CS-512 Computer Vision

Spring 2022 (Tue, Thu 5:00pm – 6:15pm, SB-104)

http://www.cs.iit.edu/∼agam/cs512/

Administrative information

Staff

- Instructor:
  Gady Agam (*agam@iit.edu*, x7-5834)
  Office hours: Tue, Thu 6:30 - 7:30pm (CDT)
- TA:
  Kaiyue Zhu (*kzhu6@hawk.iit.edu*)
  Office hours: Tue, Thu 3:30-4:30pm (CDT)
  Google meet link: https://meet.google.com/mfy-ogmd-gai

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. As part of grading assignments students may be invited to discuss their assignments.
2. *Late days*: there is a total of 6 "free late days" with no grade penalty for all the assignments to cover various reasons such as not feeling well, being busy, network or computer problems, etc. Up to 2 free late days may be applied to each assignment. Being late beyond what is allowed by the free late days will result in a grade reduction of 25% per day. Late days are counted during weekends and holidays. The final project can not be late. No submission will be accepted beyond the last day of classes.
3. *Due time*: The time when assignments are due is 10pm on the due date. There is 2 hour grace period when no penalty is applied. Anything beyond the 2 hour grace period will incur a late day.
4. *Academic integrity*: Each member of this course bears responsibility for maintaining the highest standards of academic integrity. All breaches of academic integrity must be reported immediately. Copying of programs from any source (e.g. other students or the web) is considered to be a serious breach of academic integrity.

5. *Exams*: If you cannot attend a scheduled exam whether for justified or unjustified reason you must notify me by email. Not attending an exam without prior notification will result in failing the exam whether the reason was justified or not. Claiming not to know the date of an exam is not a valid reason and will result in failing the exam. The tentative final exam date (pending confirmation by the registrar) is: 5/3 5-7pm.
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.

Course outline

What to expect from this course

Computer vision can be covered at different levels. The focus of this course is the understanding of algorithms and techniques used in computer vision. Students in the course are expected to write computer programs implementing different techniques taught in the course. The course requires mathematical background and some programming experience. This course does *not* intend to teach how to use a specific application software.

Objectives

- Introduce the fundamental problems of computer vision.
- Provide understanding of techniques, mathematical concepts and algorithms used in computer vision to facilitate further study in this area.
- 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, scale space, edge detection, corner detection, line and curve detection, active contours, descriptors.
4. Model fitting and optimization: Hough transform, line fitting, ellipse and conic sections fitting, algebraic and Euclidean distance measures.
5. Deep learning: Deep convolutional neural networks, GPU frameworks for deep learning, hyper parameters, regularization, optimization algorithms.
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.

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 which should include simulation results. A list of possible topics will be advertised prior to the project selection due date.

Required text

- Computer Vision: Algorithms and Applications, R. Szeliski, 2nd ed., 2021.

Additional references

- Computer Vision: A Modern Approach, D. Forsyth and J. Ponce, Prentice Hall, 2nd ed., 2011.