

EE 5178 : Modern Computer Vision

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The goal of computer vision

- To extract “meaning” from pixels



What we see

0	3	2	5	4	7	6	9	8
3	0	1	2	3	4	5	6	7
2	1	0	3	2	5	4	7	6
5	2	3	0	1	2	3	4	5
4	3	2	1	0	3	2	5	4
7	4	5	2	3	0	1	2	3
6	5	4	3	2	1	0	3	2
9	6	7	4	5	2	3	0	1
8	7	6	5	4	3	2	1	0

What a computer sees

What kind of information can be extracted from an image?

- ❖ Semantic information

- ❖ Metric information

Vision as a source of semantic information



slide credit: Fei-Fei, Fergus & Torralba

Object categorization



Scene and context categorization

- outdoor
- city
- traffic
- ...



Vision as measurement device

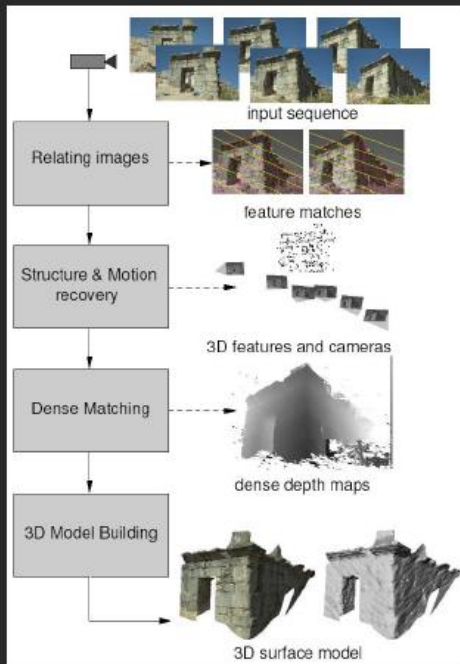
Real-time stereo



NASA Mars Rover

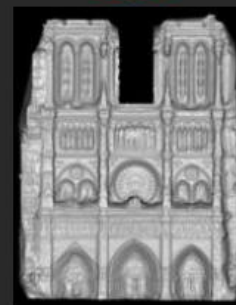


Structure from motion



Pollefeys et al.

Reconstruction from Internet photo collections



Goesele et al.

Semantic Computer Vision tasks

Object Recognition

ImageNet Challenge

Given an image,
predict one of 1000
different classes

Image credit:

www.cs.toronto.edu/~fritz/absps/imagenet.pdf



Object/face Detection (Recognition + Localization)

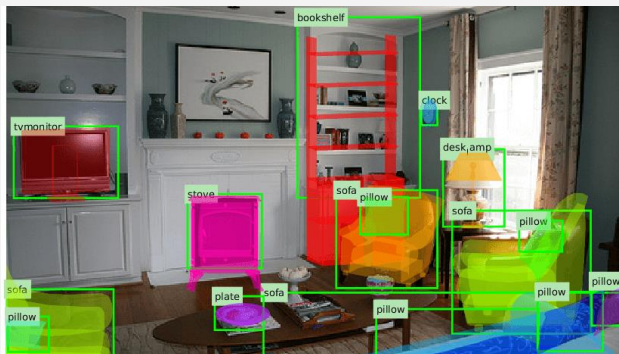
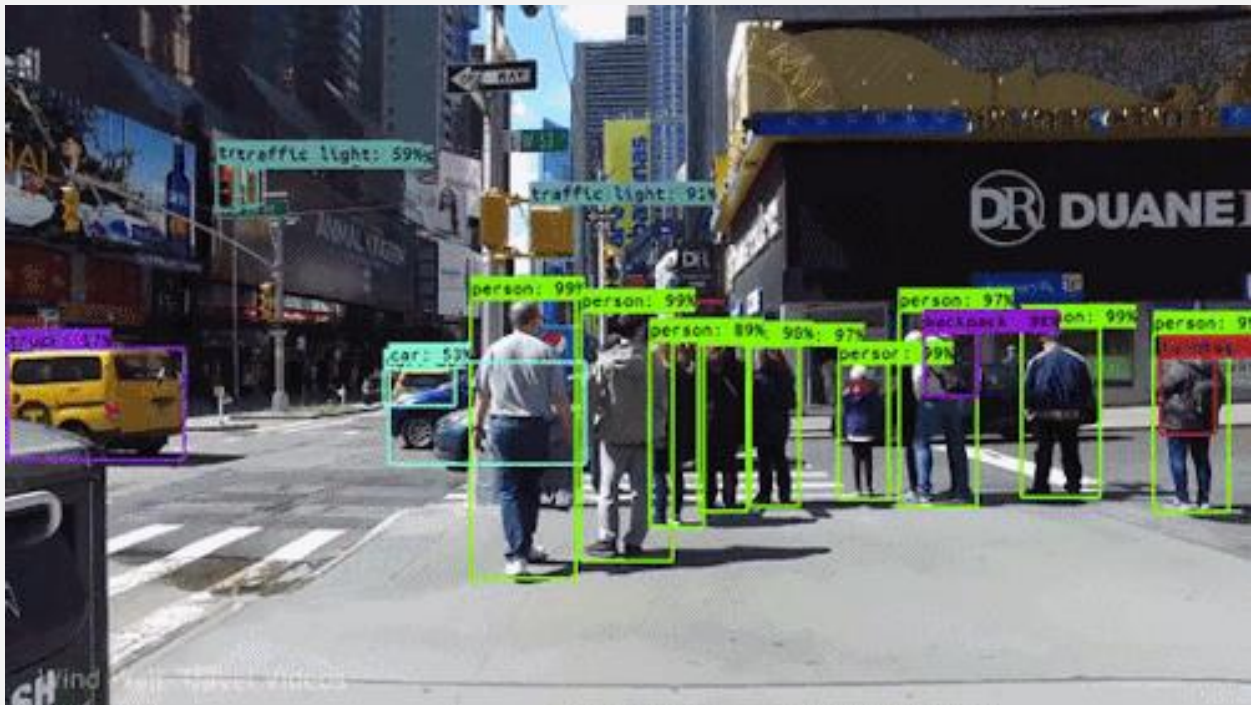
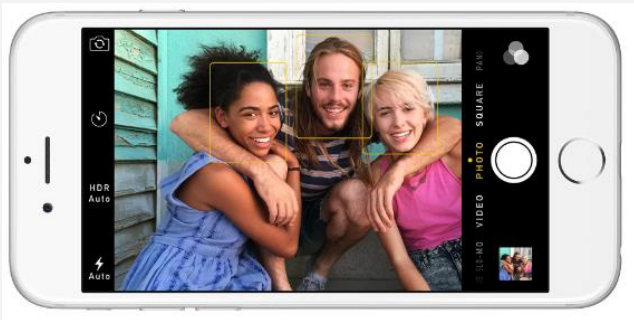


Image Source



You Only Look Once: Unified, Real-Time Object Detection

Face detection + Localization + Classification



Image Source

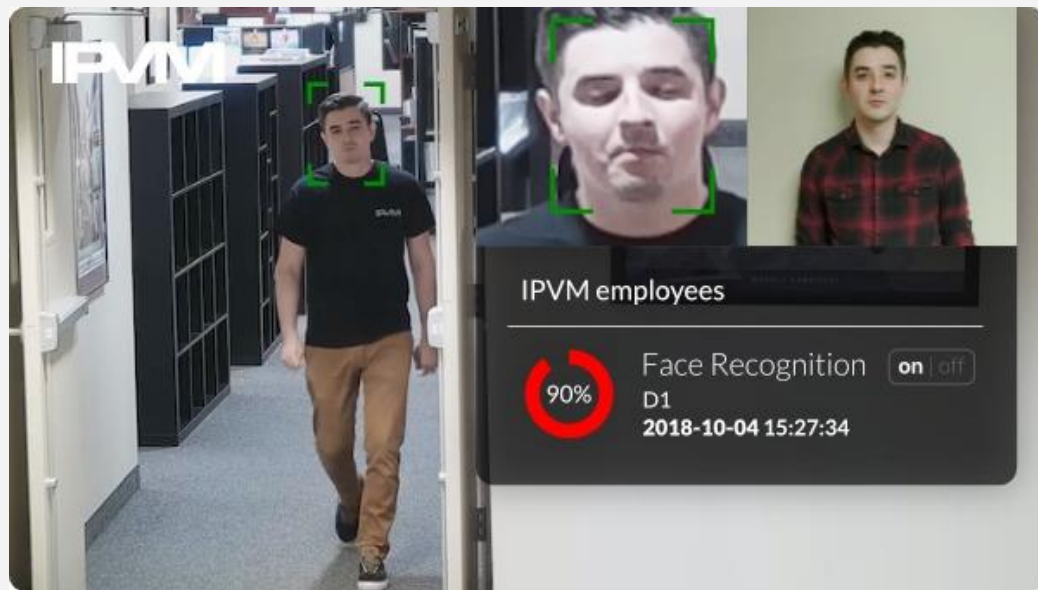


Image Source

Number Plate Reader

4YCH428
4YCH428
4YCH428

License plate readers

http://en.wikipedia.org/wiki/Automatic_number_plate_recognition

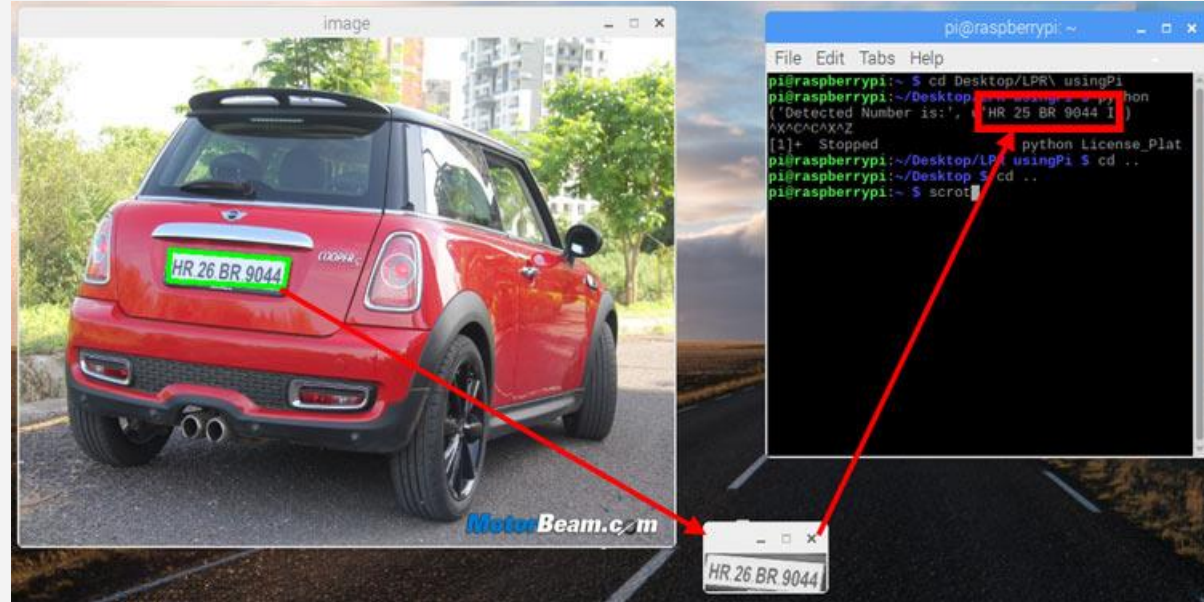
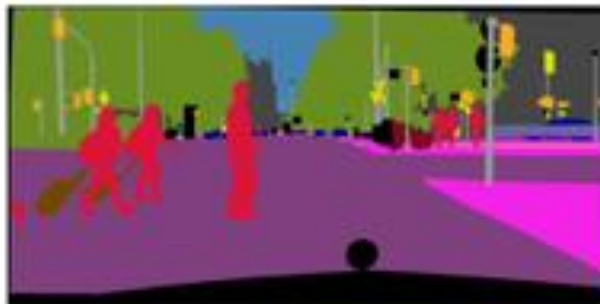


Image Segmentation



Semantic Image Segmentation

DeepLab V3 xception_cityscapes_trainfine (GTX980M) INPUT_SIZE=1539
Prediction time: 407ms (2.5 fps) AVG: 337ms (3.0 fps)



Road extraction from Satellite Images

SAT
Images



Results



Hand-
drawn

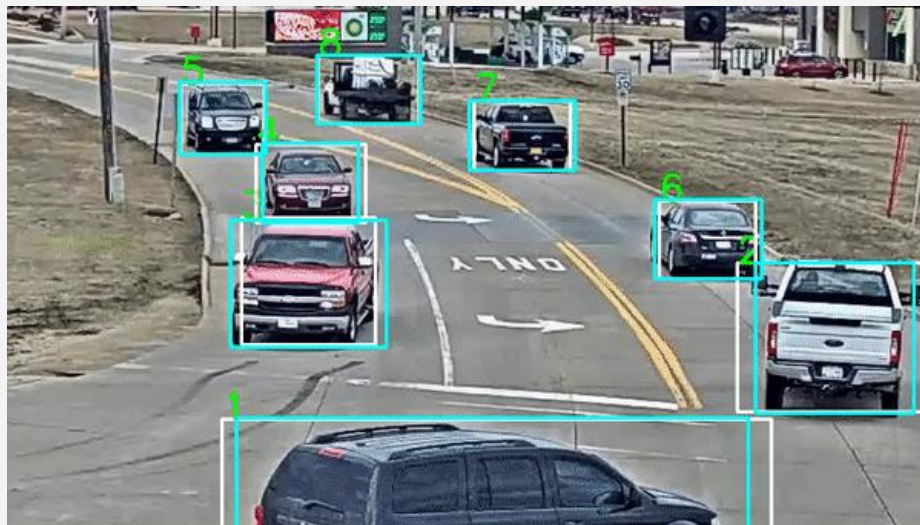


Courtesy: Prof.
Sukhendu Das

Object Tracking

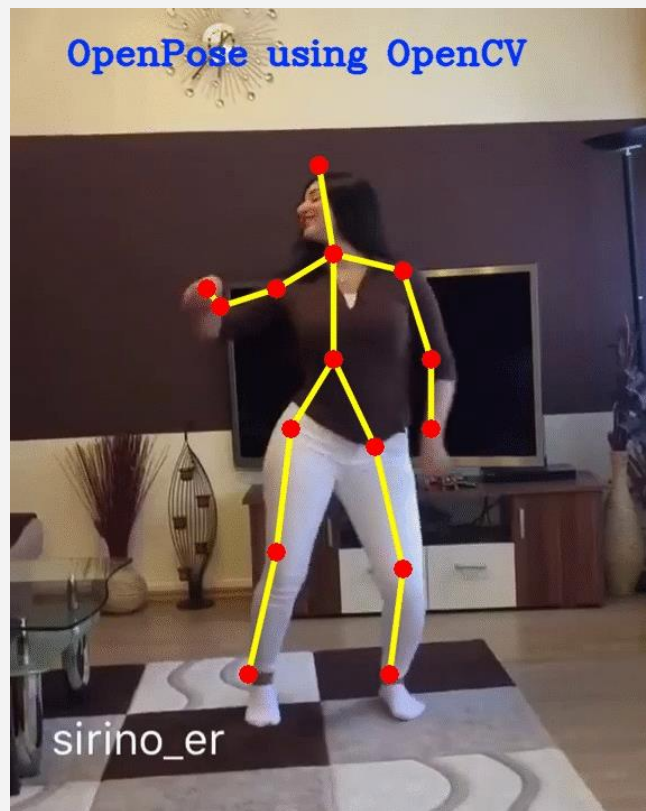


[Image Source](#)

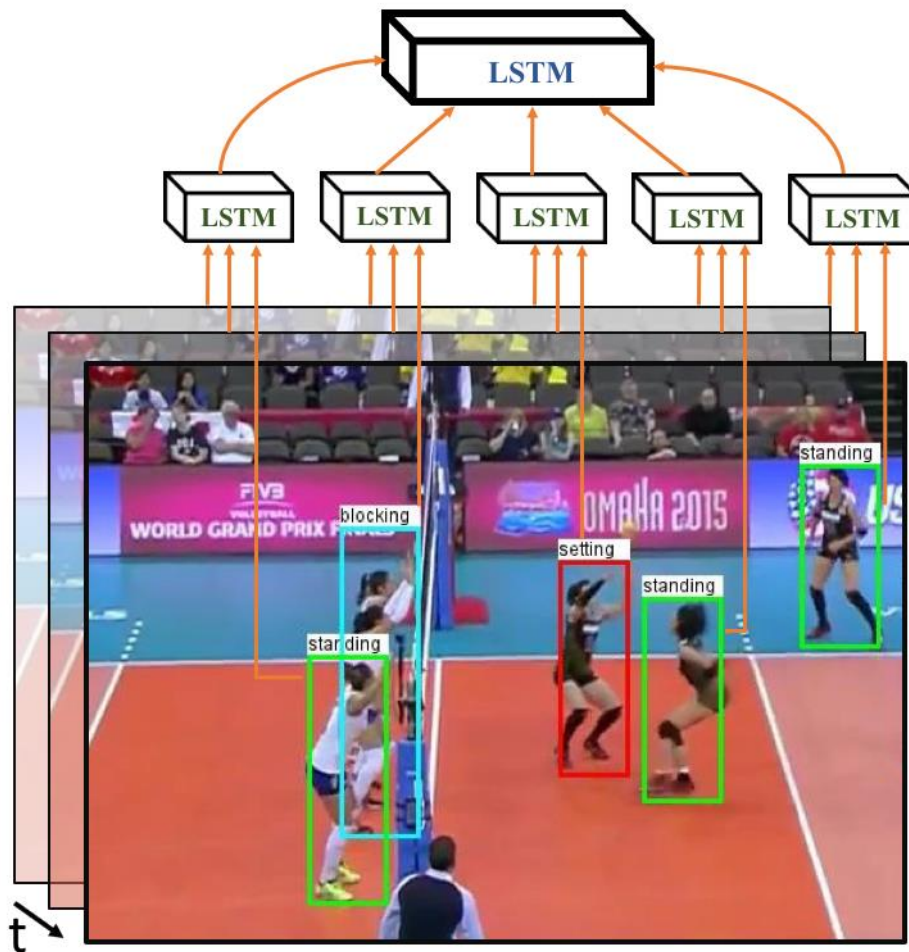


[DeepSORT: Deep Learning to track custom objects in a video](#)

Pose estimation



Activity Recognition



Group Dynamics

Person Dynamics

 Standing

 Setting

 Blocking

Image Captioning

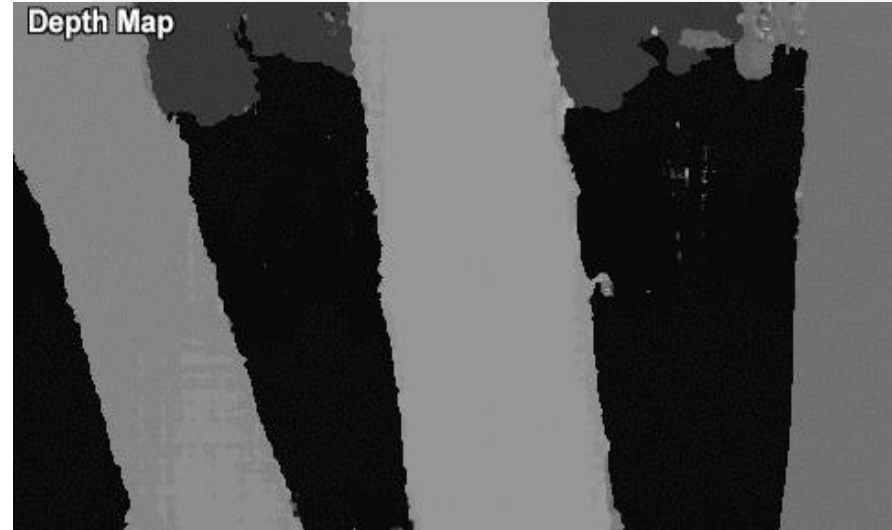
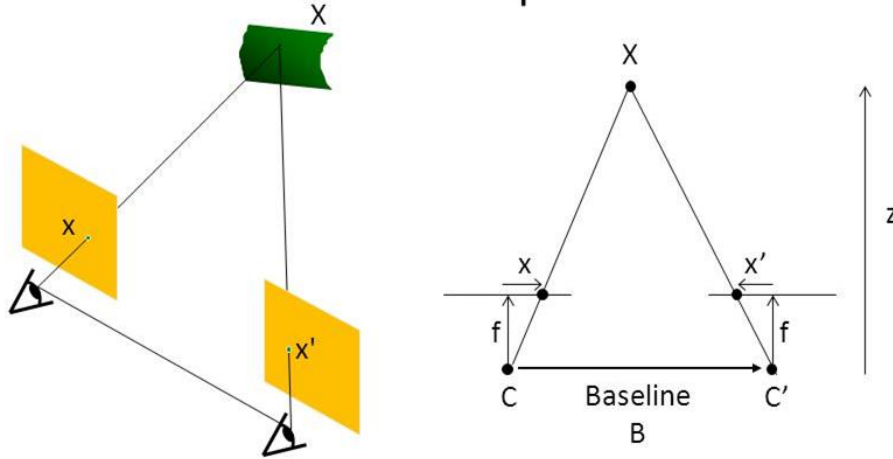
Describes without errors	Describes with minor errors	Somewhat related to the image	Unrelated to the image
 <p>A person riding a motorcycle on a dirt road.</p>	 <p>Two dogs play in the grass.</p>	 <p>A skateboarder does a trick on a ramp.</p>	 <p>A dog is jumping to catch a frisbee.</p>
 <p>A group of young people playing a game of frisbee.</p>	 <p>Two hockey players are fighting over the puck.</p>	 <p>A little girl in a pink hat is blowing bubbles.</p>	 <p>A refrigerator filled with lots of food and drinks.</p>
 <p>A herd of elephants walking across a dry grass field.</p>	 <p>A close up of a cat laying on a couch.</p>	 <p>A red motorcycle parked on the side of the road.</p>	 <p>A yellow school bus parked in a parking lot.</p>

Geometric Computer Vision :

Vision for measurement

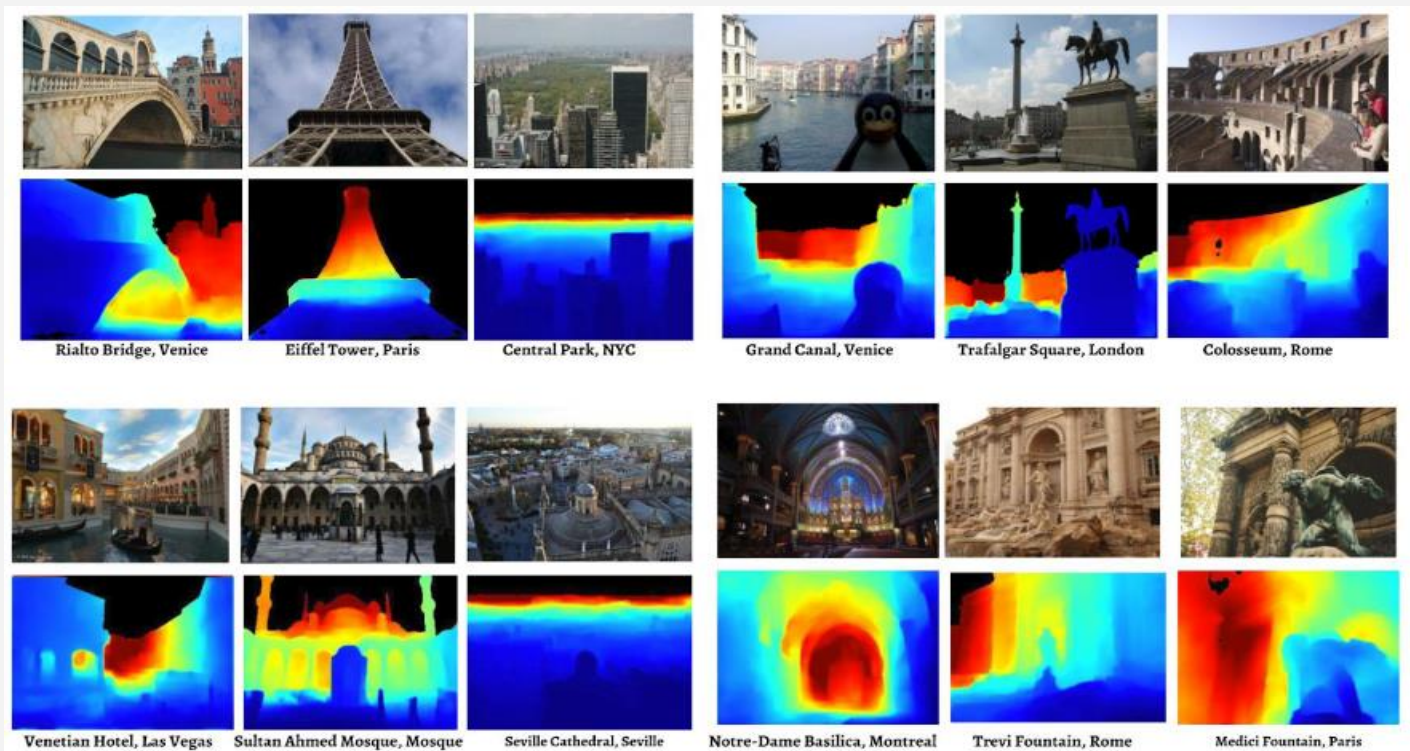
Depth from stereo

- Goal: recover depth by finding image coordinate x' that corresponds to x



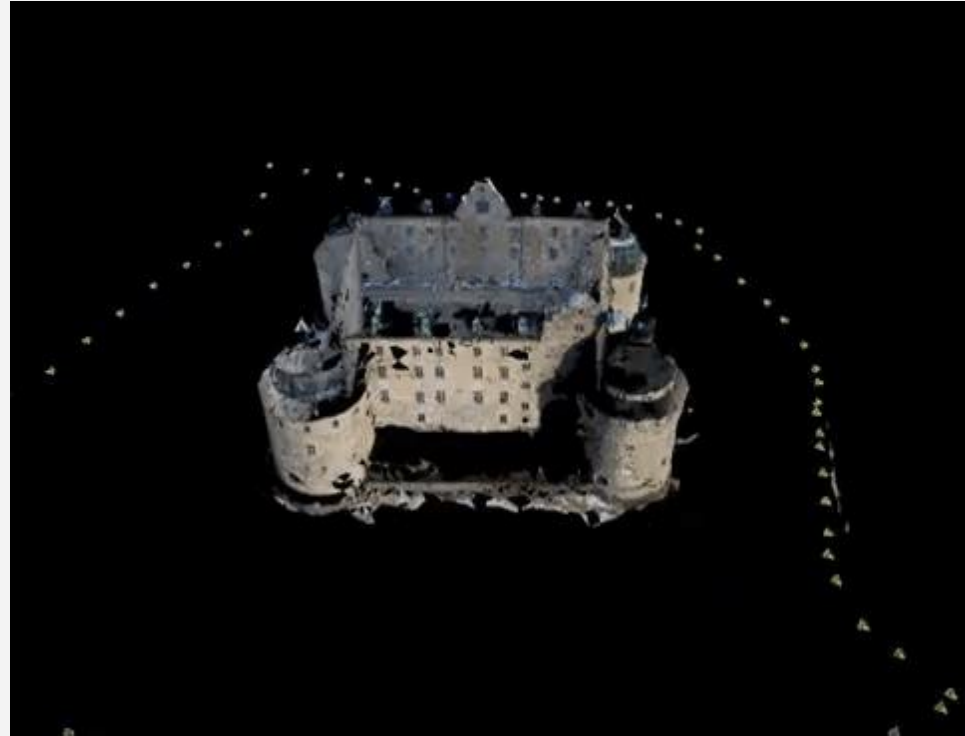
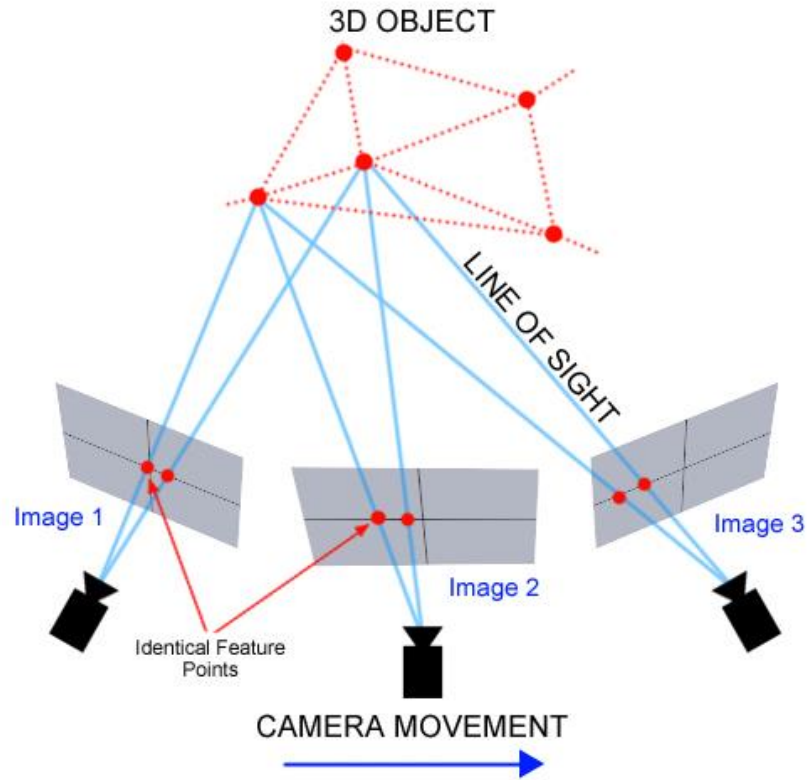
Source: Simon Jacobs

Depth from a single image



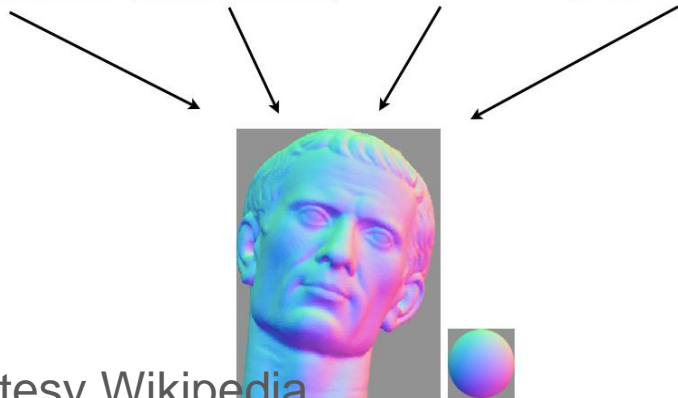
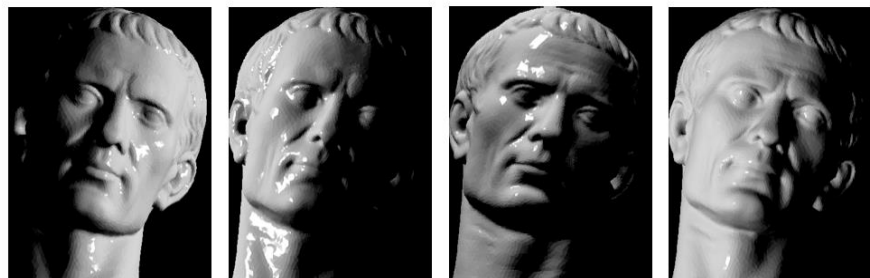
Courtesy Noah Snavely

Structure From Motion

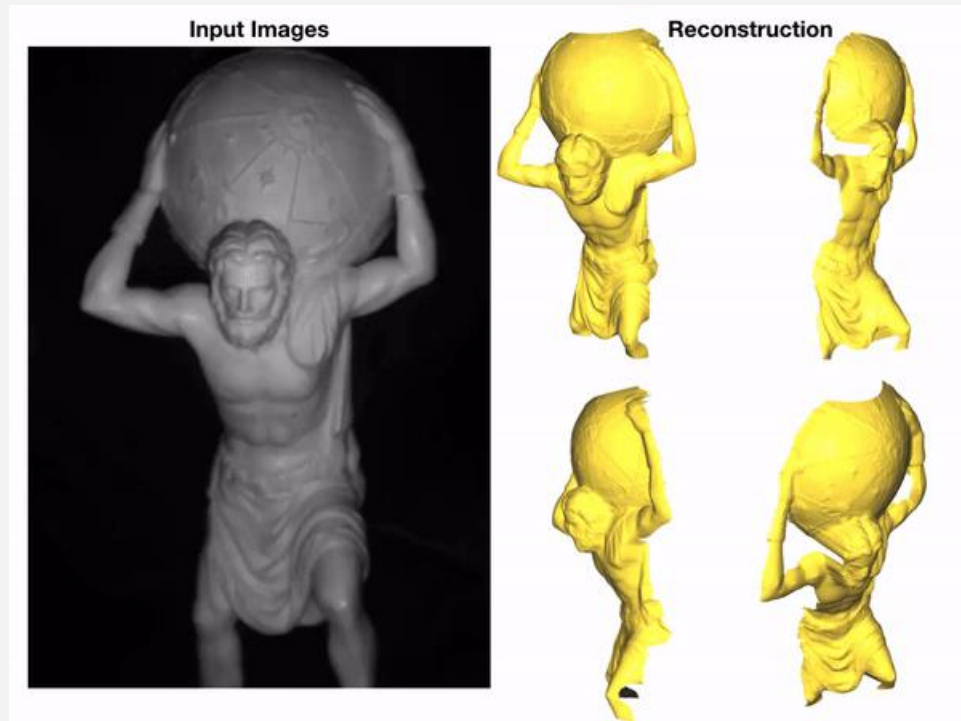


Source: Dr. Calle Olsson

Photometric stereo



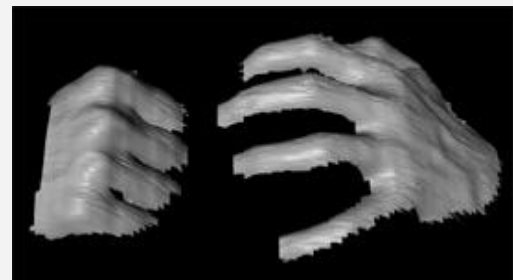
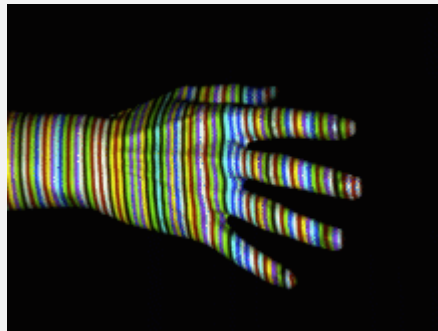
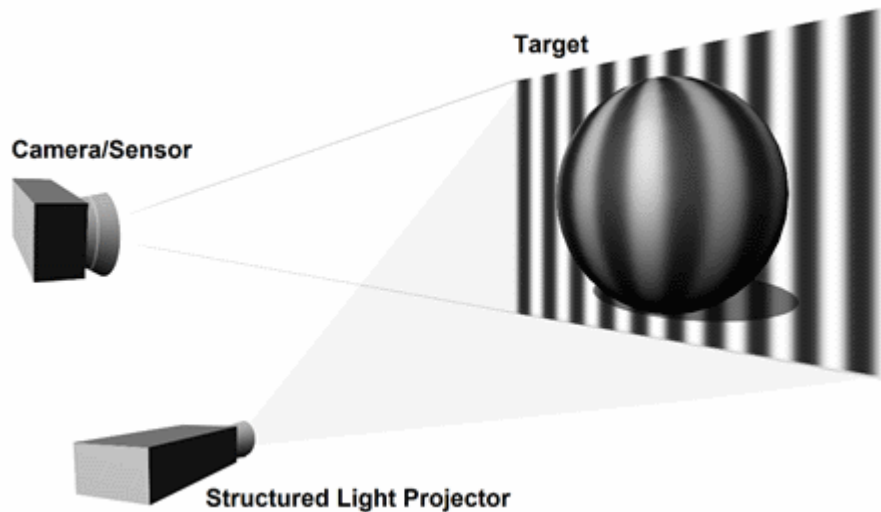
Courtesy Wikipedia



" Near-Light Photometric Stereo using Circularly Placed Point Light Sources "

Structured light

Like Stereo, but replace one camera with Projector



“Rapid Shape Acquisition Using Color Structured Light and Multi-pass Dynamic Programming”

**You just saw many examples of
current systems.**

But what challenges do they face ?

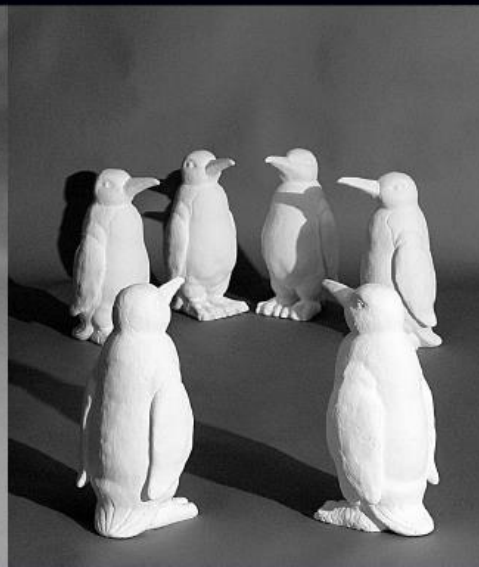
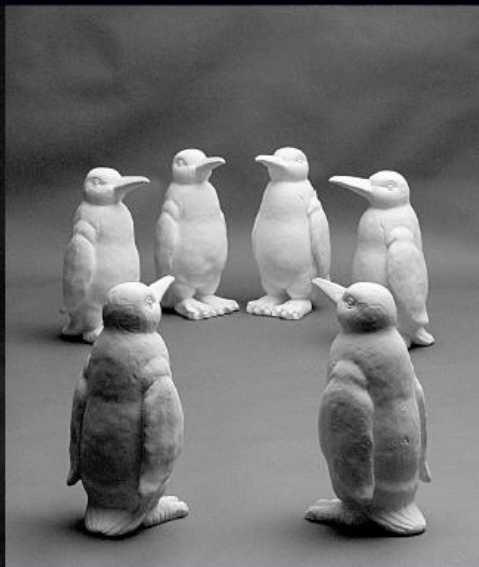
Challenges: viewpoint variation



Michelangelo 1475-1564

slide credit: Fei-Fei, Fergus & Torralba

Challenges: illumination

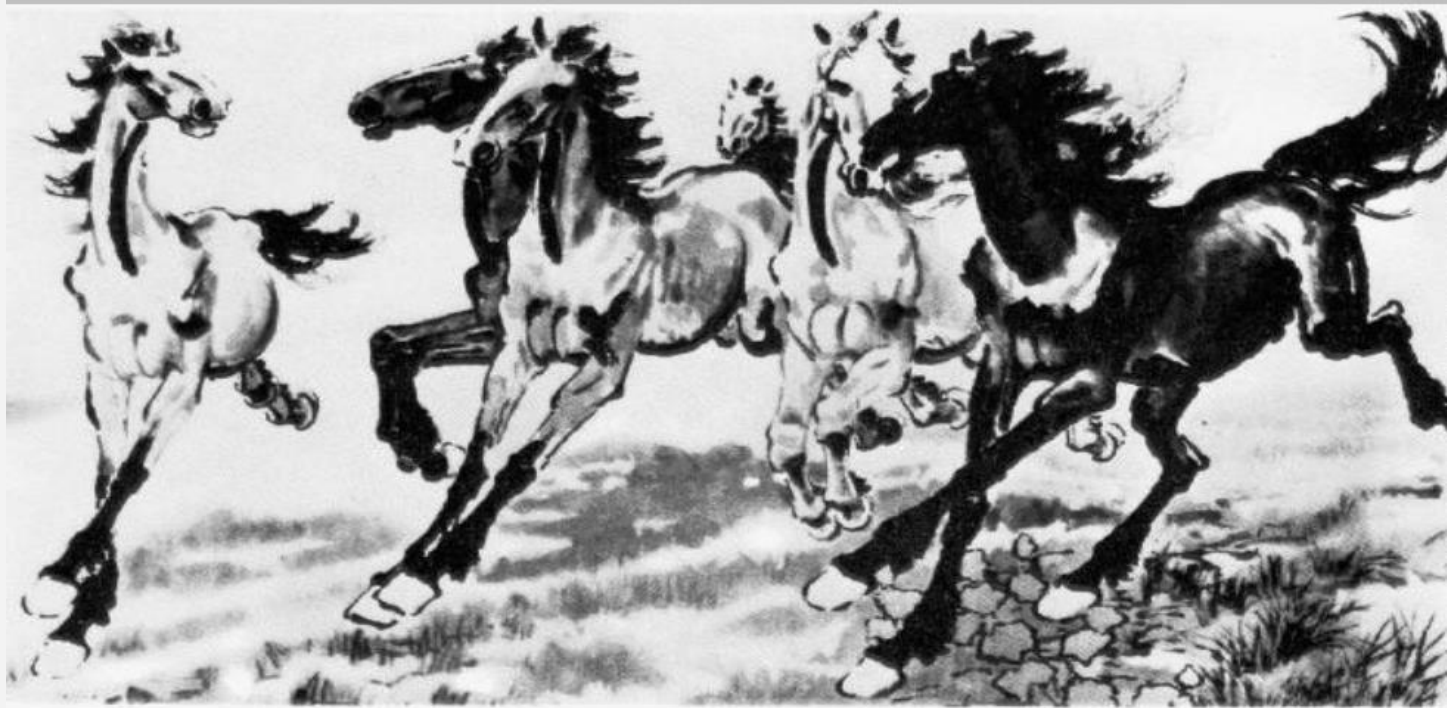


Challenges: scale



slide credit: Fei-Fei, Fergus & Torralba

Challenges: deformation



Xu, Beihong 1943

Challenges: occlusion



Magritte, 1957

slide credit: Fei-Fei, Fergus & Torralba

Challenges: background clutter



Emperor shrimp and commensal crab on a sea cucumber in Fiji
Photograph by Tim Laman

Challenges: Motion

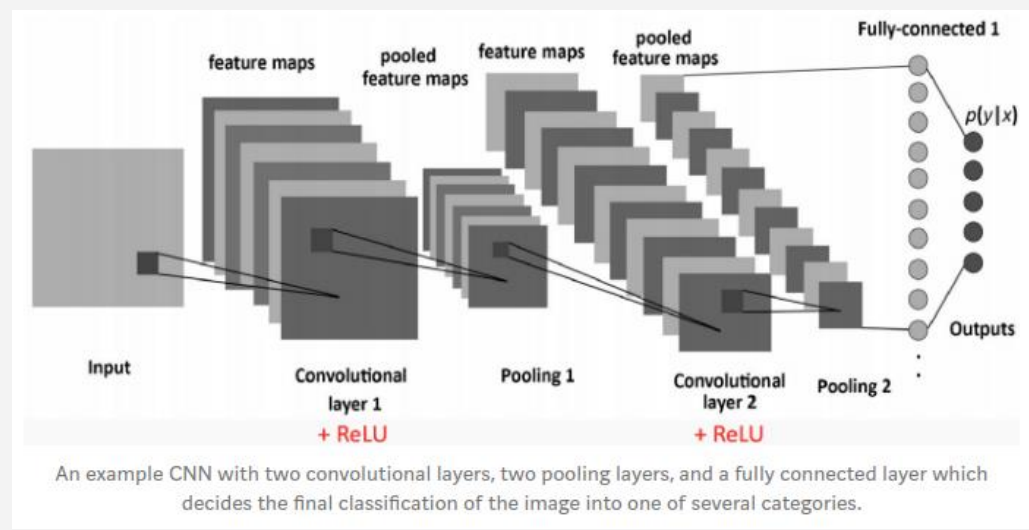
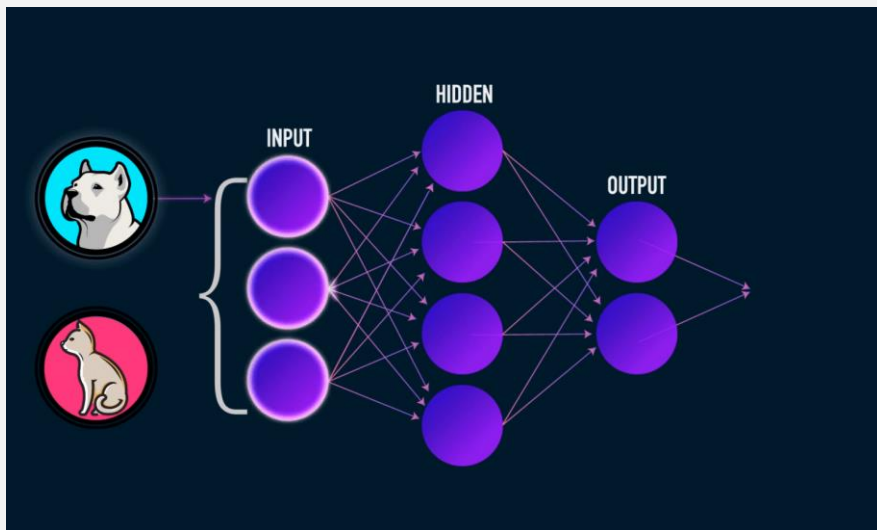


Challenges: object intra-class variation



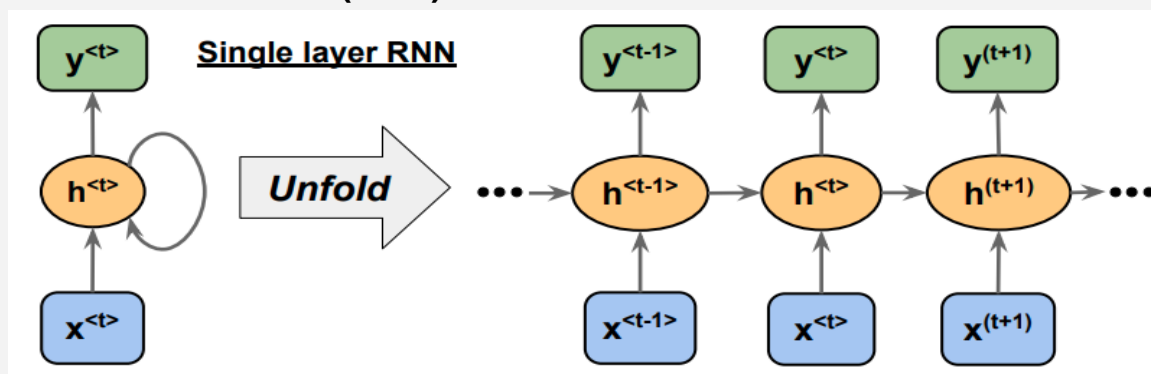
Course Content

Quick review of Deep Learning



Basic Neural Network (MLP)

Convolutional Neural Network (CNN)

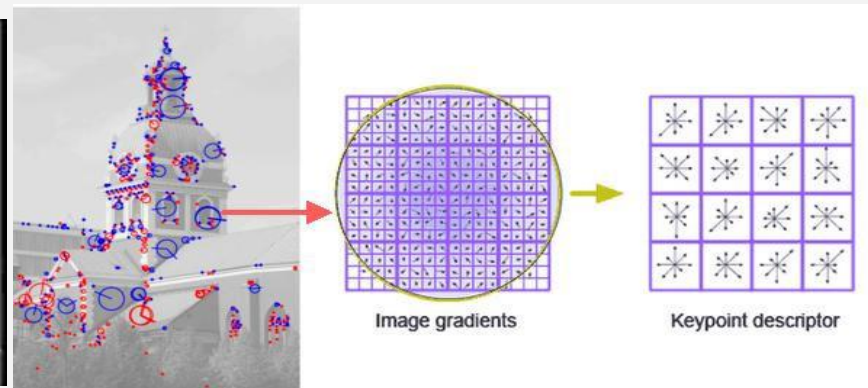


Recurrent Neural Network (RNN)

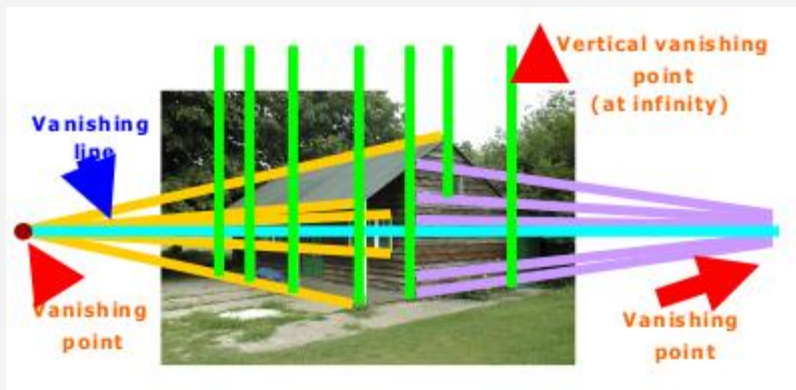
Low level vision



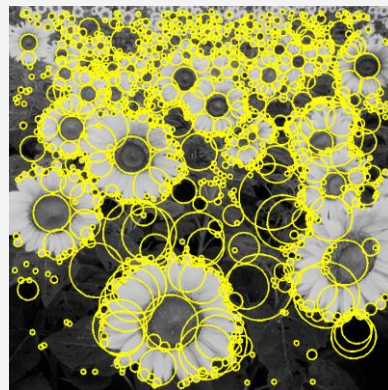
Edge Extraction



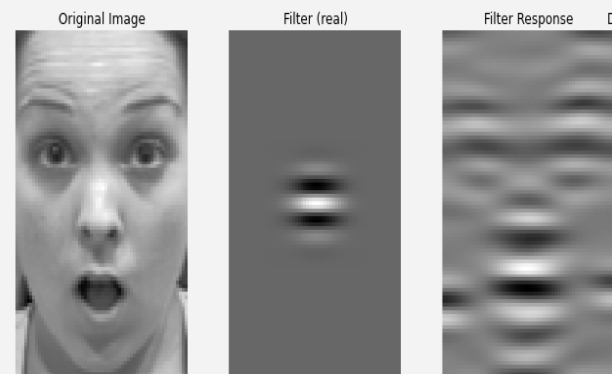
Feature Extraction



Line Detection

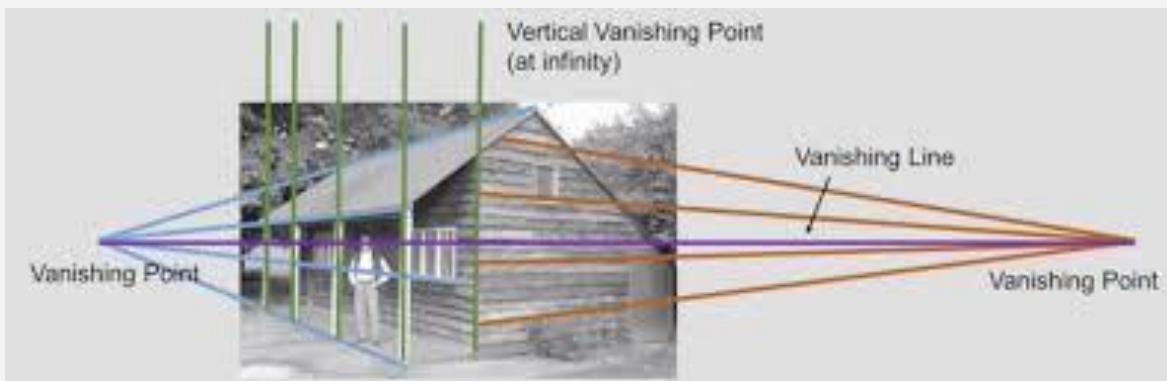


Blob detection

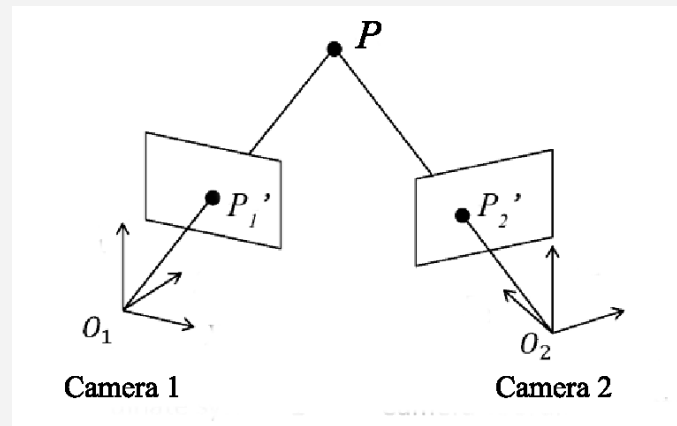


Filtering

Geometry



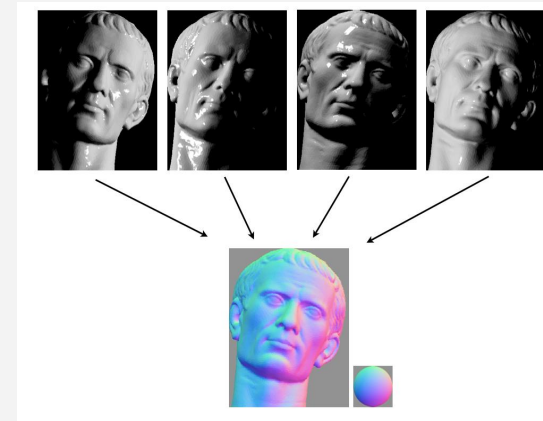
Single view geometry



Two-view geometry



Multi-view geometry



Photometric stereo

Mid-level Vision

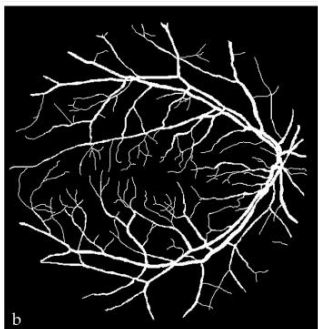
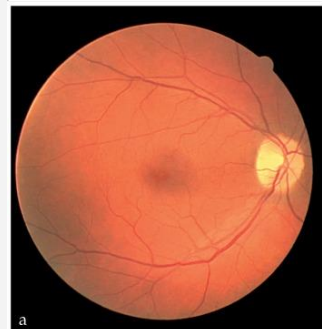
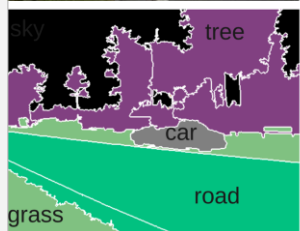
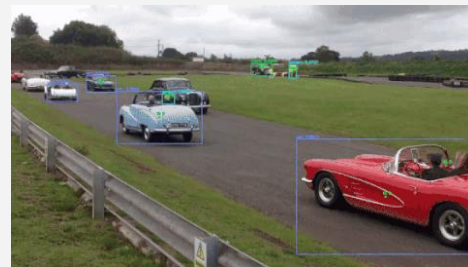
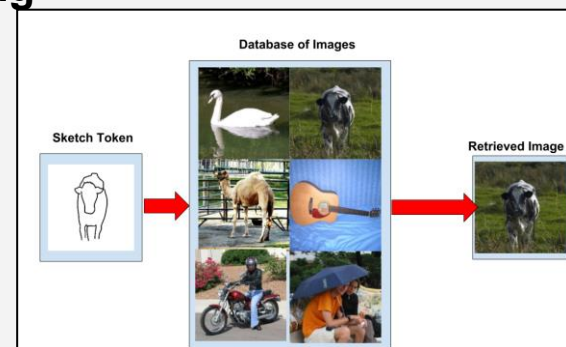


Image segmentation



Optical Flow

Tracking

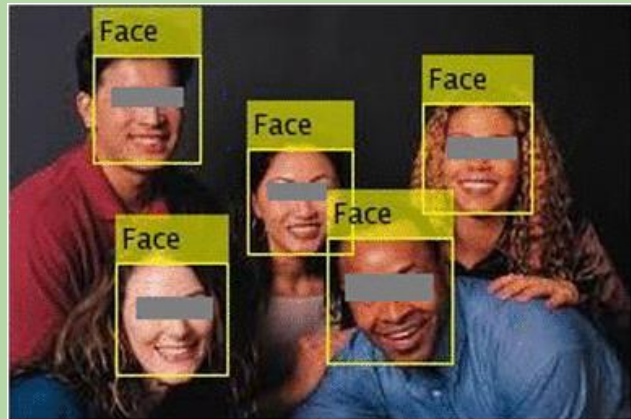


Find these landmarks

...in these images and 1M more

Image Retrieval

High level Vision



Viola Jones Face Detector



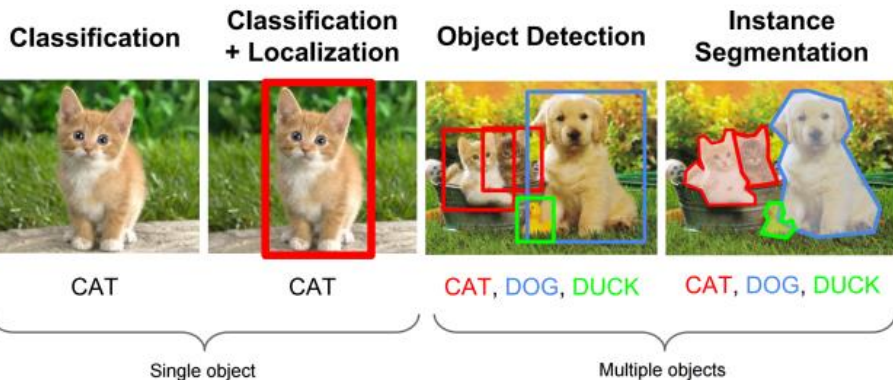
Image Captioning

The Bag of Words Representation

I love this movie! It's sweet, but with satirical humor. The dialogue is great and the adventure scenes are fun... It manages to be whimsical and romantic while laughing at the conventions of the fairy tale genre. I would recommend it to just about anyone. I've seen it several times, and I'm always happy to see it again whenever I have a friend who hasn't seen it yet!



it 6
I 5
the 4
and 3
seen 2
yet 1
would 1
whimsical 1
times 1
sweet 1
satirical 1
adventure 1
genre 1
fairy 1
humor 1
have 1
great 1
... ..



Tentative grading policy

- ❖ Regular (MCQ based) mini-quizzes (20%) – most likely 4 miniquiz
- ❖ Programming assignments (25%)
 - Around 3-4 assignments
- ❖ Kaggle Competition or Term Project (25%)
- ❖ End semester exam (30%)

Reading Material

1. Szeliski, Computer Vision: Algorithms and Applications, Springer, 2010
2. Hartley and Zisserman, Multiple View Geometry in Computer Vision, Cambridge University Press, 2004
3. Forsyth and Ponce, Computer Vision: A Modern Approach, Prentice Hall, 2002

Course Contents

- **Quick review of Deep Learning:** Multilayer perceptron (MLP), Convolutional Neural Network (CNN), Recurrent Neural Network (RNN)
- **Low level vision:** Edge, line and corner detections; Image filtering; Features
- **Geometry:** Single-view geometry; Stereo geometry; Multi-view geometry; Photometric stereo
- **Mid-level vision:** Optical flow, Image segmentation; Tracking; CB Image Retrieval
- **High-level vision:** Viola-Jones detector; Bag of words model; Deformable parts model; Object recognition and detection; Image captioning