Course Title: **3D Image Processing and Computer Vision**
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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 fact, the goal of computer vision is to use observed image data to infer something about the world. In this course we concentrate on statistical and geometrical models of visual data. Assuming a statistical model for the visual data, we talk about learning and inference. We cover modeling of the data densities, regression and classification methods and how we can use graphical models (e.g., Vitterbi, belief propagation) to solve learning and inference problems.
In the other part of this course we take a geometrical approach to image formation and look at problems such as image blending and stitching 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 image from a moving video camera, stereo camera rig or multiple views from a still camera.

Learning Objectives:

- Model image formation in single camera and multi-camera setups
- Mathematically understand the relation between the 3D world and it's projection in 2D images and learn how to use these to reconstruct a 3D scene model from several 2D images
- Find appropriate models for complex data densities
- Choose the right regression model for a vision problem
- Be able to use graphical models to simplify complex data models
- Be able to apply computational photography techniques in order to solve image processing and computer vision problems

Content:

- Learning and inference in vision
    - Regression models
    - Classification models
    - Application of graphical models for learning and inference in vision
    - Modeling complex data densities and Expectation Maximization
    - Kernel methods
- Image formation and 3D reconstruction
    - Geometric primitives and transformations
    - Photometric image formation
    - Digital camera pipeline
    - Pinhole camera model
    - Multiple cameras model
    - Stereo correspondence

    - Image-based rendering
- Computational photography
    - Image blending and compositing
    - Image retargeting
    - Texture synthesis and transfer
    - Image completion / inpainting
    - Super-resolution, deblurring, and denoising
    - High dynamic range imaging
    - Depth and defocus
    - Coded aperture photography
    - Image stitching

Textbooks:

- C. M. Bishop, "Pattern Recognition and Machine Learning", Springer, 2006. Chapters 1, 3, 4, 6, 8 and 9 will be covered.
- Richard Hartley, Andrew Zisserman, "Multiple View Geometry in Computer Vision" Second Edition, Cambridge University Press, 2004. Electronic version available online. Chapters 6 to 11 will be covered.
- Richard Szeliski, "Computer Vision: Algorithms and Applications", Springer; 2011. Chapters 2, and 9-13 will be covered (time permitting).
  Electronic version of the book is available free at: http://szeliski.org/Book/

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

Prerequisite: undergraduate level DSP, undergraduate level probability, undergraduate level image processing

Duration of the course: Lectures will end on April 7th. Project presentations will be scheduled for late April.

Assessment:

- Homework: 35%
- Exam: 45%
- Project: 20%

Project: The project can be in the form of a survey about a computer vision related topic, part of a vision related research or developing a vision related application. A one-page project proposal is due by mid February. The project report is due at the time of presentation. Presentations will be scheduled for late April.

Academic dishonesty

Academic dishonesty consists of misrepresentation by deception or by other fraudulent means and can result in serious consequences, e.g. the grade of zero on an assignment, loss of credit with a notation on the transcript (notation reads: "Grade of F assigned for academic dishonesty"), and/or suspension or expulsion from the university.

It is your responsibility to understand what constitutes academic dishonesty. For information on the various kinds of academic dishonesty please refer to the Academic Integrity Policy, specifically Appendix 3, located at http://www.mcmaster.ca/senate/academic/ac_integrity.htm

The following illustrates only three forms of academic dishonesty:

1. Plagiarism, e.g. the submission of work that is not one's own or for which other credit has been obtained (e.g., using others' project materials without proper referencing).
2. Improper collaboration in group work.
3. Copying or using unauthorized aids in tests and examinations.

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"Students are reminded that they should read and comply with the Statement on Academic Ethics and the Senate Resolutions on Academic Dishonesty as found in the Senate Policy Statements distributed at registration and available in the Senate Office."