Introduction to Computer Vision

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SCHOOL OF C and IT

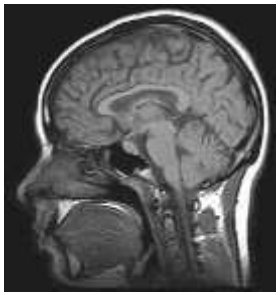
What is Computer Vision?

- **Computer vision** is the science and technology of machines that see.

- Concerned with the theory for building artificial systems that obtain information from images.

- The image data can take many forms, such as a video sequence, depth images, views from multiple cameras, or multi-dimensional data from a medical scanner





Computer Vision

Make computers understand images and videos.

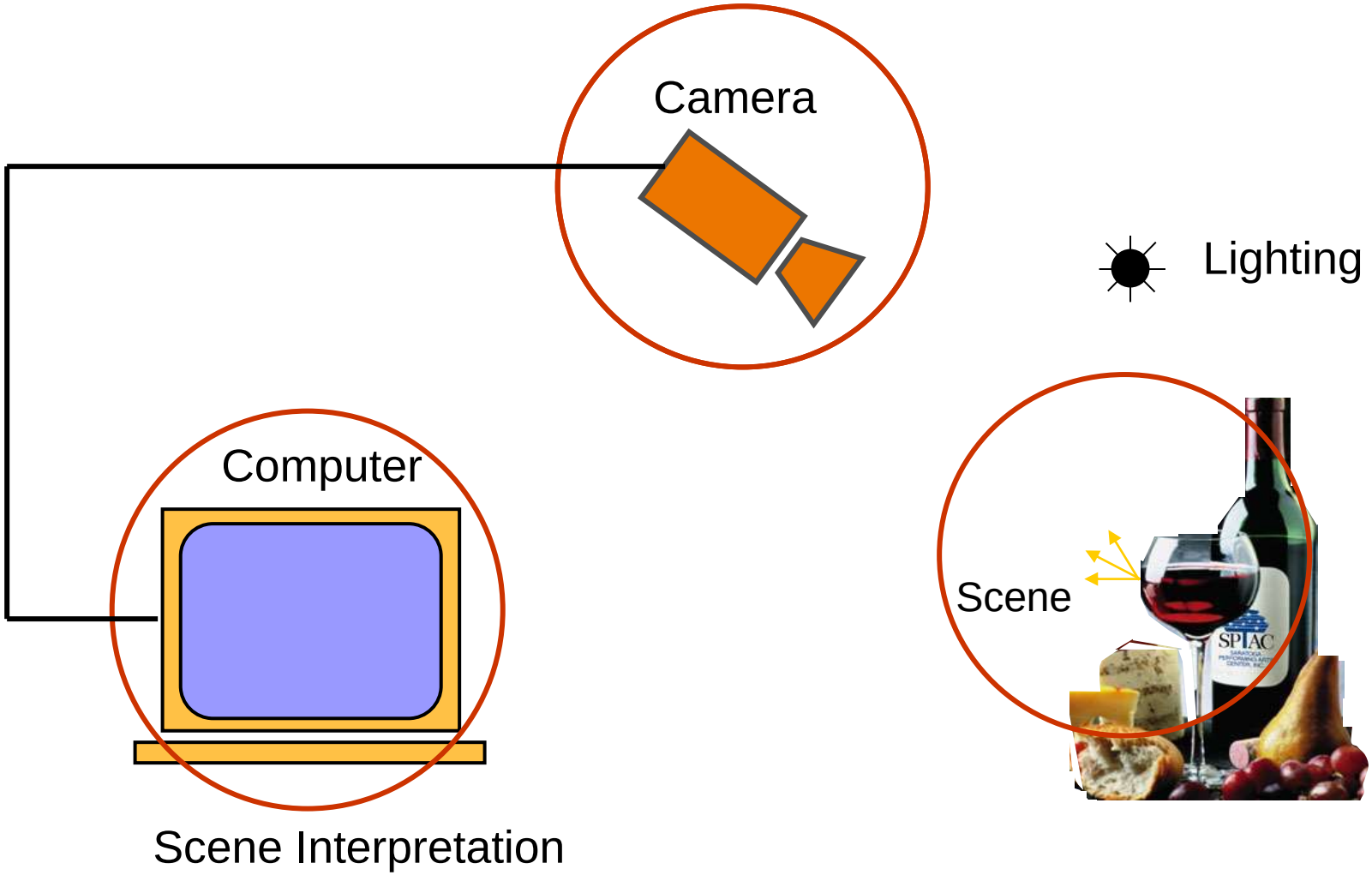
What kind of scene?

Where are the cars?

How far is the building?

…

Components of a computer vision system



Srinivasa Narasimhan's slide

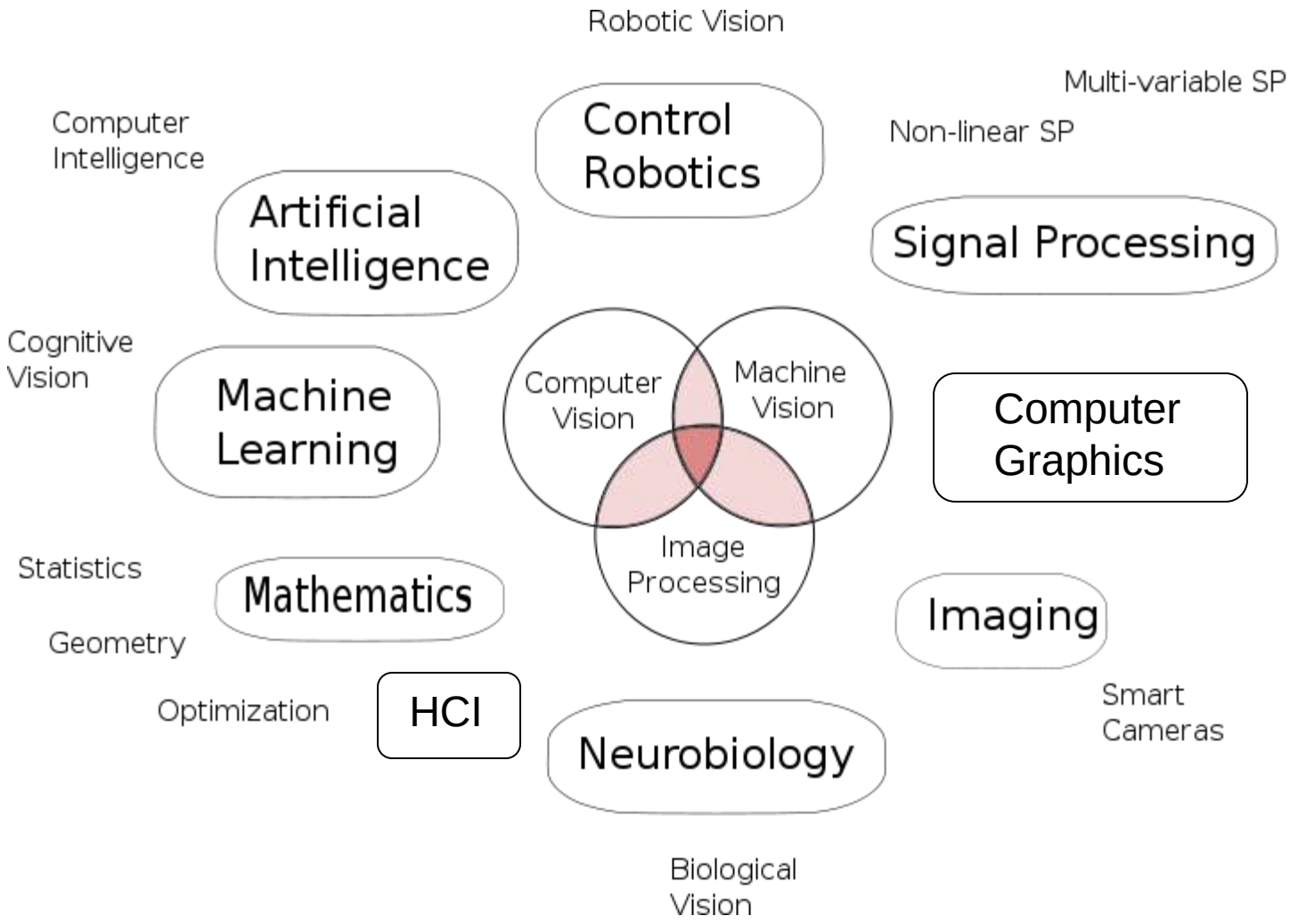
Computer vision vs human vision

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

Vision is multidisciplinary



From wiki

Why computer vision matters

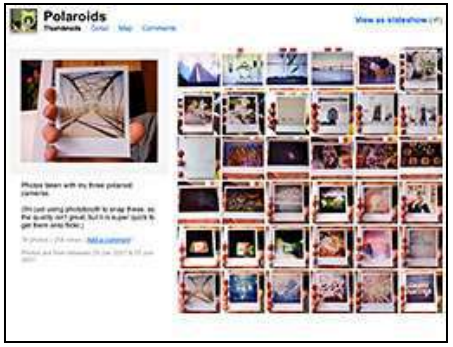
Safety

Health

Security

Comfort

Fun



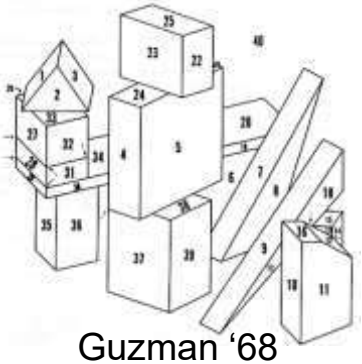
Access

A little story about Computer Vision

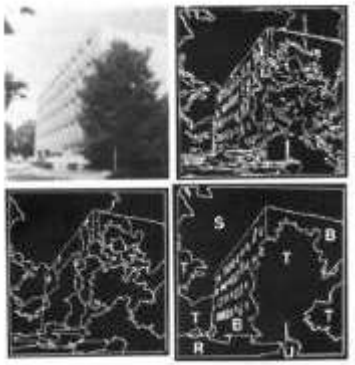
In 1966, Marvin Minsky at MIT asked his undergraduate student Gerald Jay Sussman to “spend the summer linking a camera to a computer and getting the computer to describe what it saw”. We now know that the problem is slightly more difficult than that. (Szeliski 2009, Computer Vision)

brief history of computer vision

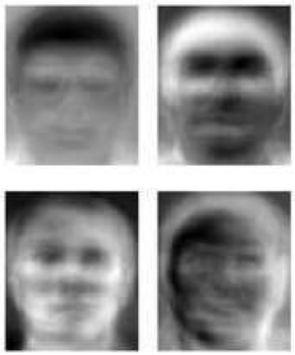
- 1966: Minsky assigns computer vision as an undergrad summer project
- 1960's: interpretation of synthetic worlds
- 1970's: some progress on interpreting selected images
- 1980's: ANNs come and go; shift toward geometry and increased mathematical rigor
- 1990's: face recognition; statistical analysis in vogue
- 2000's: broader recognition; large annotated datasets available; video processing starts; vision & graphis; vision for HCI; internet vision, etc.



Guzman '68



Ohta Kanade '78



Turk and Pentland '91

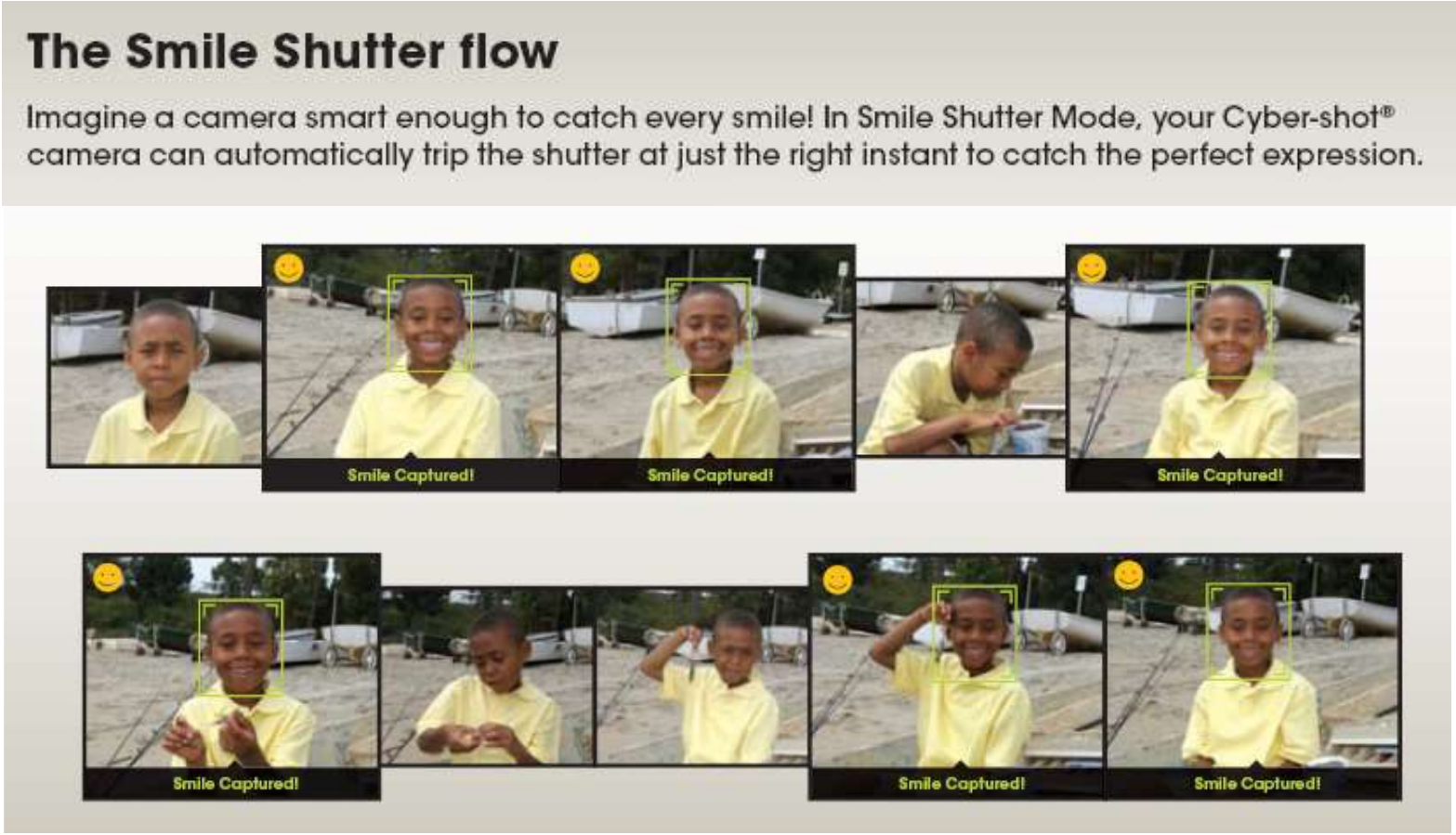
How vision is used now

- Examples of state-of-the-art

Face detection

- Many new digital cameras now detect faces
  - Canon, Sony, Fuji, …

Smile detection



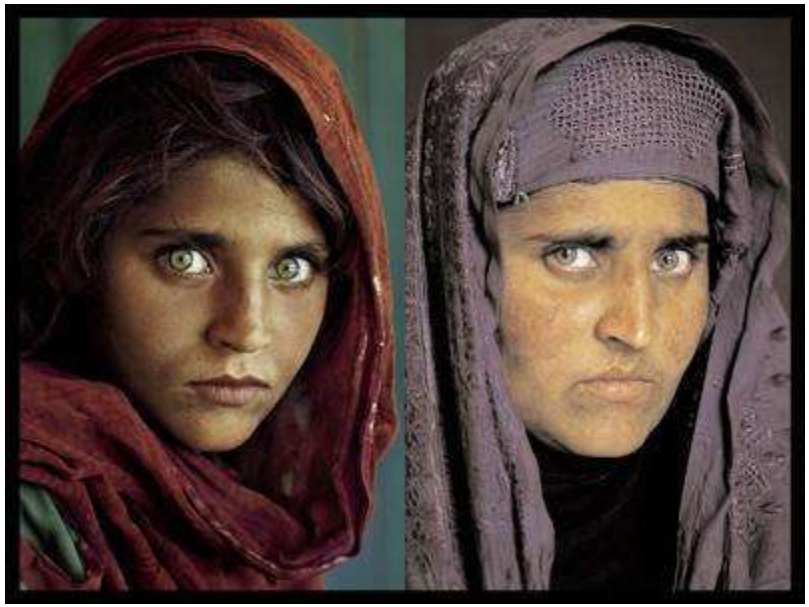
[Sony Cyber-shot® T70 Digital Still Camera]

Object recognition (in supermarkets)

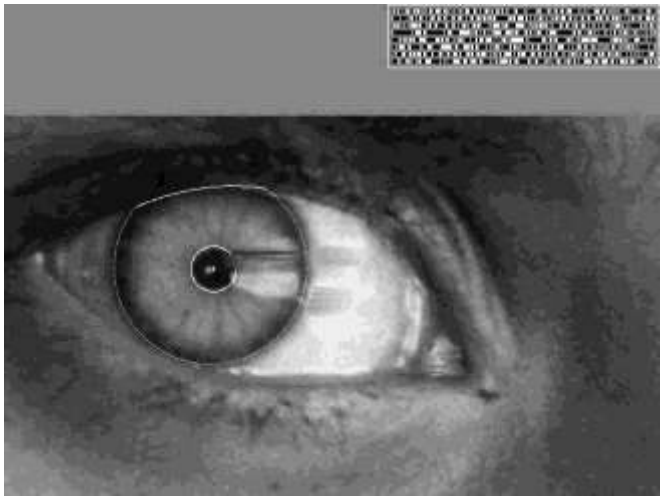
LaneHawk by EvolutionRobotics

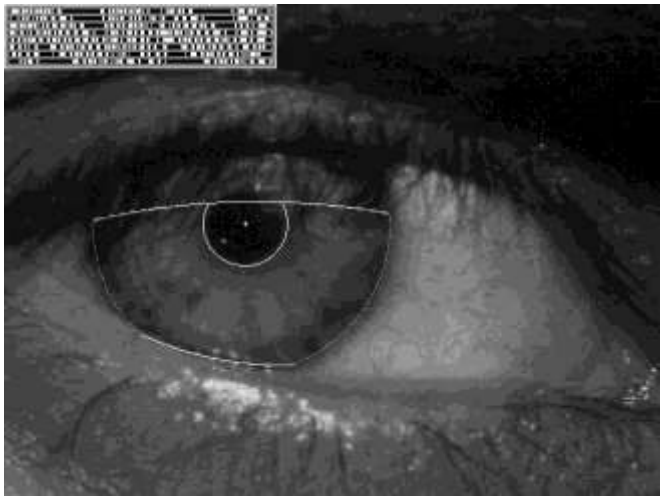
“A smart camera is flush-mounted in the checkout lane, continuously watching for items. When an item is detected and recognized, the cashier verifies the quantity of items that were found under the basket, and continues to close the transaction. The item can remain under the basket, and with LaneHawk,you are assured to get paid for it… “

Vision-based biometrics



"*How the Afghan Girl was Identified by Her Iris Patterns*" Read the story wikipedia





Login without a password…

Fingerprint scanners on many new laptops, other devices

Face recognition systems now beginning to appear more widely
http://www.sensiblevision.com/

Object recognition (in mobile phones)

[Point & Find](), [Nokia]()

[Google Goggles]()

Sports

Sportvision first down line
Nice explanation on www.howstuffworks.com

http://www.sportvision.com/video.html

Smart cars

Slide content courtesy of Amnon Shashua

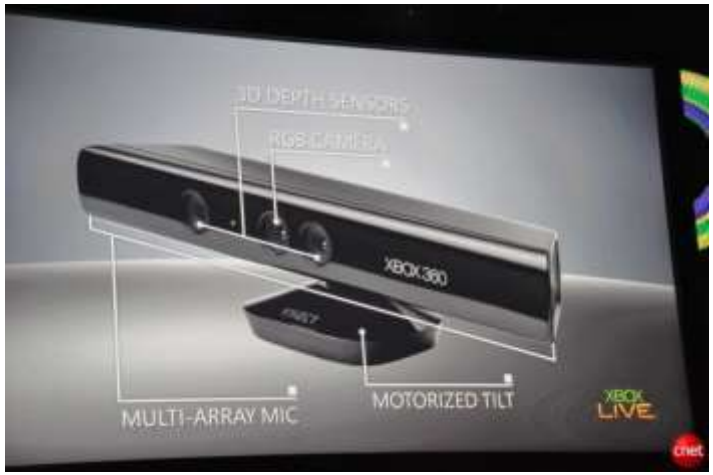
- Mobileye [wiki article]
  - Vision systems currently in many car models

Google cars

http://www.nytimes.com/2010/10/10/science/10google.html?ref=artificialintelligence

Interactive Games: Kinect

- Object Recognition: http://www.youtube.com/watch?feature=iv&v=fQ59dXOo63o
- Mario: http://www.youtube.com/watch?v=8CTJL5lUjHg
- 3D: http://www.youtube.com/watch?v=7QrnwoO1-8A
- Robot: http://www.youtube.com/watch?v=w8BmgtMKFbY
- 3D tracking, reconstruction, and interaction: http://research.microsoft.com/en-us/projects/surfacerecon/default.aspx



Vision in space

NASA'S Mars Exploration Rover Spirit captured this westward view from atop a low plateau where Spirit spent the closing months of 2007.

Vision systems (JPL) used for several tasks

- Panorama stitching
- 3D terrain modeling
- Obstacle detection, position tracking
- For more, read "Computer Vision on Mars" by Matthies et al.

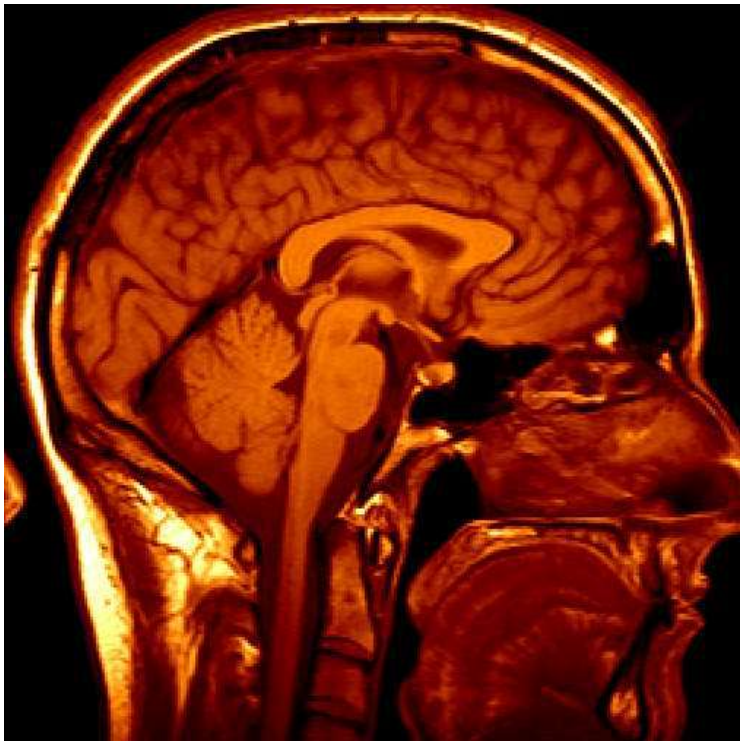
Mobile robots

NASA's Mars Spirit Rover
http://en.wikipedia.org/wiki/Spirit_rover

http://www.robocup.org/

Saxena et al. 2008
STAIR at Stanford

Medical imaging



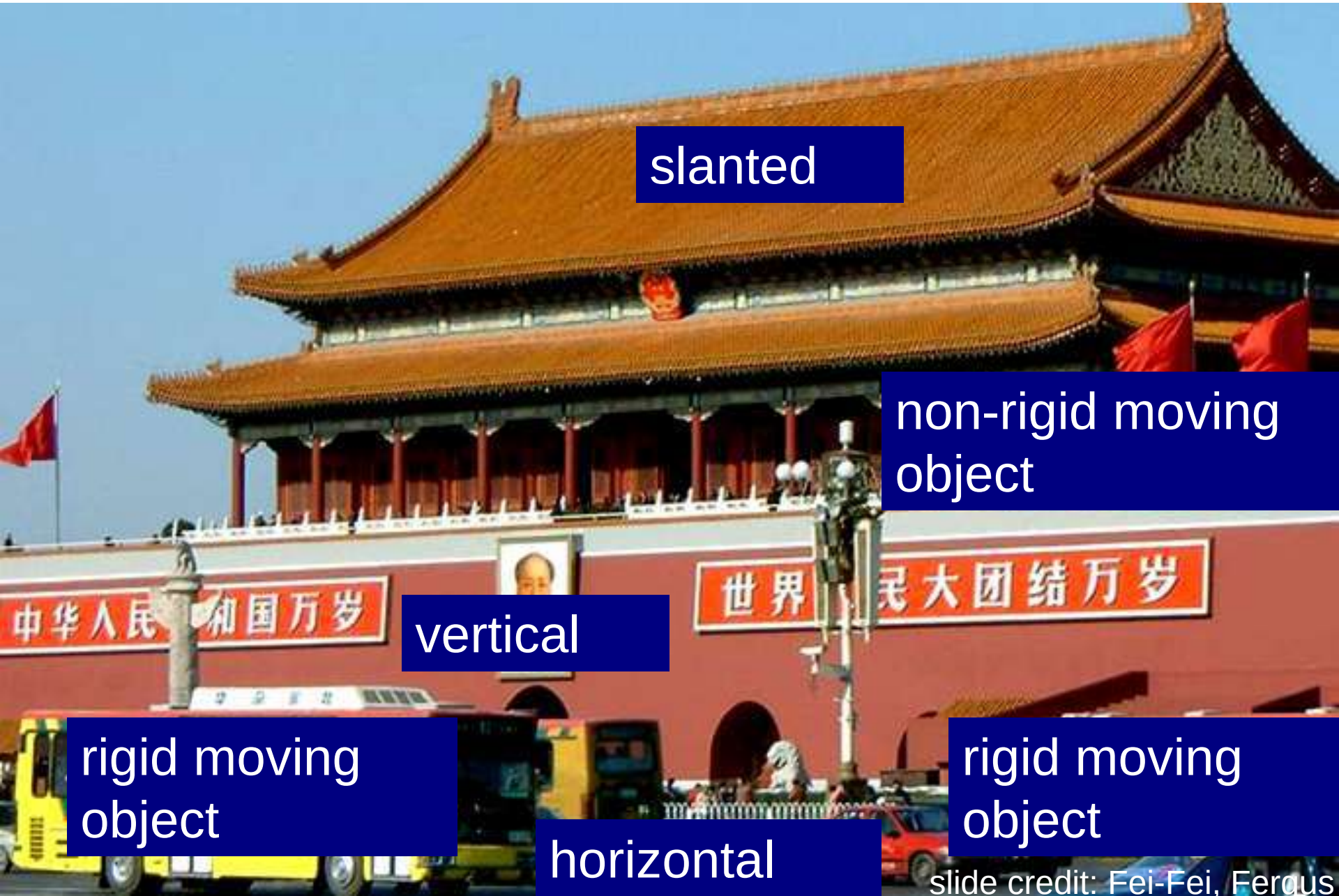
3D imaging
MRI, CT

Image guided surgery
Grimson et al., MIT

Object categorization

slide credit: Fei-Fei, Fergus

Qualitative spatial information



slide credit: Fei-Fei, Fergus

Challenges: viewpoint variation

Michelangelo 1475-1564

slide credit: Fei-Fei, Fergus

Challenges: illumination

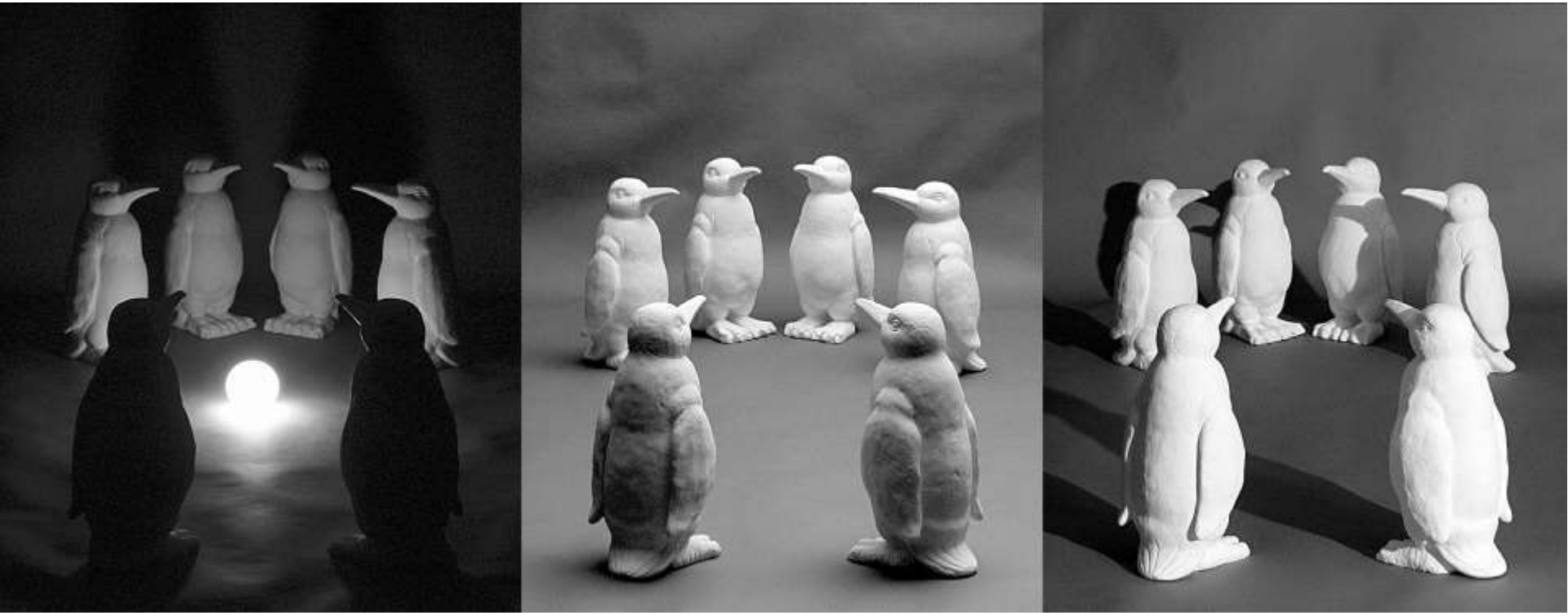
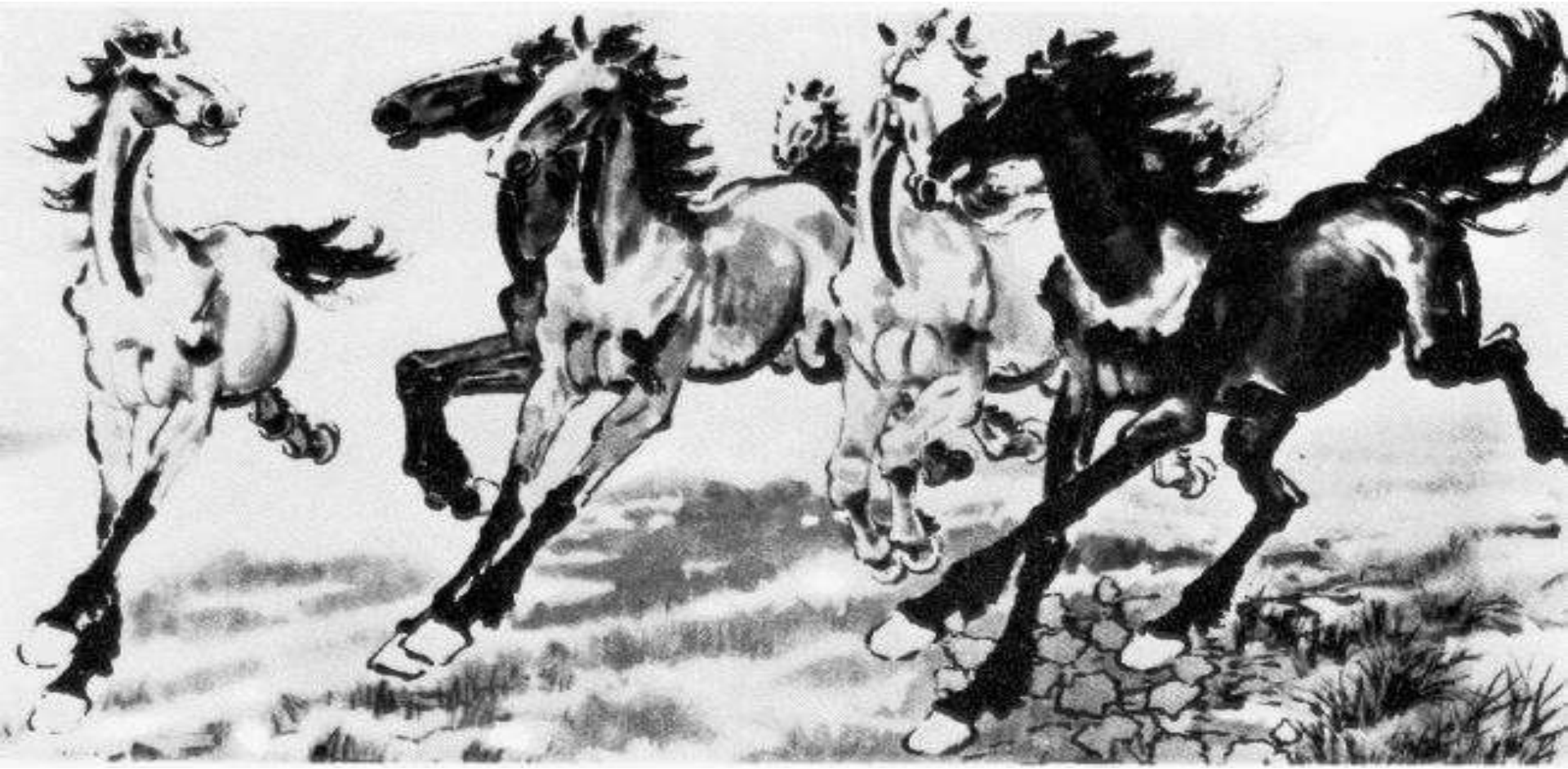


image credit: J. Koenderi

Challenges: scale

slide credit: Fei-Fei, Fergus

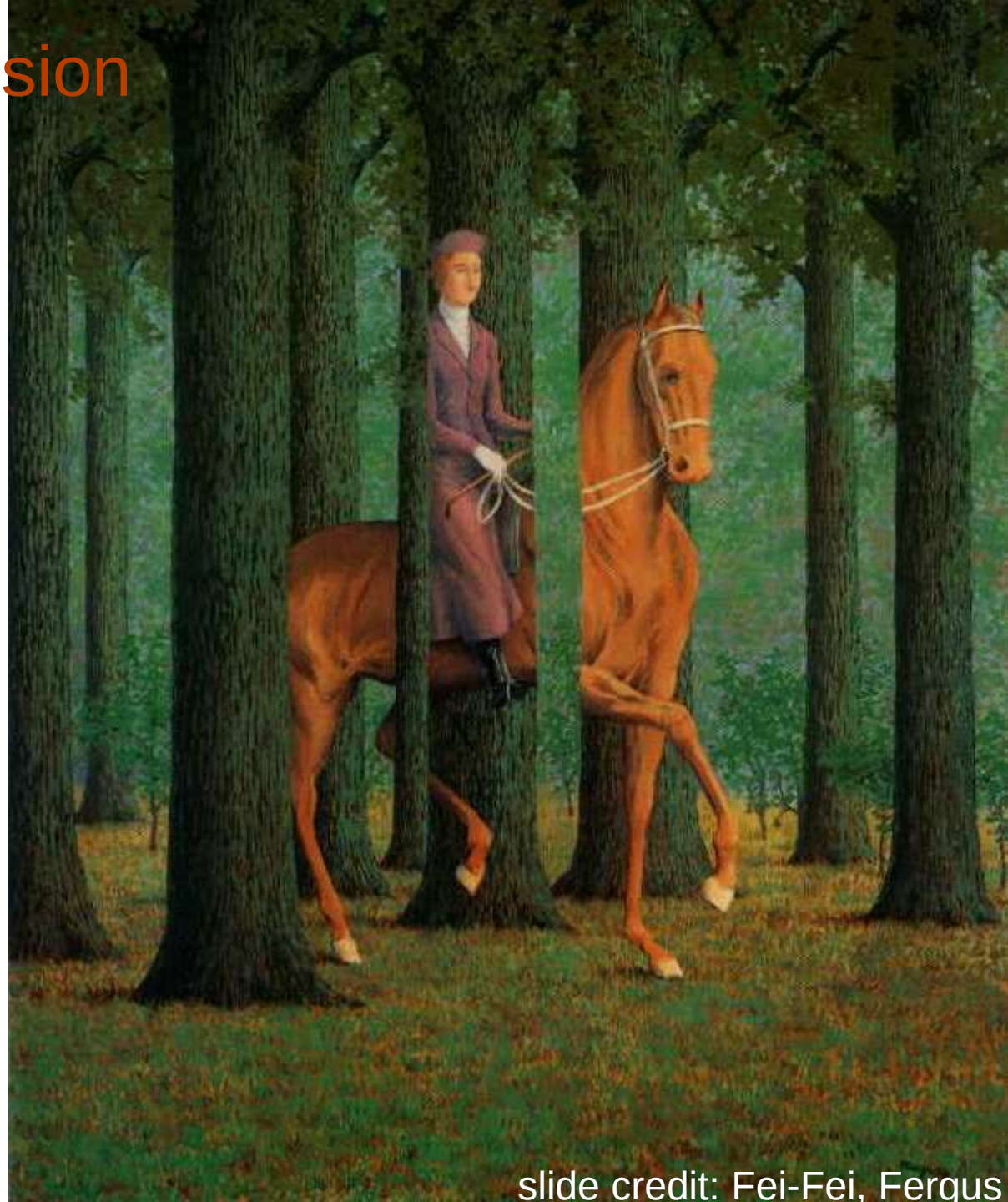
Challenges: deformation



Xu, Beihong 1943

slide credit: Fei-Fei, Fergus

Challenges: occlusion



Magritte, 1957

slide credit: Fei-Fei, Fergus

Challenges: background clutter

Challenges: object intra-class variation






slide credit: Fei-Fei, Fergus

Challenges or opportunities?

- Images are confusing, but they also reveal the structure of the world through numerous cues
- Our job is to interpret the cues!

Computer Vision Publications

- Journals
  - IEEE Trans. on Pattern Analysis and Machine Intelligence (TPAMI)
    - #1 IEEE, Thompson-ISI impact factor: 5.96
    - #1 in both electrical engineering and artificial intelligence
    - #3 in all of computer science
  - Internal Journal of Computer Vision (IJCV)
    - ISI impact factor: 5.358, Rank 2 of 94 in “CS, artificial intelligence
  - IEEE Trans. on Image Processing
  - …
- Conferences
  - Conf. of Computer Vision and Pattern Recognition (CVPR), once a year
  - International Conference on Computer Vision (ICCV), once every two years
  - Europe Conference on Computer Vision (ECCV), once every two years