Wrap-up
Course announcements

• Homework 7 is due on Sunday 5\textsuperscript{th}.
  - You can use any of your remaining late days.
  - Any questions about homework 7?
  - How many of you have looked at/started/finished the homework?

• Office hours this week:
  - Yannis will have additional office hours on Thursday, 6 – 8 pm.
  - On Friday, Bruce and Yannis will switch office hours.
Class evaluation*s* – please take them!

- CMU’s Faculty Course Evaluations (FCE): [https://cmu.smartevals.com/](https://cmu.smartevals.com/)
- 16-385 end-of-semester survey: Will be posted on Piazza.
- Please take both, super helpful for developing future offerings of the class.
- Thanks in advance!
Course overview

1. Image processing. \[\Rightarrow\] Lectures 1 – 7
   See also 18-793: Image and Video Processing

2. Geometry-based vision. \[\Rightarrow\] Lectures 7 – 12
   See also 16-822: Geometry-based Methods in Vision

3. Physics-based vision. \[\Rightarrow\] Lectures 13 – 16
   See also 16-823: Physics-based Methods in Vision
   See also 15-462: Computer Graphics
   See also 15-463: Computational Photography

4. Semantic vision. \[\Rightarrow\] Lectures 17 – 20
   See also 16-824: Vision Learning and Recognition
   See also 10-703: Deep Reinforcement Learning

5. Dealing with motion. \[\Rightarrow\] Lectures 21 – 24
   See also 16-831: Statistical Techniques in Robotics
   See also 16-833: Robot Localization and Mapping
Image processing

Image filtering

Image pyramids

Fourier filtering

Image gradients

Boundaries

Hough Transform
Image features

Corner detection  Multi-scale detection

Haar-like  HOG  SURF  SIFT
2D alignment

2D Transforms

DLT

RANSAC

Homography
Camera and multi-view geometry

\[ x = PX \]

camera matrix \quad pose estimation \quad triangulation

\[ F \]

fundamental matrix \quad epipolar geometry \quad Reconstruction
Stereo

Stereo Rectification

Block matching

Energy minimization
Image formation and physics

Radiometry and image formation

Photometric stereo

Image processing pipeline

Radiometric and color calibration
Object recognition

- Bag-of-words
- K-means

- Nearest Neighbor
- Naive Bayes
- SVM
Neural networks

Perceptron

Convolutional Neural Networks

Gradient Decent
Optical flow and alignment

\[
\begin{bmatrix}
I_x(p_1) & I_y(p_1) \\
I_x(p_2) & I_y(p_2) \\
\vdots & \vdots \\
I_x(p_{25}) & I_y(p_{25})
\end{bmatrix}
\begin{bmatrix}
u \\ v
\end{bmatrix} = -
\begin{bmatrix}
I_i(p_1) \\
I_i(p_2) \\
\vdots \\
I_i(p_{25})
\end{bmatrix}
\]

\[
\min_{u, v} \sum_{i,j} \left\{ E_d(i, j) + \lambda E_s(i, j) \right\}
\]

Constant Flow

Horn-Schunck

Lucas-Kanade
(Forward additive)

Baker-Matthews
(Inverse Compositional)
Tracking in videos

KLT

Mean shift

Kalman Filtering

SLAM
Things you should know how to do

1. Detect lines (circles, shapes) in an image.
2. Perform automatic image warping and basic AR.
3. Reconstruct 3D scene structure from two images.
4. Do photometric stereo and render simple images.
5. Recognize objects using a bag-of-words model.
6. Recognize objects using deep CNNs.
7. Track objects in video.
Questions?
Do you plan on taking any other vision courses?
Which part of the class did you like the most?
Which part of the class did you like the least?
Any topics you wanted to learn more about?
Any topics you wanted to learn less about?
Would the class work better if we did learning first?
Which was your favorite homework?
Which was your least favorite homework?
How does homework difficulty compare to other classes?
Would it be better if homeworks were in Python?