

# Wrap-up



# Class evaluation\*s\* – please take them!

- CMU's Faculty Course Evaluations (FCE): <https://cmu.smartevals.com/>
- 16-385 end-of-semester survey:  
[https://docs.google.com/forms/d/e/1FAIpQLSfdE0h-FteRYJyDzsx3Pp5hmWUOTiz8A2gJgthA5Vlty7yG0A/viewform?usp=sf\\_link](https://docs.google.com/forms/d/e/1FAIpQLSfdE0h-FteRYJyDzsx3Pp5hmWUOTiz8A2gJgthA5Vlty7yG0A/viewform?usp=sf_link)
- Please take both, super helpful for developing future offerings of the class.
- Thanks in advance!

# Course overview

1. Image processing. ← Lectures 1 – 7  
See also 18-793: Image and Video Processing
2. Geometry-based vision. ← Lectures 7 – 12  
See also 16-822: Geometry-based Methods in Vision
3. Physics-based vision. ← 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. ← Lectures 17 – 20  
See also 16-824: Vision Learning and Recognition  
See also 10-703: Deep Reinforcement Learning
5. Dealing with motion. ← Lectures 21 – 24  
See also 16-831: Statistical Techniques in Robotics  
See also 16-833: Robot Localization and Mapping

# Image processing



Image filtering

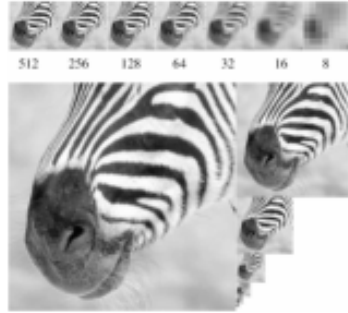


image pyramids



Fourier filtering

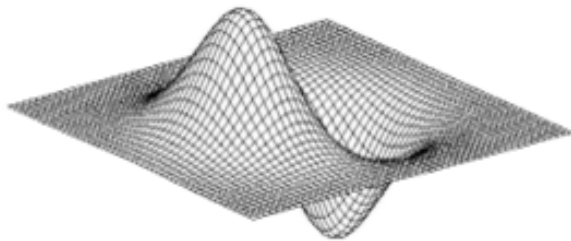
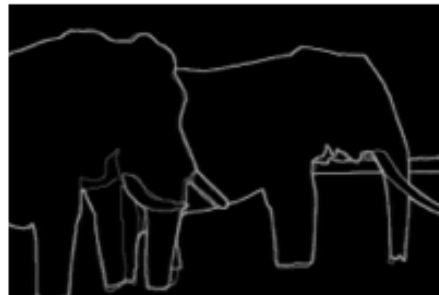
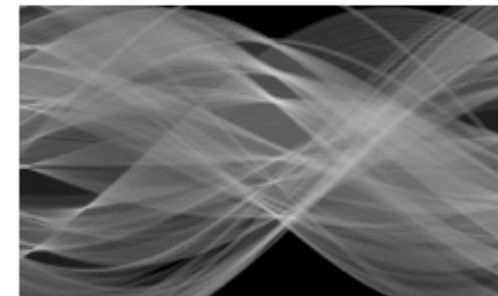


Image gradients



Boundaries



Hough Transform

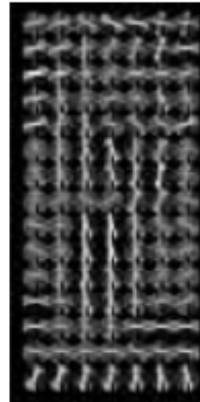
# Image features



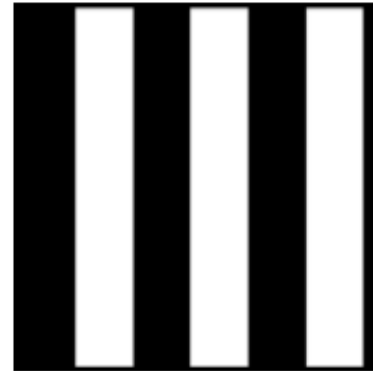
Corner detection    Multi-scale detection



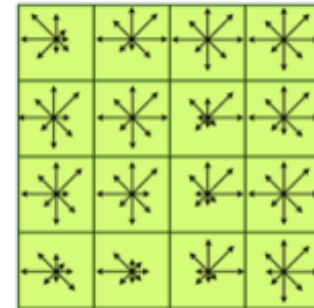
Haar-like



HOG



SURF



SIFT

# 2D alignment

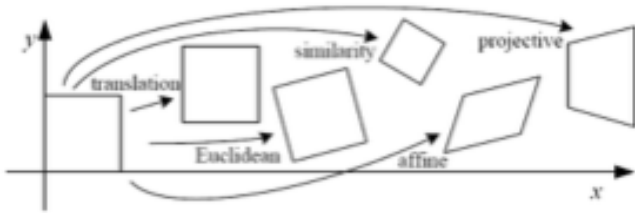
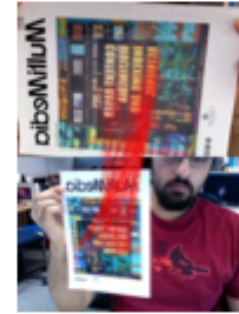


Figure 1: Basic set of 2D planar transformations

2D Transforms



DLT



RANSAC

# H

Homography

# Camera and multi-view geometry

$$x = PX$$

camera matrix

**P**

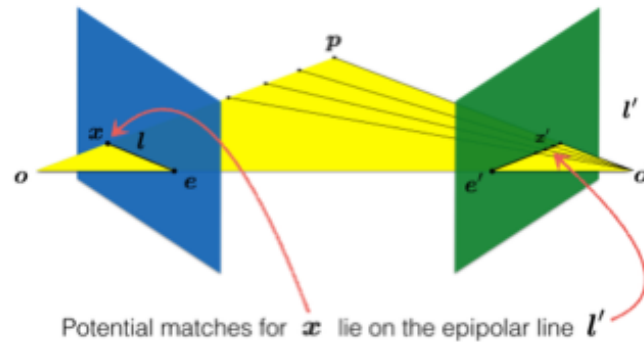
pose estimation

**X**

triangulation

**F**

fundamental matrix

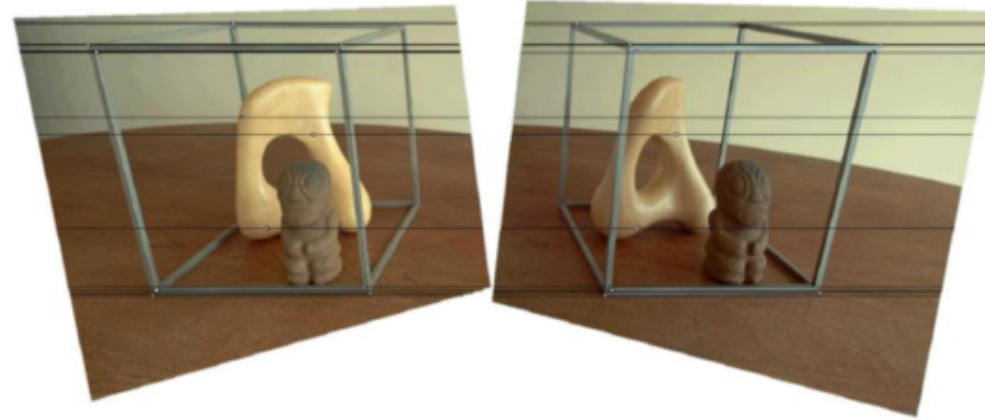


epipolar geometry

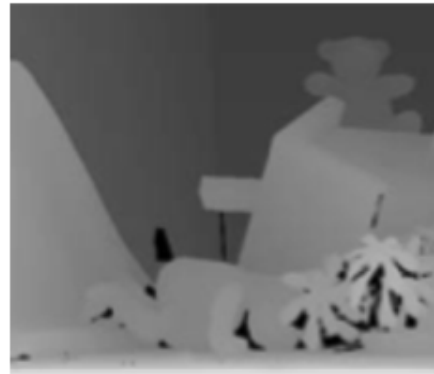


Reconstruction

# Stereo



Stereo Rectification



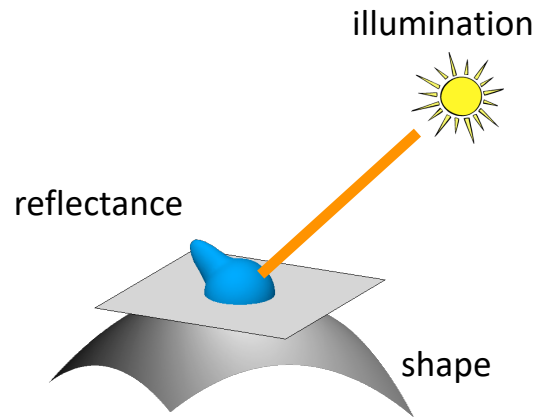
Block matching



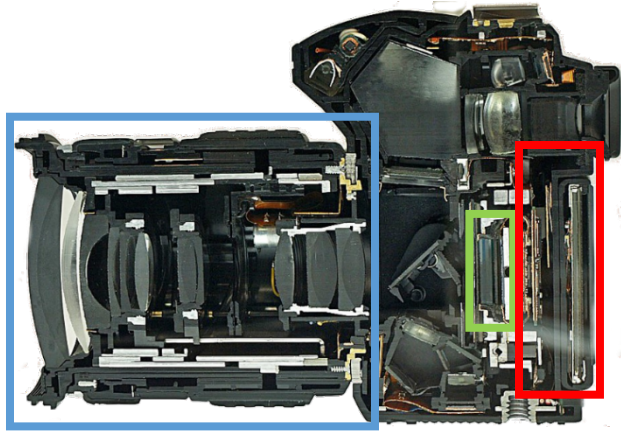
Energy minimization



# Image formation and physics

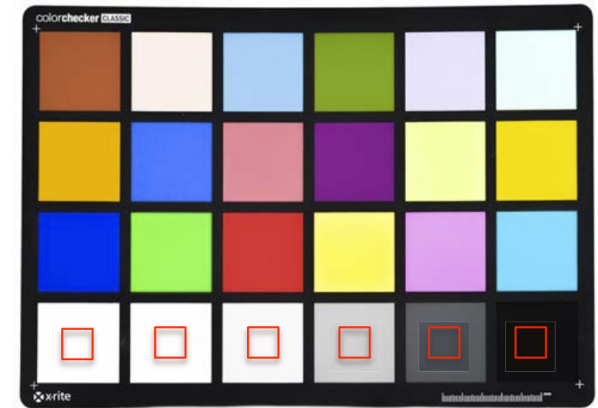


## Radiometry and image formation



## Image processing pipeline

## Photometric stereo

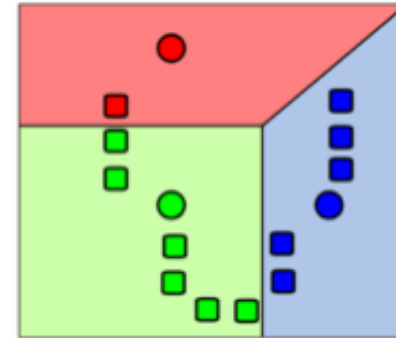


## Radiometric and color calibration

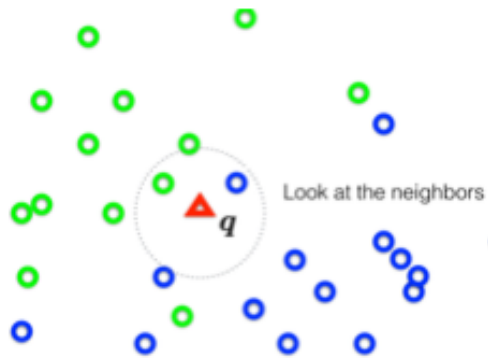
# Object recognition



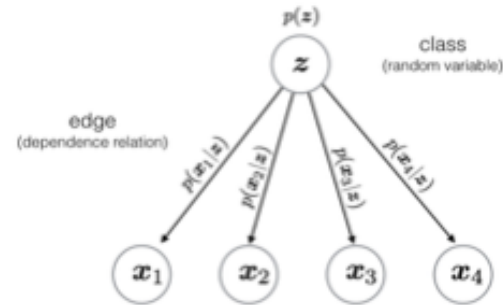
Bag-of-words



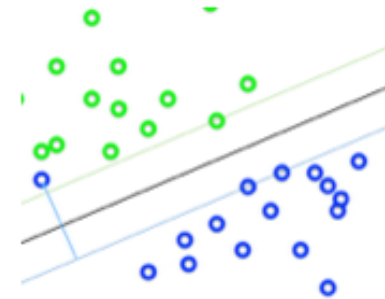
K-means



Nearest Neighbor

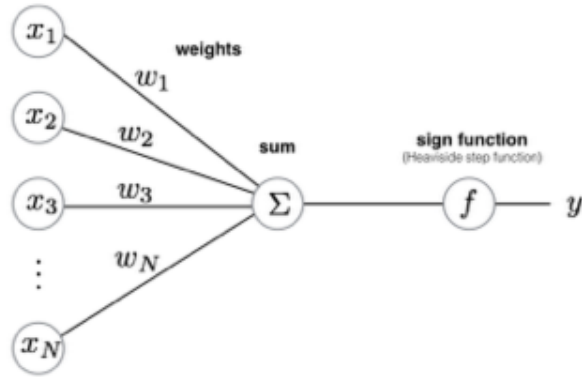


Naive Bayes

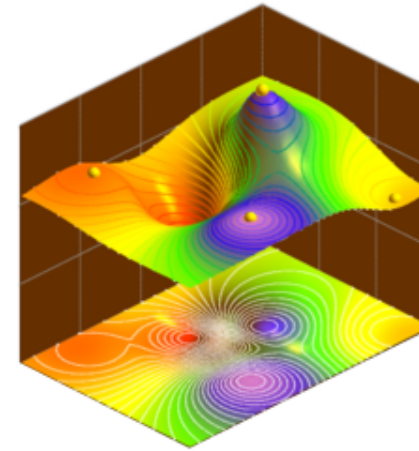


SVM

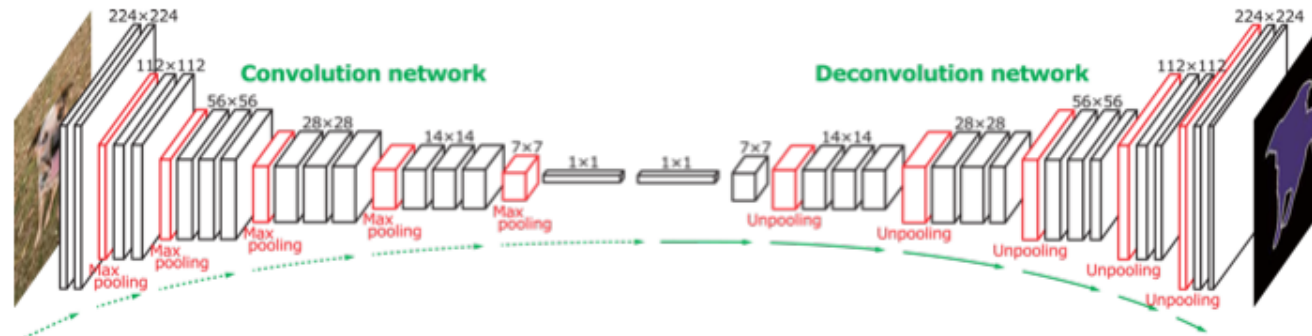
# Neural networks



Perceptron



Gradient Decent



Convolutional Neural Networks

# Optical flow and alignment

$$\begin{bmatrix} I_x(\mathbf{p}_1) & I_y(\mathbf{p}_1) \\ I_x(\mathbf{p}_2) & I_y(\mathbf{p}_2) \\ \vdots & \vdots \\ I_x(\mathbf{p}_{25}) & I_y(\mathbf{p}_{25}) \end{bmatrix} \begin{bmatrix} u \\ v \end{bmatrix} = - \begin{bmatrix} I_t(\mathbf{p}_1) \\ I_t(\mathbf{p}_2) \\ \vdots \\ I_t(\mathbf{p}_{25}) \end{bmatrix}$$

Constant Flow

$$\min_{\mathbf{u}, \mathbf{v}} \sum_{ij} \left\{ E_d(i, j) + \lambda E_s(i, j) \right\}$$

Horn-Schunck



Lucas-Kanade  
(Forward additive)

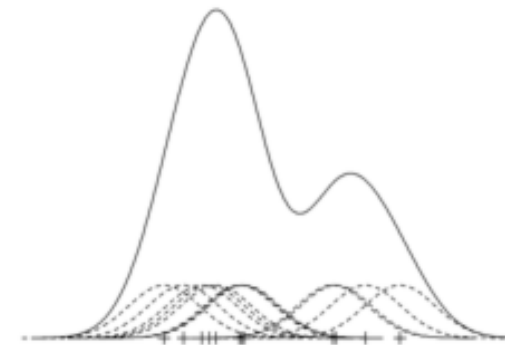


Baker-Matthews  
(Inverse Compositional)

# Tracking in videos



KLT



Mean shift

# 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?

Which was your favorite programming assignment?

Which was your least favorite programming assignment?

Would it be better if programming assignments were  
in Matlab?

Do the take-home quizzes work?



How does course workload compare to other classes?

How does course difficulty compare to other classes?

Did you find the course website feed useful?

Did you find the course notebooks/demos useful?

Did you find the Discord server useful?