Lahore University of Management Sciences

CS 436 / CS 5310 / EE513 : Computer Vision Fundamentals

Spring 2018-19

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Course URL (if any)	LMS

Course Basics				
Credit Hours	3			
Lecture(s)	Nbr of Lec(s) Per Week	2	Duration	75
Recitation/Lab (per week)	Nbr of Lec(s) Per Week	0	Duration	N/A
Tutorial (per week)	Nbr of Lec(s) Per Week	0	Duration	N/A

Course Distribution	
Core	No
Elective	Yes
Open for Student Category	Graduate, Senior, Junior
Close for Student Category	Freshman

COURSE DESCRIPTION

This course gives a broad overview of the field of computer vision, laying the foundations for advanced graduate level classes and research work in vision. This course will be conducted with an application perspective. Therefore students will be expected to implement several techniques learnt in the lectures. A good calculus, linear algebra and programming background is expected for this class. Knowledge of probability and random variables is also needed to understand the ideas presented in some modules.

The nature of the field of Computer Vision is such that it combines and integrates ideas from several different areas, including statistics, pattern recognition, machine intelligence, decision theory and image processing. Therefore, in an introductory class, it is not possible to cover each of these aspects in depth. Instead, the focus of this course is on breadth, presenting several different techniques and systems in moderate detail, so as to familiarize the student with the Computer Vision area in general, and to present some specific examples of Computer Vision systems.

COURSE PREREQUISITE(S)

- CS 200 - Introduction to Programming
- Math 220/ Math 221 – Linear Algebra

COURSE OBJECTIVES

By the end of the semester, a student should have acquired the following skills:

1. Explain some successful applications of computer vision algorithms and how they work.
2. Recognize the difficulty in solving the general 'image understanding' problem.
3. Write programs to solve basic computer vision problems using MATLAB.
4. Understand the mathematical basis of several computer vision techniques in the areas of image formation, transformations, feature detection, motion estimation, stereo, structure from motion and others.
5. Read and understand a research paper of moderate difficulty in the area of computer vision.
6. Formulate an approach to a computer vision problem, implement it, debug it, and then suggest improvements.
7. Be poised to undertake further graduate study and research in this area.

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Learning Outcomes	
	The broad goals of this course are: 1. Acquire a broad overview of the theory and applications of Computer Vision. 2. Understand and appreciate the difficulty of developing computer vision software and its reasons. 3. Acquire an understanding of basic computer vision techniques and mathematical models in the areas of the geometry of image formation, transformations, feature detection, computation of 3D structure, motion estimation, registration and recognition. 4. Understand the mathematical basis of computer vision techniques, including a few robust estimation techniques which are commonly used in computer vision research. 5. Develop skills to write (and debug) programs to solve computer vision problems, through solving several programming assignments. 6. Learn about some current 'hot' problems in computer vision research and the approaches that are being pursued.

Grading Breakup and Policy	
Assignment(s):	40%
Quiz(s):	5%
Class Participation:	0%
Attendance:	0%
Midterm Examination:	25%
Project:	0
Final Examination:	30%

Examination Detail	
Midterm Exam	Yes/No: Yes Combine Separate: N/A Duration: 120 min Preferred Date: 7th Week Exam Specifications: Written
Final Exam	Yes/No: Combine Separate: Comprehensive Duration: 150 min Exam Specifications: Written

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Module	Lectures	Topic	Book Chapters
Introduction	1-2	Introduction • Course Introduction, policies, who should take this course • Why are computer vision problems hard? • Examples of successful computer vision applications • Overview of course topics	Szeliski Ch 1
Geometric Transformations and Camera Models	3-10	Geometric Transformations and Camera Models • 2D transformations/3D transformations • 3D – 2D transformations • Camera Models • Camera Calibration	Szeliski Ch 2
Feature Detection	11-14	Feature Detection • Edge Detection (2D convolution) • Corner Detection and Feature based alignment • Fitting Lines to Data Points • Dealing with noisy data and multiple lines	Szeliski Ch 4 Trucco Ch 4-5
	15	***Midterm Exam***	
Visual Recognition	16-19	Deep Learning Overview • Introduction to Neural Nets and Gradient Descent • Convolutional Neural Network • Hands on session on Tensor Flow, Keras (Tutorial) Object Classification • ImageNet Challenge, AlexNet, GoogleLeNet etc Object Localization • Classification + Regression Head • R-CNN, Fast R-CNN	Research papers
Dense Motion Estimation and Image Stitching	20-22	Dense Motion Estimation and Image Stitching • Optical Flow • Pyramids • Parametric Methods for Image Alignment	Szeliski Ch 8-9
Structure from Motion	23-24	Structure from Motion • Rigid SFM (Factorization Method)	Szeliski Ch 7
Stereo	25-27	Stereo • Basic Formulation • Epipolar Constraint • Estimation of Fundamental Matrix • Point cloud from depth image	Trucco Ch 7-8

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Tentative Assignment Plan

Topic	Mode
Exploring Perspective Images	Written
2D Transformation	Written
3D Transformation	Written
Warping	Programming
Deep Learning – Object Localization	Programming
Rigid Structure from Motion	Programming
Photogrammetry	Programming
Image Mosaicing	Programming

Textbook(s)/Supplementary Readings

Computer Vision: Algorithms and Applications: This is the draft of a textbook recently written by Richard Szeliski, one of the leading researchers in the area, available in PDF form at http://szeliski.org/Book/

Introductory Techniques for 3D Computer Vision: This text, by Emanuel Trucco and Alessandro Verri, is very useful, especially for topics related to geometry.

Deep Learning: Ian Goodfellow, Yoshua Bengio, Aaron Courville, , MIT Press 2016, this is the most comprehensive and latest text on Deep Learning, and particularly discusses application in Computer Vision, http://www.deeplearningbook.org/