FALL 2022

16-720B Computer Vision

Last updated August 24, 2022

Days MW
Room DH A302 [Doherty Hall]
Time 11:50AM - 1:10 PM
Units 12
Lecturer Kris Kitani
TAs Rawal Khirodkar, Sheng-Yu Wang, Rohan Choudhury, Jinkun Cao, Arkadeep Chaudhury
Class Discussion and Slides `piazza.com/cmu/fall2022/16720b/home` (Code: 16720)
Zoom (Live Stream Only) Meeting ID: 947-7776-5416 (Passcode: 16720)

Description
This course introduces the fundamental techniques used in computer vision, that is, the analysis of patterns in visual images to reconstruct and understand the objects and scenes that generated them. Topics covered include image processing basics, Hough Transforms, feature detection, feature descriptors, image representations, image classification and object detection. We will also cover camera geometry, multi-view geometry, stereo, 3D reconstruction from images, optical flow, motion analysis and tracking.

Version
Version B of 16-720 is intended for students with prior knowledge of computer vision and prior exposure to machine learning. Undergraduate students should take 16-385 which is the undergraduate version of the class. Those with no exposure to computer vision or machine learning should take the A version of the class. Those with advance experience in computer vision should take the 800 level computer vision courses.

Prerequisites (self evaluation)
Linear Algebra, Multivariate Calculus, Probability theory, Programming

Grading
Programming Assignments 100% (6 assignments total).
(1) Hough Transform (10%)
(2) Bag of Visual Words (18%)
(3) Neural Networks (18%)
(4) Homography (18%)
(5) 3D Reconstruction (18%)
(6) LK Image Alignment and Tracking (18%)

Grades determined on an absolute scale. Typically 90% and above is A, 80% - 89% is B, 70% - 79% is C, 60% - 69% D, 59% or below is R. There will be extra credit opportunities for students who want to go deeper into the material.

Homework Submission, Regrades and Allowed Late Days
5 late days for the entire semester. Use up to 2 late days on one assignment. No credit for assignments submitted after using all late days (to prevent delay of grading). All regrade requests must be made within 2 weeks of the deadline. Additional late day can be granted for factors outside of your control (e.g., medical emergencies, sudden family emergencies, multiple overlapping assignment deadlines) but will not be granted for planned activities (*e.g.*, conference deadlines, vacation travel).

Educational Outcomes
(1) Implement the Hough Transform to detect lines in an image
(2) Extract SIFT features to build a Bag-of-Words representation of an image for classification
(3) Perform object recognition using a convolutional neural network
(4) Detect Harris Corners and implement the RANSAC algorithm to find the homography between two images
(5) Perform 3D reconstruction and stereo rectification to implement stereo block matching using two images
(6) Implement a gradient descent based image alignment algorithm to track objects in a video
(7) Students will learn how to use Python and PyTorch through the programming assignments

Academic Integrity
All encouraged to work together BUT you must do your own work (code and write up). If you work with someone, please include their name in your write up and inside any code that has been discussed. If we find highly identical write-ups or code without proper accreditation of collaborators, we will take action according to university policies. If you use someone's material, please given them credit by including a citation where necessary.

Take Care of Yourself
Do your best to maintain a healthy lifestyle this semester by eating well, exercising, avoiding drugs and alcohol, getting enough sleep and taking some time to relax. This will help you achieve your goals and cope with stress. All of us benefit from support during times of struggle. You are not alone. There are many helpful resources available on campus and an important part of the college experience is learning how to ask for help. Asking for support sooner rather than later is often helpful. If you or anyone you know experiences any academic stress, difficult life events, or feelings like anxiety or depression, we strongly encourage you to seek support. Counseling and Psychological Services (CaPS) is here to help: call 412-268-2922 and visit their website at `http://www.cmu.edu/counseling/`. Consider reaching out to a friend, faculty or family member you trust for help getting connected to the support that can help.

Class Schedule

Date	Topic	Due
	Image Representations	
Aug-29	Introductions, Policies, Grading, Applications of CV	
Aug-31	Filtering, Image Pyramids, Reconstruction	
Sept-5	NO CLASS (Labor Day)	
Sep-7	Fourier Domain	
Sep-12	Image Boundaries: Gradient Filters, Hough Transform	HW1 Released
Sep-14	Feature Detection: Harris Corners, Multi-scale Detection	
Sep-19	Feature Descriptors: SIFT, HOG	
Sep-21	Image Representations: GIST, BOW	HW1 Due
	Visual Cognition	
Sep-26	Classfication methods: K-NN, Naive Bayes, SVM	HW2 Released
Sep-28	Training Neural Networks: Perceptron, Gradient Descent, SGD	HW1 Graded
Oct-3	Optimization (Momentum, ADAM), Convolutional Neural Networks	
Oct-5	LeNet, AlexNet (ReLU, LN, dropout), VGG, GoogleNet	HW2 Due
Oct-10	ResNet, RCNN, Fast RCNN, Faster RCNN, YOLO, SSD	HW3 Released
Oct-12	Visual Transformers (ViT, DETR), GAN, VAE	HW2 Graded
Oct-17	NO CLASS (Fall break)	
Oct-19	NO CLASS (Fall Break)	
	Motion and Structure	
Oct-24	2D Transformations (Euclidean, similarity, affine, projective)	
Oct-26	Homography estimation (algebraic, data-driven)	HW3 Due
Oct-31	Single View Geometry (camera matrix, vanishing points)	HW4 Released
Nov-2	Pose Estimation, Triangulation, Epipolar Geometry	HW3 Graded
Nov-7	Fundamental Matrix Estimation (algebraic, data-driven)	HW4 Due
Nov-9	SFM (Reconstruction, Bundle Adjustment)	HW5 Released
Nov-14	Stereo (Rectification, Block Matching, Graph Cut, data-driven)	HW4 Graded
Nov-16	Optical Flow (Constant Flow, Horn and Schunck, data-driven)	HW5 Due
Nov-21	Image Alignment (Lucas-Kanade, Baker-Matthews)	HW6 Released
	New Topics	
Nov-23	NO CLASS (THANKSGIVING)	
Nov-28	Advanced Topics	HW5 Graded
Nov-30	Advanced Topics	HW6 Due
Dec-5	Advanced Topics	HW6 Graded
Dec-7	Advanced Topics	