with the instructor if this is a concern for you.

ACADEMIC ACCOMMODATIONS OF STUDENTS WITH DISABILITIES

Students with disabilities who require academic accommodation must contact Student Accessibility Services (SAS) at 905-525-9140 ext. 28652 or sas@mcmaster.ca to make arrangements with a Program Coordinator. For further information, consult McMaster University's *Academic Accommodation of Students with Disabilities* policy.

ACADEMIC ACCOMMODATION FOR RELIGIOUS, INDIGENOUS OR SPIRITUAL OBSERVANCES (RISO)

Students requiring academic accommodation based on religious, indigenous or spiritual observances should follow the procedures set out in the RISO policy. Students should submit their request to their Faculty Office ***normally within 10 working days*** of the beginning of term in which they anticipate a need for accommodation or to the Registrar's Office prior to their examinations. Students should also contact their instructors as soon as possible to make alternative arrangements for classes, assignments, and tests.

EXTREME CIRCUMSTANCES

The University reserves the right to change the dates and deadlines for any or all courses in extreme circumstances (e.g., severe weather, labour disruptions, etc.). Changes will be communicated through regular McMaster communication channels, such as McMaster Daily News, A2L and/or McMaster email.

RESEARCH ETHICS

The two principles underlying integrity in research in a university setting are these: a researcher must be honest in proposing, seeking support for, conducting, and reporting research; a researcher must respect the rights of others in these activities. Any departure from these principles will diminish the integrity of the research enterprise. This policy applies to all those conducting research at or under the aegis of McMaster University. It is incumbent upon all members of the university community to practice and to promote ethical behaviour. To see the Policy on Research Ethics at McMaster University, please go to http://www.mcmaster.ca/policy/faculty/Conduct/ResearchEthicsPolicy.pdf.

www.eng.mcmaster.ca/ece