Lahore University of Management Sciences
CS 436 / CS 5310 / EE513 : Computer Vision Fundamentals
Fall 2023

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Course URL (if any)	LMS

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

COURSE PREREQUISITE(S)
CS 200 - Introduction to Programming Math 120/ Math 121 – Linear Algebra

Course Offering Details				
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 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 OpenCV/python. 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.

Grading Breakup and Policy

Assessment	**Weight (%)**
Assignments	30% (including programming and written assignments)
Quizzes	5%
Project	20%
Mid-term	20%
Final	25%

COURSE OVERVIEW

Module	Lectures	Topic	Book Chapters
Introduction	1	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
Feature Detection	2	Feature Detection • Edge Detection (2D convolution) • Corner Detection and Feature based alignment	Szeliski Ch 4 Trucco Ch 4-5
Visual Recognition	4	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
Geometric Transformations and Camera Models	10	Geometric Transformations and Camera Models • 2D transformations/3D transformations • 3D – 2D transformations • Camera Models • Camera Calibration	Szeliski Ch 2
Dense Motion Estimation and Image Stitching	2	Dense Motion Estimation and Image Stitching • Optical Flow • Pyramids	Szeliski Ch 8-9
Structure from Motion	2	Structure from Motion · Rigid SFM (Factorization Method)	Szeliski Ch 7
Stereo	5	Stereo • Basic Formulation • Epipolar Constraint • Estimation of Fundamental Matrix • Point cloud from depth image	Trucco Ch 7-8

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/