CS6350: Computer Vision

July-Nov Semester 2023
Slot; G
Slots: Monday: 12:00-12:50pm, Wednesday: 5:00-5:50pm
Thursday: 10:00-10:50am, Friday: 9:00-9:50am

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Updated on August 15, 2023

Note: The course webpage is `www.cse.iitm.ac.in/~vplab/computer_vision.html`. A google group will be formed for course related communications; please check the e-mail regularly.

1 Course Objectives

Computer Vision focuses on development of algorithms and techniques to analyze and interpret the visible world around us. This requires an understanding of the fundamental concepts related to multi-dimensional signal processing, feature extraction, pattern analysis visual geometric modeling, stochastic optimization etc. Knowledge of these concepts is necessary in this field, to explore and contribute to research and further developments in the field of computer vision. Applications range from biometrics, medical diagnosis, document processing, mining of visual content, to surveillance, advanced rendering etc.

2 Learning Outcomes

- To apply mathematical modeling methods for low-, intermediate- and high- level image processing tasks
- To be able to design new algorithms to solve recent state of the art computer vision problems.
- To perform software experiments on computer vision problems and compare their performance with the state of the art.
- To develop a broad knowledge base so as to easily relate to the existing literature.
- To gather a basic understanding about the geometric relationships between 2D images and the 3D world.
- To build a complete system to solve a computer vision problem.

3 Course prerequisite(s)

COT

4 Classroom Mode

Traditional lectures ($4 \times$ [50 mins. slots] per week) with slides. 5-6 tutorials are tentatively planned to be conducted within these slots.

5 Textbooks

- Richard Szeliski, Computer Vision: Algorithms and Applications, Springer-Verlag London Limited 2011.
- Richard Hartley and Andrew Zisserman, Multiple View Geometry in Computer Vision, 2ndEdition, Cambridge University Press, March 2004

6 Reference Books

- R. Bishop; Pattern Recognition and Machine Learning, Springer, 2006
- R.C. Gonzalez and R.E. Woods, Digital Image Processing, Addison- Wesley, 1992.
- K. Fukunaga; Introduction to Statistical Pattern Recognition, Second Edition, Academic Press,Morgan Kaufmann, 1990.

7 Course Requirements

You are required to attend all the lectures. If you miss any of them it is your responsibility to find out what went on during the classes and to collect any materials that may be handed out. Class participation is strongly encouraged to demonstrate an appropriate level of understanding of the material being discussed in the class. Regular feedback from the class regarding the lectures will be very much appreciated.

8 Planned Syllabus

- Digital Image Formation and low-level processing: Overview and State-of-the-art, *Fundamentals of Image Formation, Transformation: Orthogonal, Euclidean*, Affine, Projective, etc; *Fourier Transform*, Convolution and Filtering, Image Enhancement, Restoration, *Histogram Processing*

- Depth estimation and Multi-camera views: *Perspective, Binocular Stereopsis*: Camera and Epipolar Geometry; Homography, Rectification, DLT, RANSAC, 3-D reconstruction framework; Auto-calibration.

- Feature Extraction: Edges - Canny, LOG, DOG; Line detectors (Hough Transform), Corners - Harris and Hessian Affine, Orientation Histogram, SIFT, SURF, HOG, GLOH, Scale-Space Analysis- Image Pyramids and Gaussian derivative filters, Gabor Filters and DWT.

- Image Segmentation: *Region Growing, Edge Based approaches to segmentation*, Graph-Cut, Mean-Shift, MRFs, Texture Segmentation; Object detection.

- Pattern Analysis: *Basics of Probability and Statistics*, Clustering: K-Means, K-Medoids, Mixture of Gaussians, Classification: Discriminant Function, Supervised, Un-supervised, Semi-supervised; Classifiers: Bayes, KNN, ANN models; Dimensionality Reduction: PCA, LDA, ICA; Non-parametric methods.

- Motion Analysis: Background Subtraction and Modeling, Optical Flow, KLT, Spatio-Temporal Analysis, Dynamic Stereo; Motion parameter estimation.

- Shape from X: Light at Surfaces; Phong Model; Reflectance Map; Albedo estimation. Photometric Stereo; Use of Surface Smoothness Constraint; Shape from Texture, color, motion and edges.

The topics shown in *italic* font will be left for self-study.

9 Tentative Grading Policy

The following allocation of marks is **tentative**. The flexibility will be used to the benefit of average grades for the entire class.

Quiz (50 mins)	15-20
End Sem Exam (120-150 mins)	35-40
TPA*	30-35
Tuts(best n-1)	10-15
Total	100

∗ Students are expected to make their own arrangements- personal laptops, servers or desktops in their respective departments, or even use Google Colab. Only during final demo, a GPU-based system will be kept ready for installation and use.

10 Tentative Schedule (Dates)

Tentative dates of activities throughout the semester:

Finalizing the groups by students	21/08/2023
Choice of TPA by students	28/08/2023
TPA Assignment to each group	31/08/2023
TA Interaction for TPA	27/09/2023
Interim TPA Review (optional)	18/10/2023
Final TPA Demo/Viva Slot 1	21/11/2023
Final TPA Demo/Viva Slot 2	27/11/2023
Tutorial 1	10/08/2023,
Tutorial 2	24/08/2023
Tutorial 3	07/09/2023
Tutorial 4	5/10/2023
Tutorial 5	19/10/2023
Tutorial 6	2/11/2023 (Optional)
Mid Semester exam	21/09/2023
Extra Classes	TBA
End Semester Exam	15/11/2023

Please note that whatever is announced in class will be final.

11 Academic Honesty

Academic honesty is expected from each student participating in the course. NO sharing (willing, unwilling, knowing, unknowing) of assignment code between students, submission of downloaded code (from the Internet, or anywhere else) is allowed.

Academic violations will be handled by IITM Senate Discipline and Welfare (DISCO) Committee. Typically, the first violation instance will result in ZERO marks for the corresponding component of the Course Grade and a drop of one-penalty level in final course grade. The second instance of code copying will result in same as above for marks but drop of two levels of final course grades at end of semester. The DISCO Committee of IIT Madras will also be intimated of the matter.

Please protect your Moodle account password. Do not share it with ANYONE. Do not share your academic disk drive space on the Campus LAN.

Each proxy in the attendance will be penalized by 5% of (absolute) marks. It becomes 2% each for the donor & beneficiary, if both accept the fault.

Tutorials are not exams. Occasional exchange of technical ideas is permitted, but not copying. No complaints of copying will be entertained after the tutorial. If you find anybody copying, immediately inform the TA's present. If guilty, their copies will be taken away and they will obtain 0 marks for that tutorial. In case if classes are conducted in online mode, recording of any discussions on your digital device without taking permission of the teacher is disallowed. If any found to do that, it will be reported to Deptt/IITM level ethical committee. Recorded video lectures may not be distributed to anyone else, other than TAs, registered students. Posting same on any online/digital media platform is illegal and will also be reported.

12 Basic Preparation and Background Knowledge

The students are expected to have a basic knowledge of the following:

- Linear Algebra
- Fundamentals of Probability and Statistics
- Basics of DSP
- Euclidean Geometry
- Programming - Python/ C/C++ / Matlab
- Basics of PRML, DL (basics may give you an advantage)

Miscellaneous Instructions:

- Self-study topics of the syllabus, as announced, may be studied without delay.
- Advisable to use OpenCV techniques
- Clarification of topics covered in class can be asked over email to TA or Google form circulated.