cs512 Computer Vision

Fall 2024 (Tuesday, Thursday 5-6:15pm, SB-104)

Administrative Information

Staff

- **Instructor:** *Gady Agam (agam@iit.edu)*
- **TA:** *Kaiyue Zhu (kzhu6@hawk.iit.edu)*
- **TA:** *Gai Hao (ghao3@hawk.iit.edu)*
- *Office hours and contact information: Link*

Grading

Component	*Description*	*Weight*
Assignments	*4-7 TBD*	*30%*
Project	*Project + Presentation*	*20%*
Midterm Exam	*Open notes (1 double-sided 8.5x11" page)*	*10%*
Final Exam	*Open notes (2 double-sided 8.5x11" pages)*	*40%*
Total	*Grade Scale: A > 90%, B > 80%, C > 70%, ...*	*100%*

Rules

1. **Assignments***: In addition to the regular course assignments, there is an additional mandatory assignment (Assignment 0) which does not carry any credit. There is a penalty of 5% for not submitting this assignment. Students may be invited to discuss their assignments as part of grading.*

2. **Late Days***: There is a total of 6 "free late days" with no grade penalty for all assignments to cover various reasons such as illness, being busy, network or computer problems, etc. Up to 2 free late days may be applied to each assignment. Beyond the allowed free late days, a grade reduction of 25% per day will be applied. Late days are counted during weekends and holidays. The final project cannot be late. No submission will be accepted beyond the last day of classes.*

3. **Due Time**: *Assignments are due at 10 PM on the due date. There is a 2-hour grace period where no penalty is applied. Anything submitted beyond the 2-hour grace period will incur a late day.*

4. **Academic Integrity**: *Each member of this course is responsible for maintaining the highest standards of academic integrity. All breaches of academic integrity must be reported immediately. Copying programs from any source (e.g., other students or the web) is considered a serious breach of academic integrity.*

5. **Exams**: *If you cannot attend a scheduled exam, whether for justified or unjustified reasons, you must notify the instructor by email. Not attending an exam without prior notification will result in failing the exam, regardless of whether the reason was justified. Claiming not to know the date of an exam is not a valid reason and will result in failing the exam. The final exam date will be set by the registrar.*

6. **Remote Students**: *Remote students outside the IIT main campus who plan to take the exam at a remote location must contact IIT Online to arrange for a proctor at the remote location and notify the instructor by email.*

7. **Attendance**: *Attendance is not mandatory as long as you watch the recorded lectures.*

8. **Classroom Etiquette**: *Be prepared for class; pay attention, participate, and be respectful to others. Take responsibility for learning. Do not use your phone, eat, or read when class is in session. Do not have private conversations with others when class is in session. If you arrive late, sit in the back. If you need to leave early, sit in the back and inform the instructor ahead of time.*

Course Outline

What to Expect from This Course

This course focuses on the understanding of algorithms and techniques used in computer vision. Students are expected to write computer programs implementing different techniques taught in the course. A mathematical background and some programming experience are required. This course does not intend to teach how to use specific application software. Prerequisites:

- *Basic math: calculus, working with vectors and matrices*
- *Machine learning: basic neural networks, hyper parameter tuning, performance evaluation*
- *Fundamental algorithms (cs430)*

Objectives

- *Introduce the fundamental problems of computer vision.*

- *Provide an understanding of techniques, mathematical concepts, and algorithms used in computer vision to facilitate further study.*
- *Provide pointers into the literature and exercise a project based on a literature search and one or more research papers.*
- *Practice software implementation of different concepts and techniques covered in the course.*
- *Utilize programming and scientific tools for relevant software implementation.*

Outline

1. **Introduction***: Overview of computer vision, related areas, and applications; overview of software tools; overview of course objectives; introduction to OpenCV.*
2. **Image Formation and Representation***: Imaging geometry, radiometry, digitization, cameras and projections, rigid and affine transformations.*
3. **Filtering and Feature Detection***: Convolution, smoothing, differencing, and scale space. Edge detection, corner detection, descriptors.*
4. **Model Fitting***: Line fitting, ellipse and conic sections fitting, algebraic and Euclidean distance measures, robust estimation.*
5. **Deep Learning***: Deep convolutional neural networks, vision transformers.*
6. **Object Recognition***: Image classification, object classification, invariance, generalization, data-driven recognition.*
7. **Localization and Detection***: Object localization, object detection, evaluation metrics, candidate selection, single-shot detection, two-shot detection, weakly supervised approaches.*
8. **Segmentation***: Color segmentation, structural segmentation, instance segmentation, semantic segmentation.*
9. **Camera Calibration***: Camera models; intrinsic and extrinsic parameters; radial lens distortion; direct parameter calibration; camera parameters from projection matrices; orthographic, weak perspective, affine, and perspective camera models.*
10. **Epipolar Geometry***: Introduction to projective geometry; epipolar constraints; the essential and fundamental matrices; estimation of the essential/fundamental matrix.*
11. **Model Reconstruction***: Reconstruction by triangulation; Euclidean reconstruction; affine and projective reconstruction.*
12. **Motion Analysis (*)***: The motion field of rigid objects; motion parallax; optical flow, the image brightness constancy equation, affine flow; differential techniques; feature-based techniques; regularization and robust estimation; motion segmentation through EM.*

13. **Motion Tracking (*)**: *Statistical filtering; iterated estimation; observability and linear systems; the Kalman filter; the extended Kalman filter.*

14. **Final Presentation**: *Students present selected topics and develop software implementation of related techniques based on the review of relevant literature. The work should be summarized in a concluding report, including simulation results. A list of possible topics will be advertised before the project selection due date.*

Course Materials

1. *Course materials are posted at: Link*

2. *Note: To access the materials, you must be signed into your IIT email account. If you receive a permission error, sign out of any personal accounts and then sign back it to your IIT email account at https://my.iit.edu or https://mail.google.com.*

Books

1. **Computer Vision: Algorithms and Applications, 2nd ed.**, *R. Szeliski, Springer, 2022. Link*

2. **Dive into Deep Learning**, *Aston Zhang, Zachary Lipton, Mu Li, and Alexander Smola, 2021. Link*