Computer Vision
CMSC 426

Spring 2021

Logistics

- Four projects, and three homework assignments (programming + discussion): in groups of three
- Midterm exam: in class
- All information available from the Website
- Grading
  - Projects 50 %
  - Homework 25%
  - MidTerm 25%

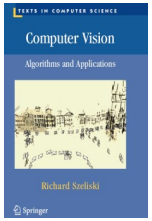
Programming

- Python
- Primer on Python?

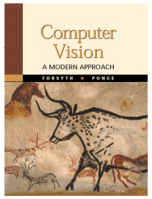
Administration

- Webpage
  - Get homework and projects
  - Syllabus
  - Other documents
- Piazza
  - Ask questions
    - do not post solutions
    - do not ask if your answer or approach is correct
  - Discuss issues
  - Public versus private
- ELMS
  - Hand in homework and projects
  - See grades

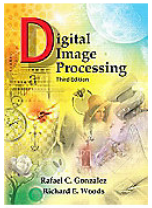
Recommended Texts



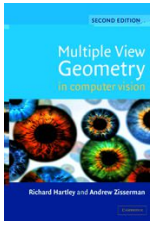
Computer Vision: Algorithms and Application, Richard Szeliski
Online: http://szeliski.org/Book/



Computer Vision: A Modern Approach
David Forsyth and Jean Ponce
Online: http://www.csd.uwo.ca/~olga/Courses/Winter2010/CS4442_9542b/CVbook.pdf

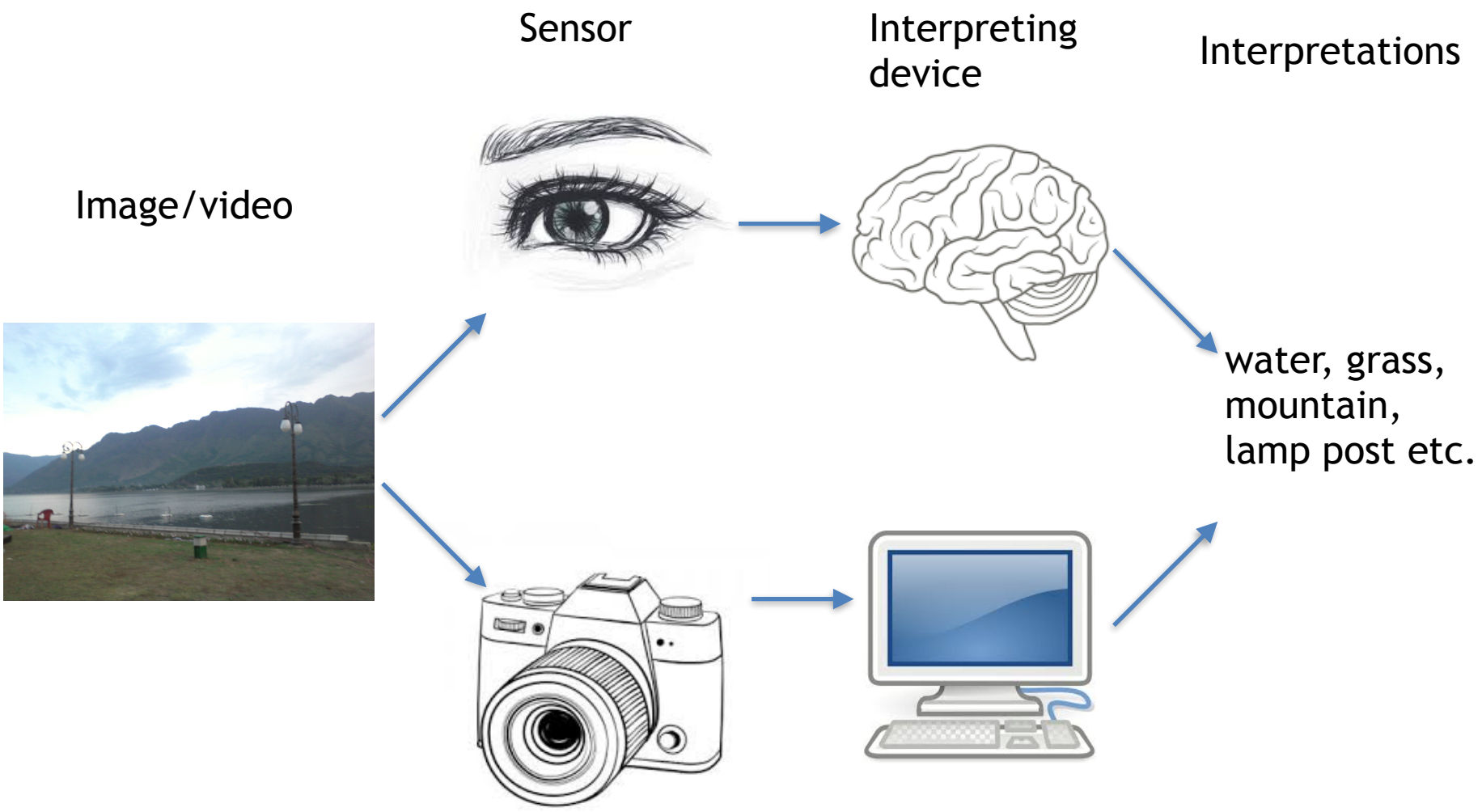


Digital Image Processing, Prentice Hall, Rafael Gonzalez, and Richard Woods, 2008.
Online: http://web.ipac.caltech.edu/staff/fmasci/home/astro_refs/Digital_Image_Processing_2ndEd.pdf

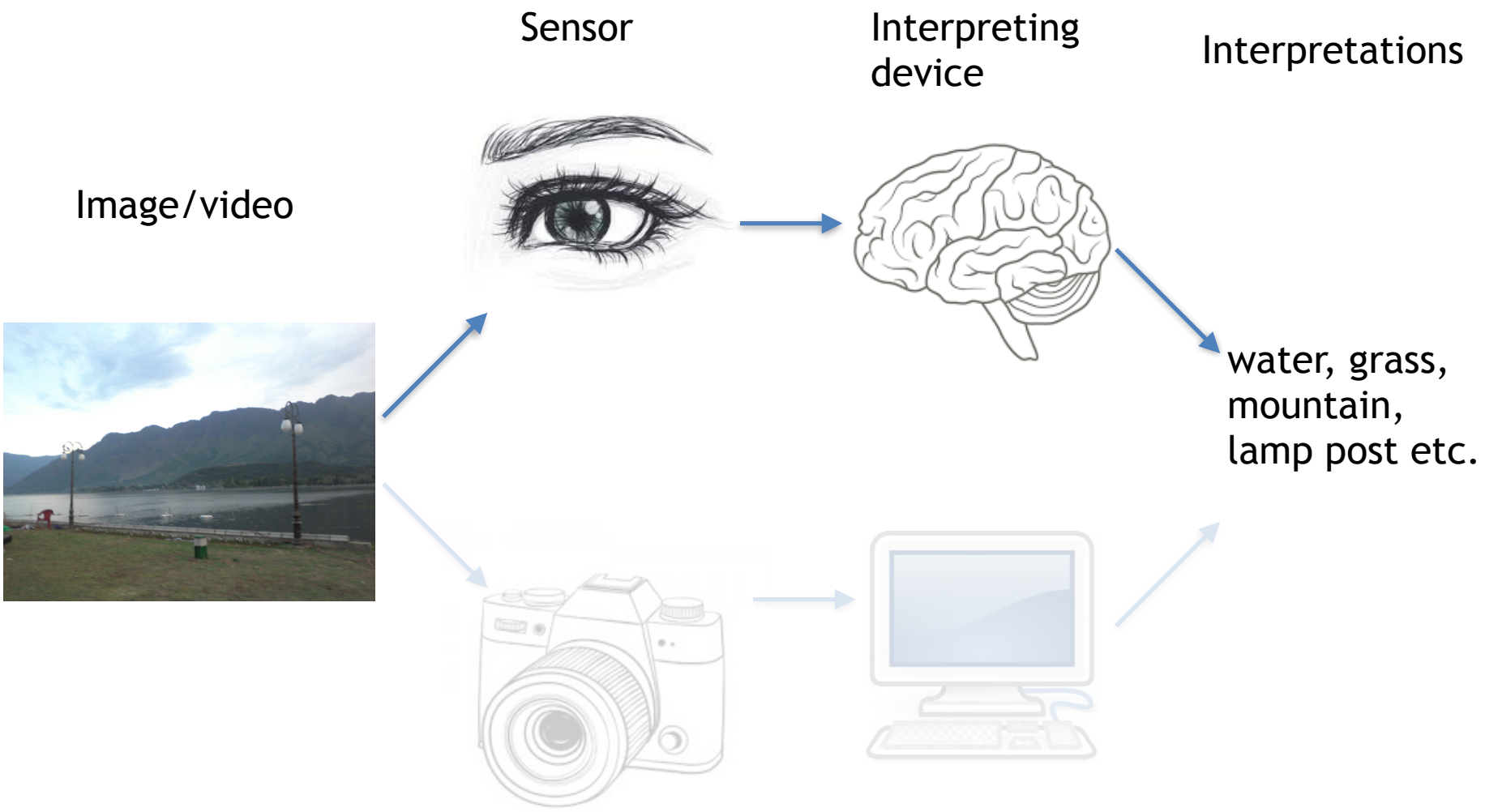


Multiple View Geometry in Computer Vision
Richard Hartley and Andrew Zisserman University Press, 2004,
selected chapters available online: http://www.robots.ox.ac.uk/~vgg/hzbook/

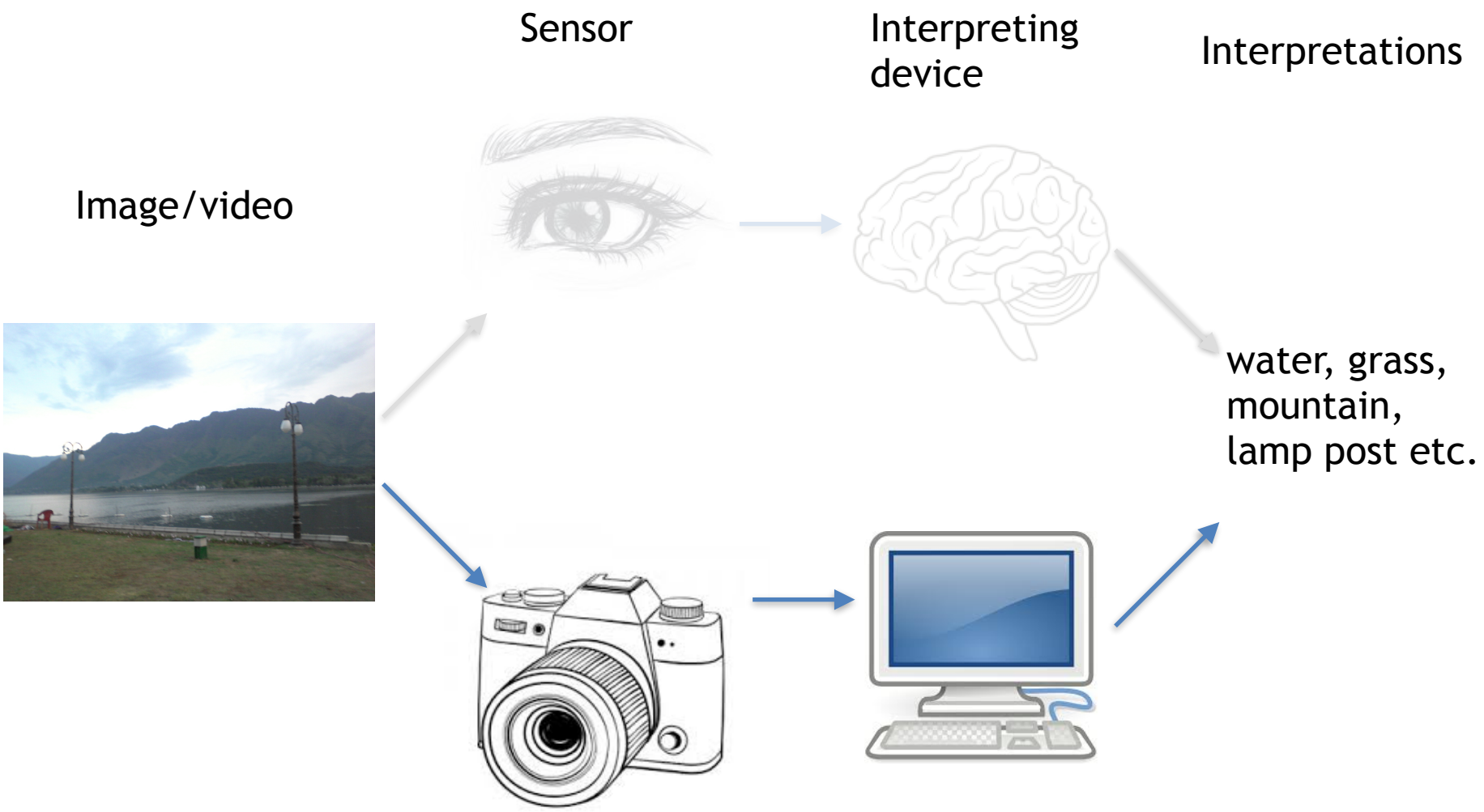
What is Computer Vision



What is Computer Vision



What is Computer Vision



Goals of Computer Vision

- Build machines and develop algorithms which can automatically replicate some functionalities of biological visual system

- Systems which navigate in cluttered environments
- Systems which can recognize objects, activities
- Systems which can interact with humans/world

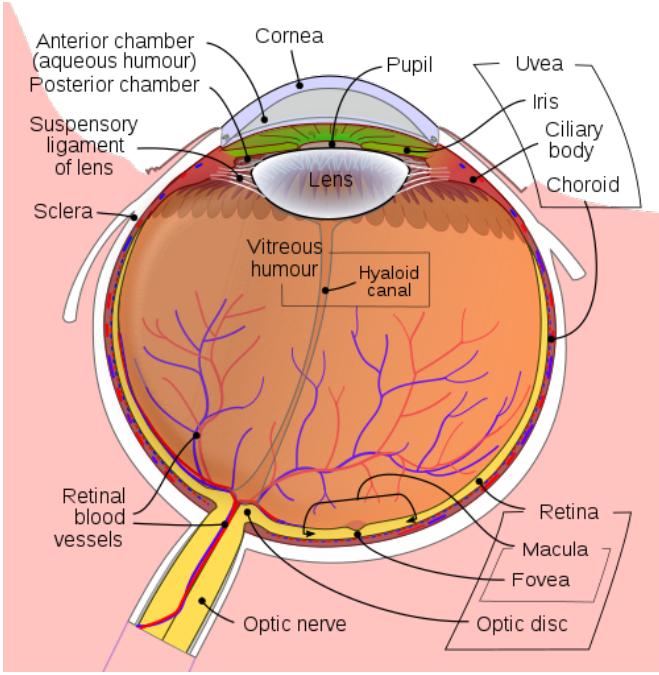
- Synergies with other disciplines and various applications Artificial Intelligence - robotics, natural language understanding

- Vision as a sensor - medical imaging, Geospatial Imaging, robotics, visual surveillance, inspection

Computer Vision

Visual Sensing

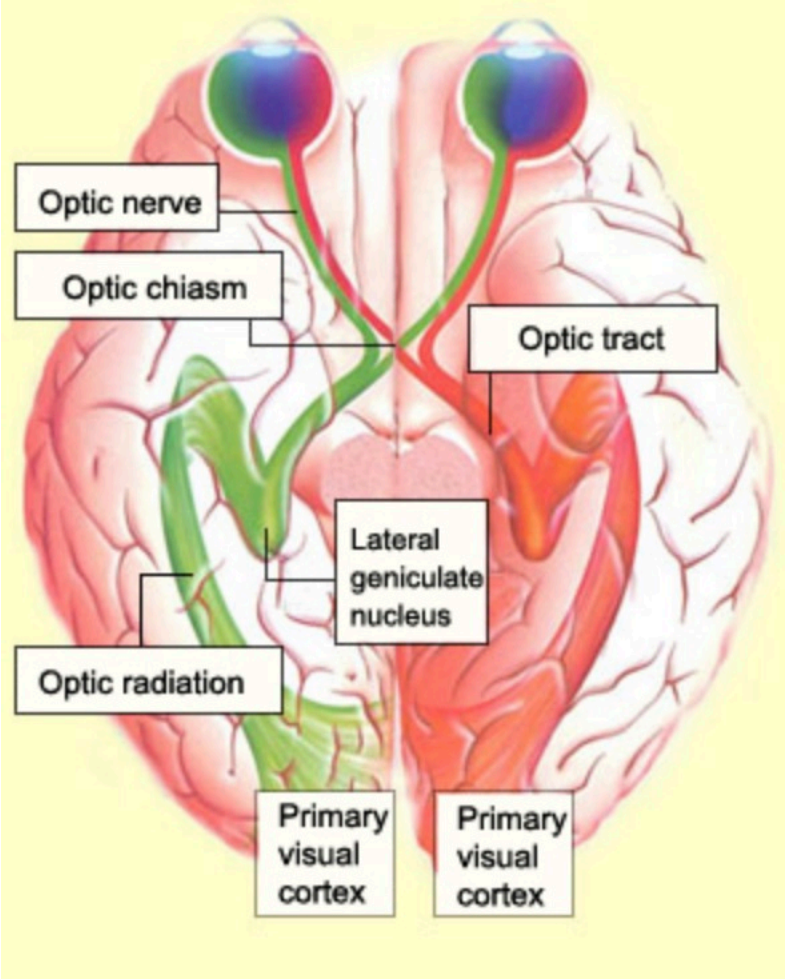
Images I(x,y) – brightness patterns



- image appearance depends on structure of the scene
- material and reflectance properties of the objects
- position and strength of light sources

Visual Information Processing

- Our vision accounts for 2/3rd of brain electrical activity.
- 50% of our neural tissue is related to vision, directly or indirectly.
- More of our neurons are dedicated to vision than other four senses combined
- About 40% of our nerve fibers connected to the brain are linked to retina
- We see immediately and can form and understand images instantly



Source: https://thebrain.mcgill.ca/flash/d/d_02/d_02_cr/d_02_cr_vis/d_02_cr_vis.html

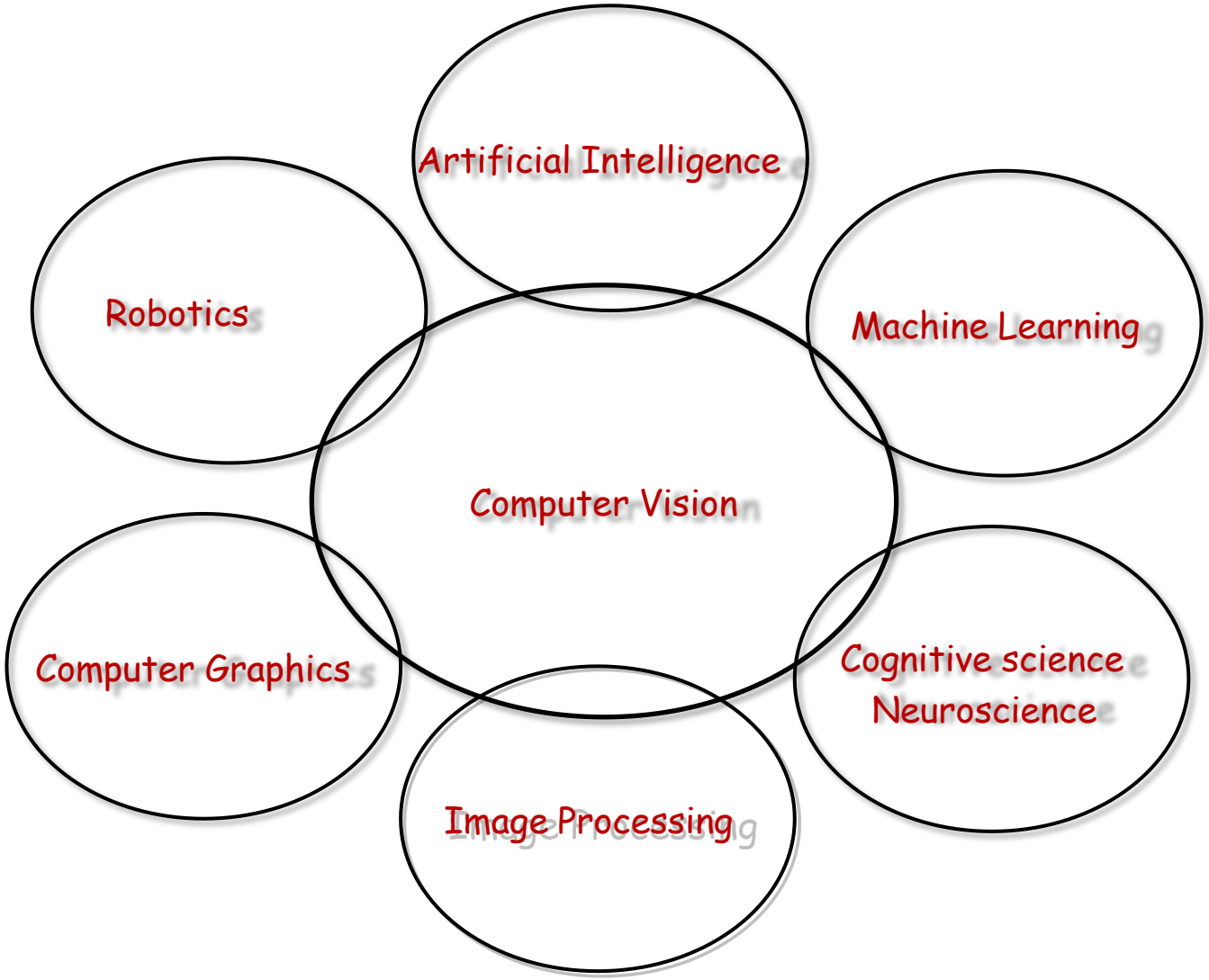
Goal of Computer Vision

what we see

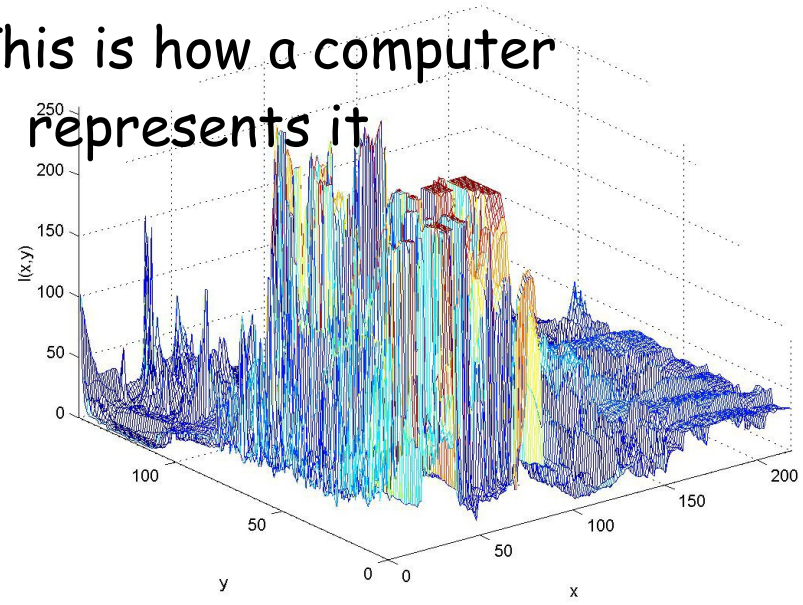
what computers see

230	25	34	123
45	0	10	52
65	11	210	42
78	87	56	90
23	18	29	61

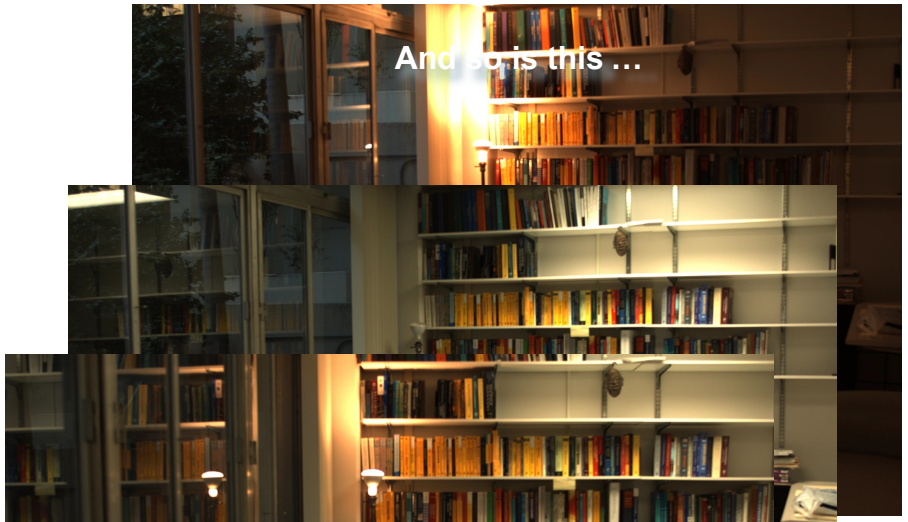
Connections to other disciplines

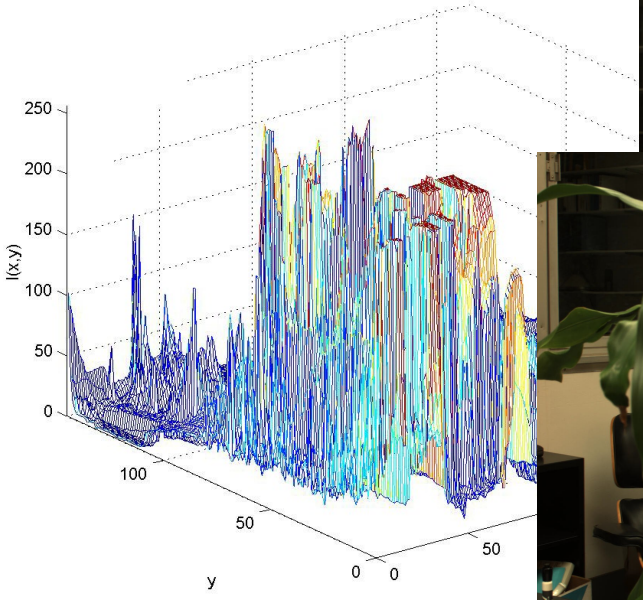


This is how a computer represents it

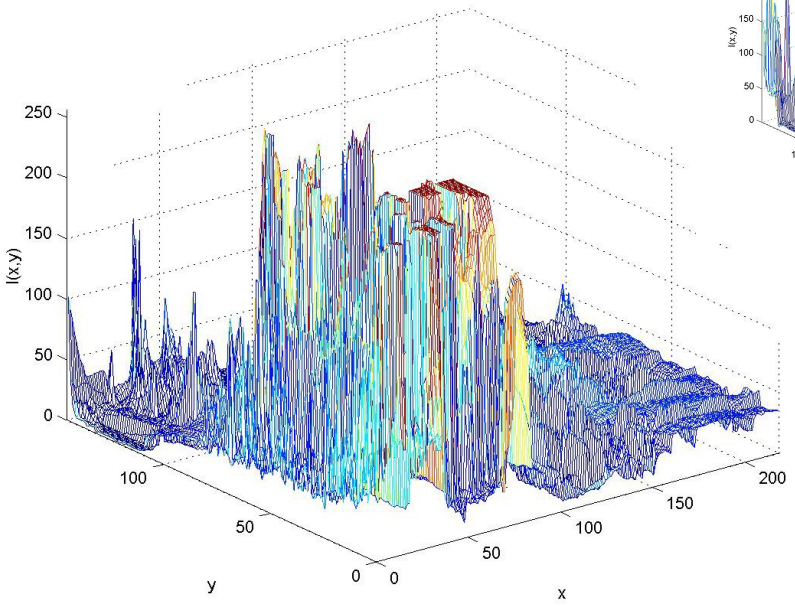


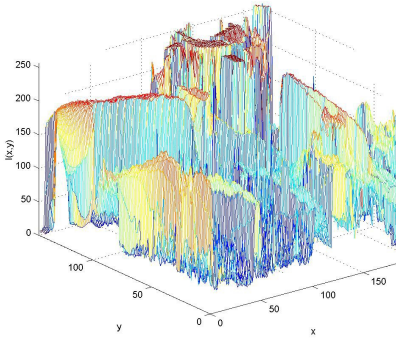
And so is this …

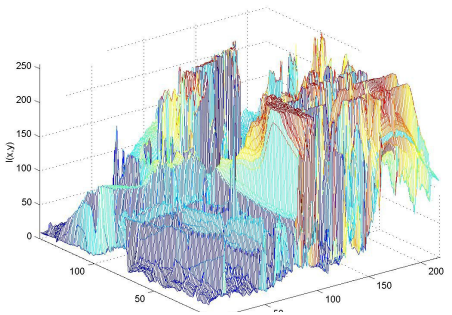


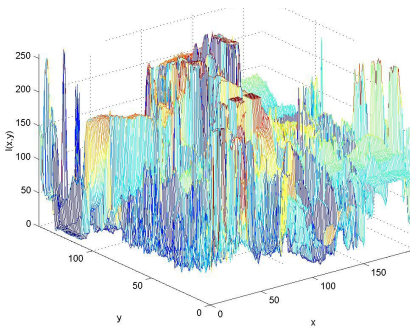


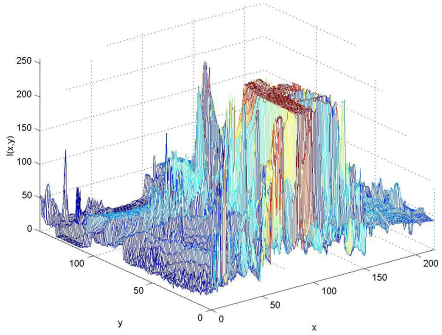
And so are these!

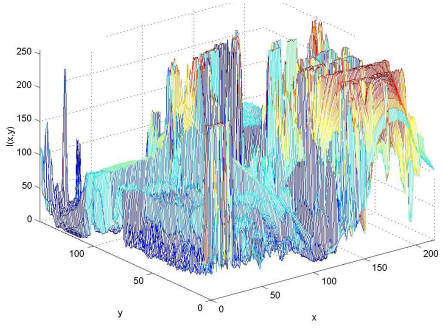






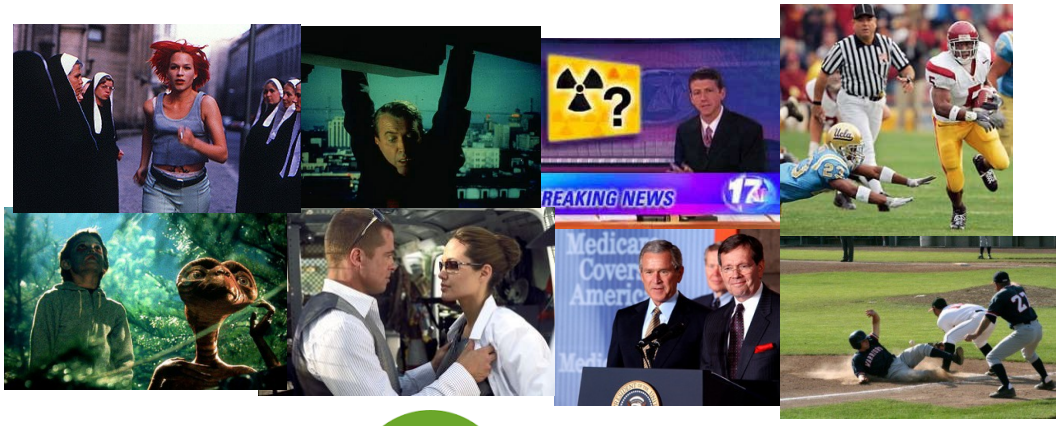




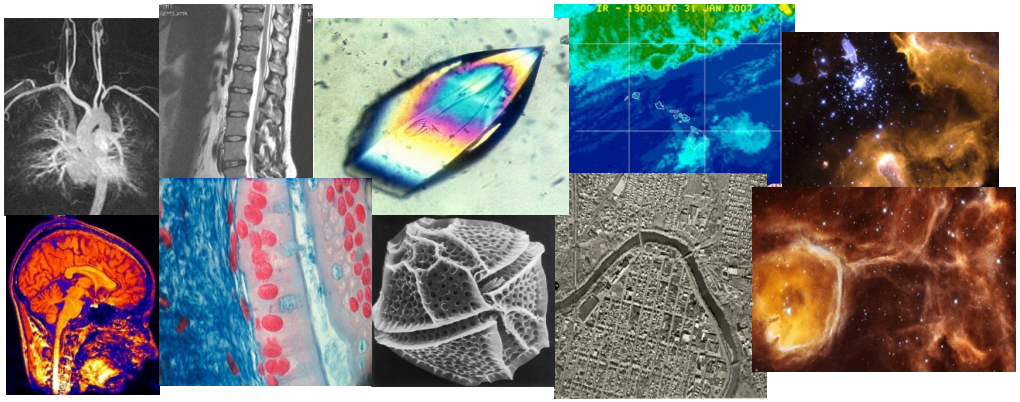


Why study computer vision?

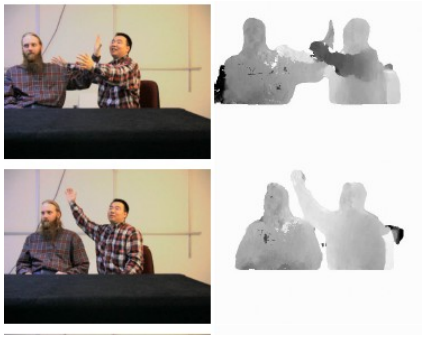
- Vision is useful: Images and video are everywhere!

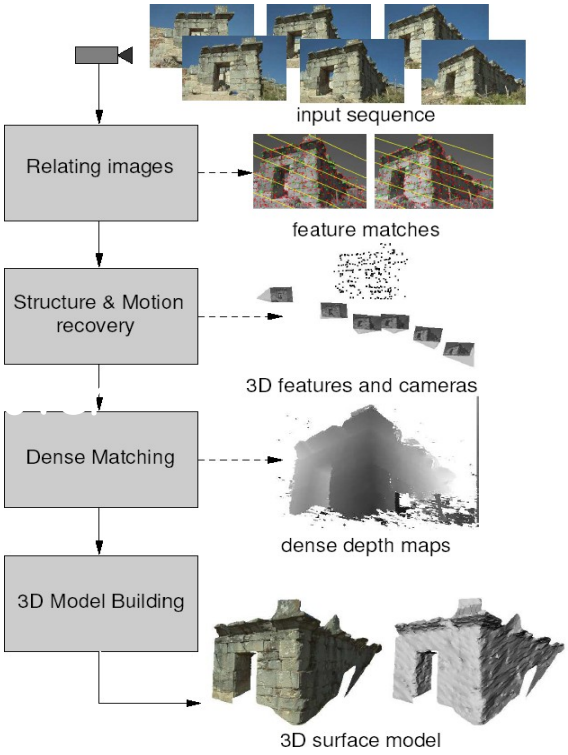


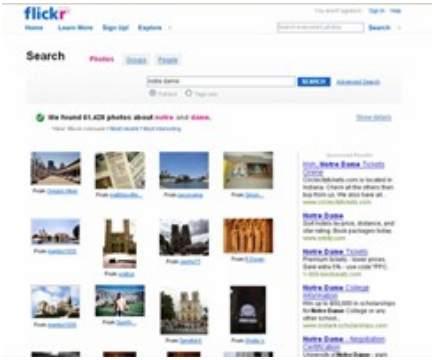
Google Image Search™ Picasa™ flickr™ pixabay picsearch™ YouTube Broadcast Yourself™

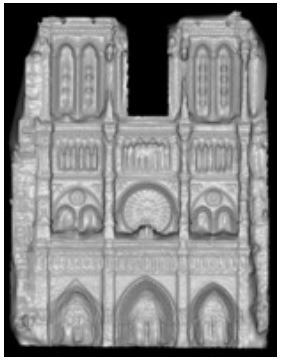


Vision as measurement device

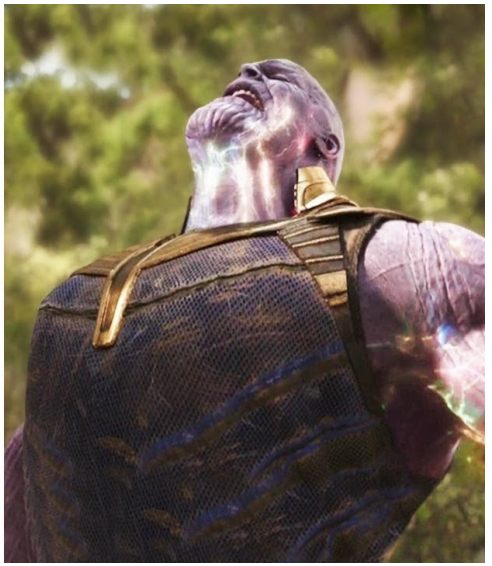




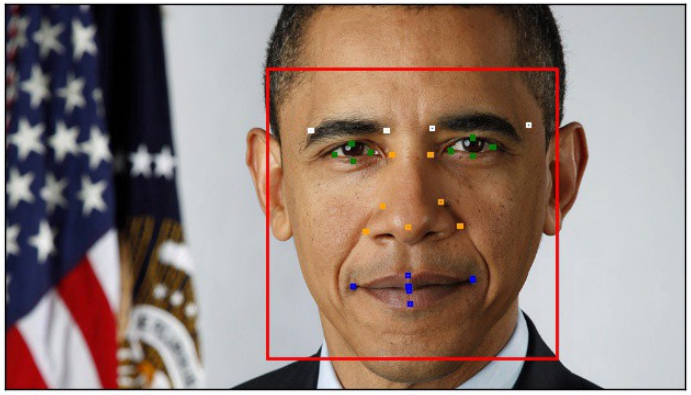




Special effects: shape and motion capture



Face recognition

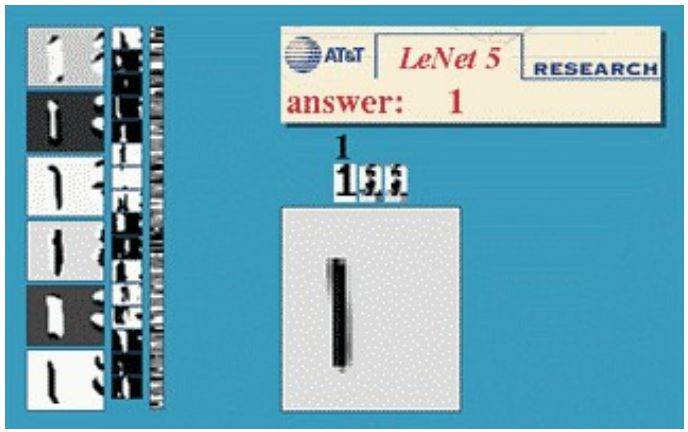


Biometrics

Optical character recognition (OCR)

Technology to convert scanned docs to text

- If you have a scanner, it probably came with OCR software



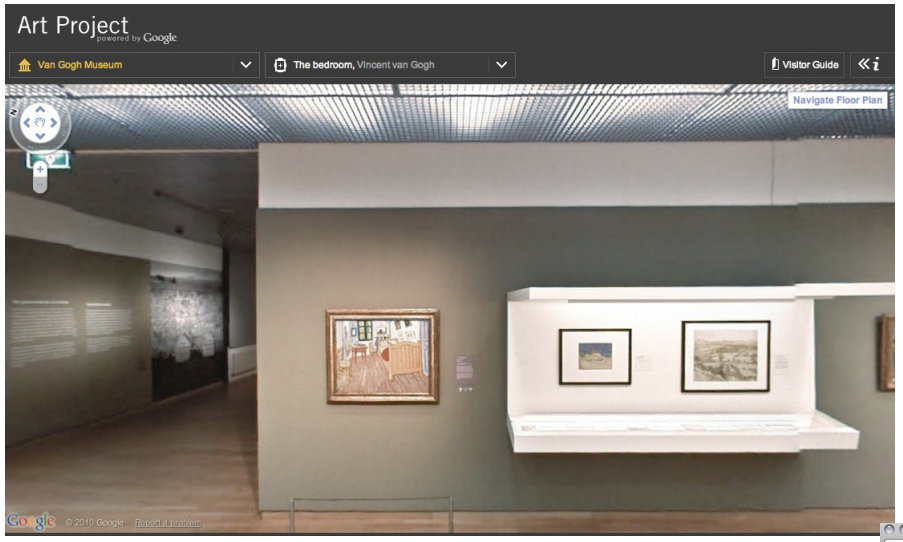
Digit recognition, AT&T labs

License plate readers http://en.wikipedia.org/wiki/Automatic_number_plate_recognition

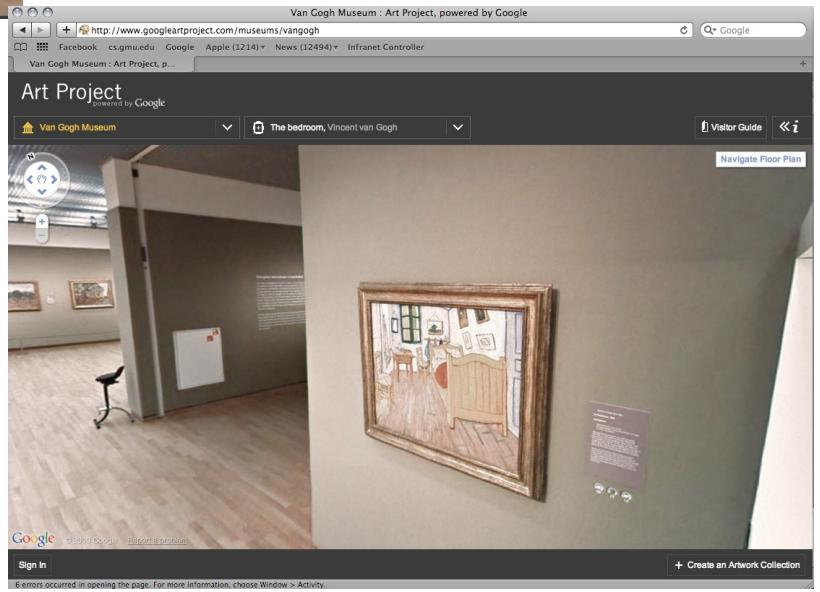
Source: S. Seitz

Mobile visual search

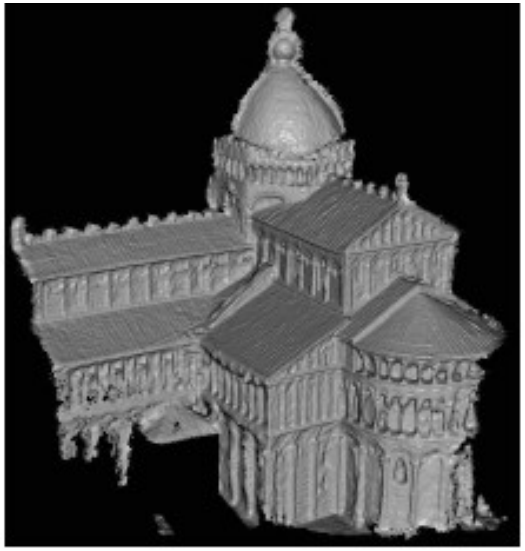
Google Art Museum Project



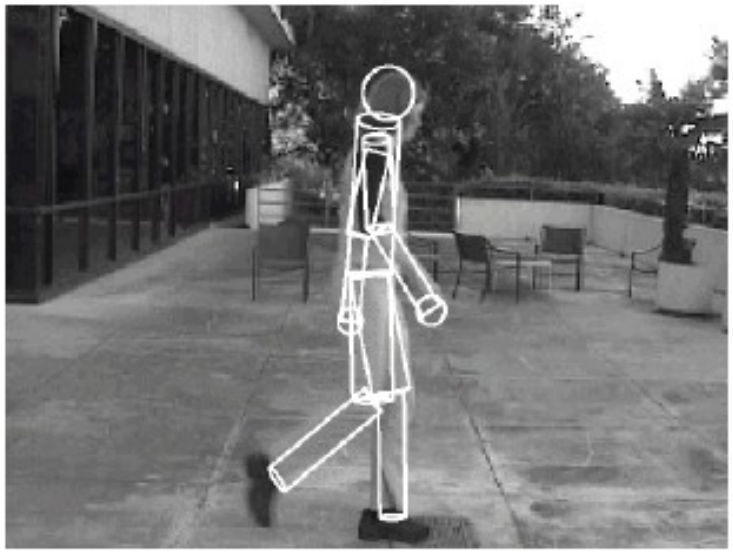
Navigate museums of the world



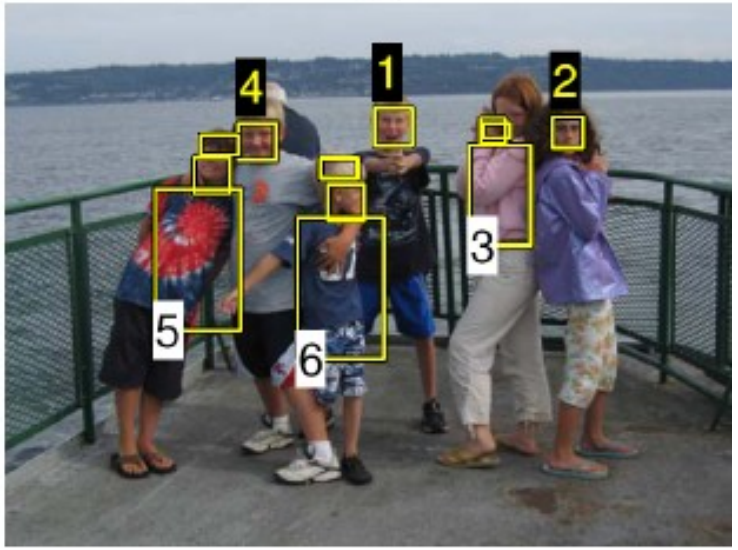
(a)



(b)



(c)



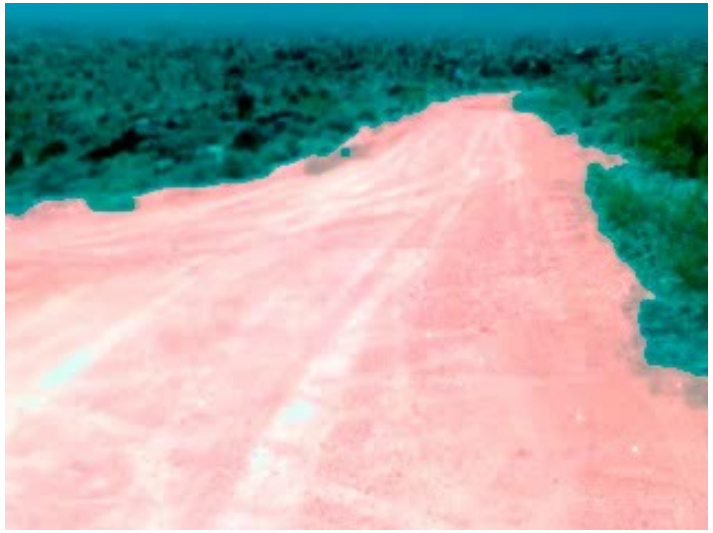
(d)

Autonomous vehicles

Vision-based interaction (and games)

Assistive technologies

Object Classification



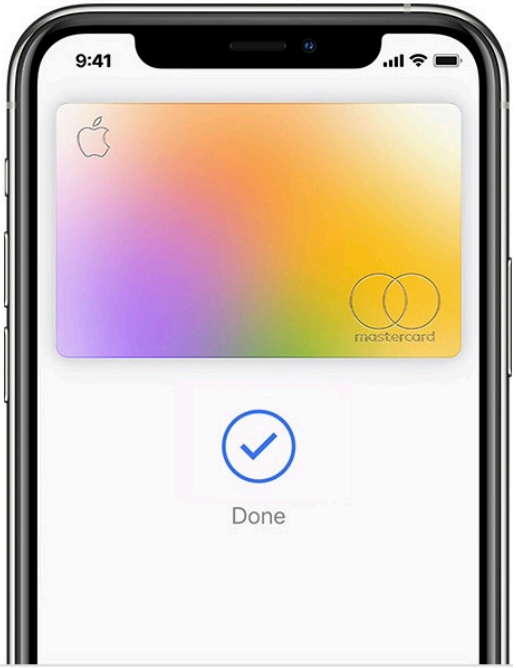
Vision as a source of semantic information

slide credit: Fei-Fei, Fergus & Torralba

Object identification

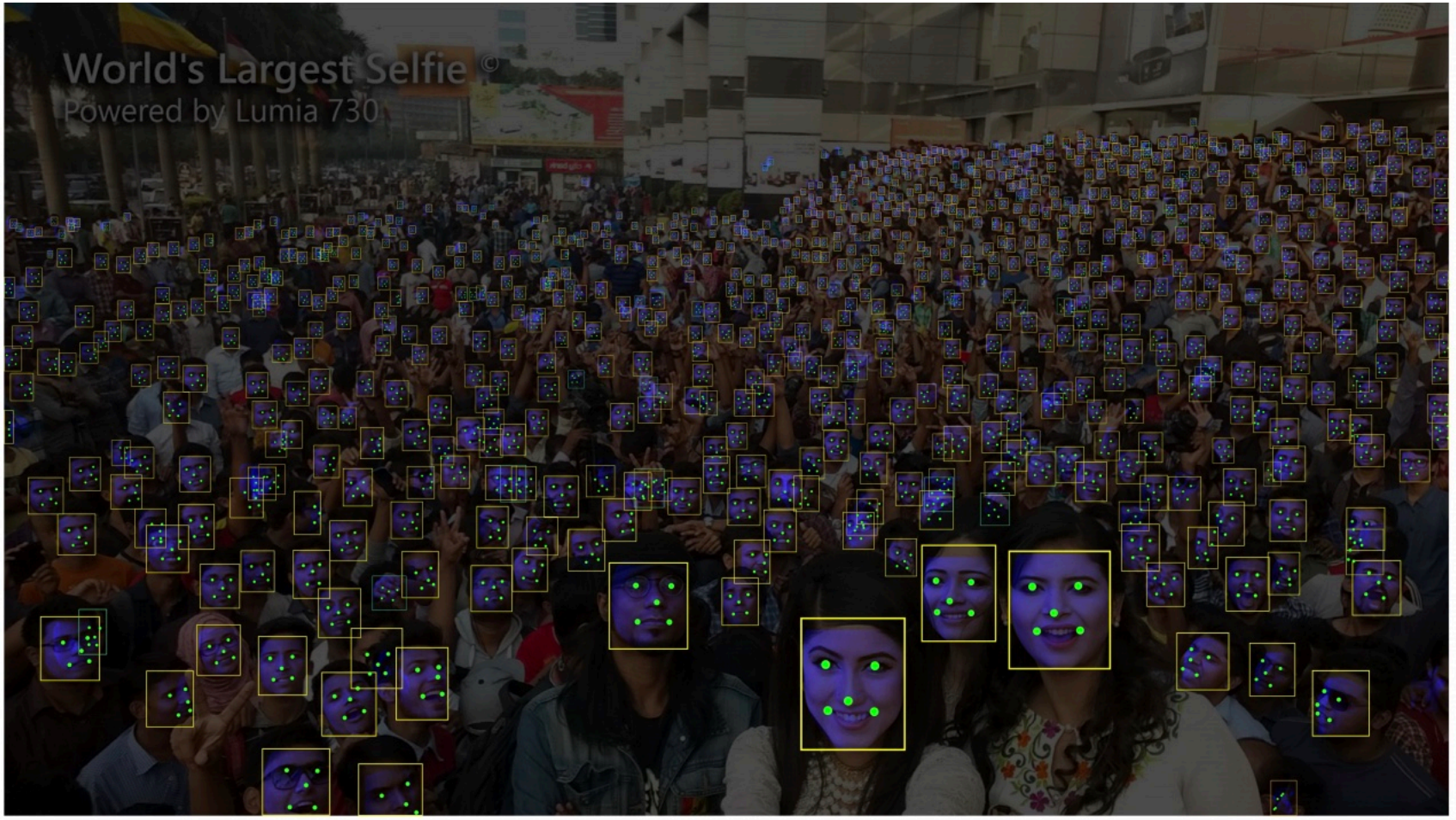
Face Verification

Are you the one who you claim to be?



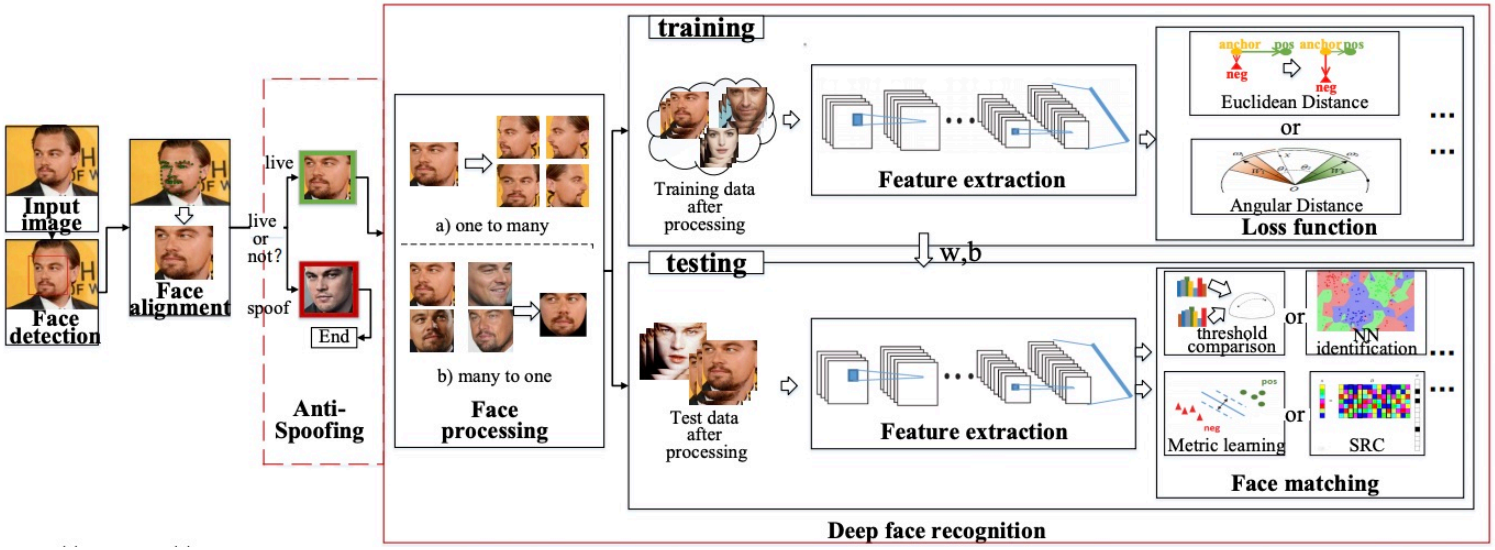
Face Detection

Locate all faces in an image

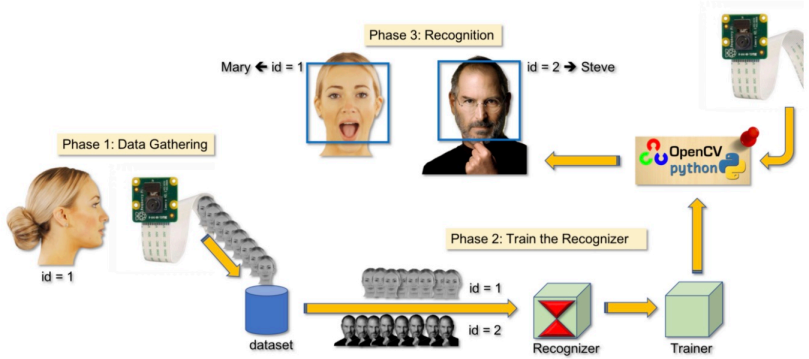


Face Recognition

Recognize a person in a gallery of images



Source: Deep Face Recognition: A Survey

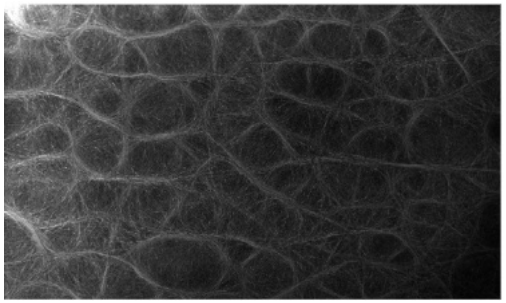


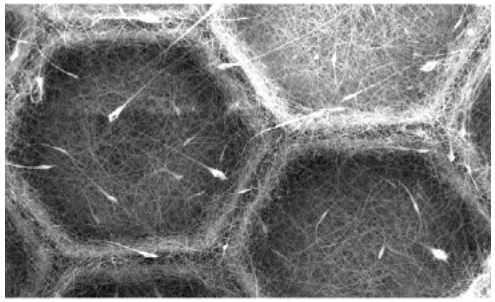
https://towardsdatascience.com/real-time-face-recognition-an-end-to-end-project-b738bb0f7348

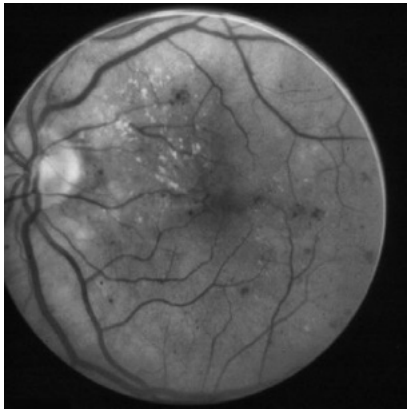
Challenges: viewpoint variation

Source: D. Glasner et al. / Image and Vision Computing 30 (2012) 923–933

Challenges: illumination

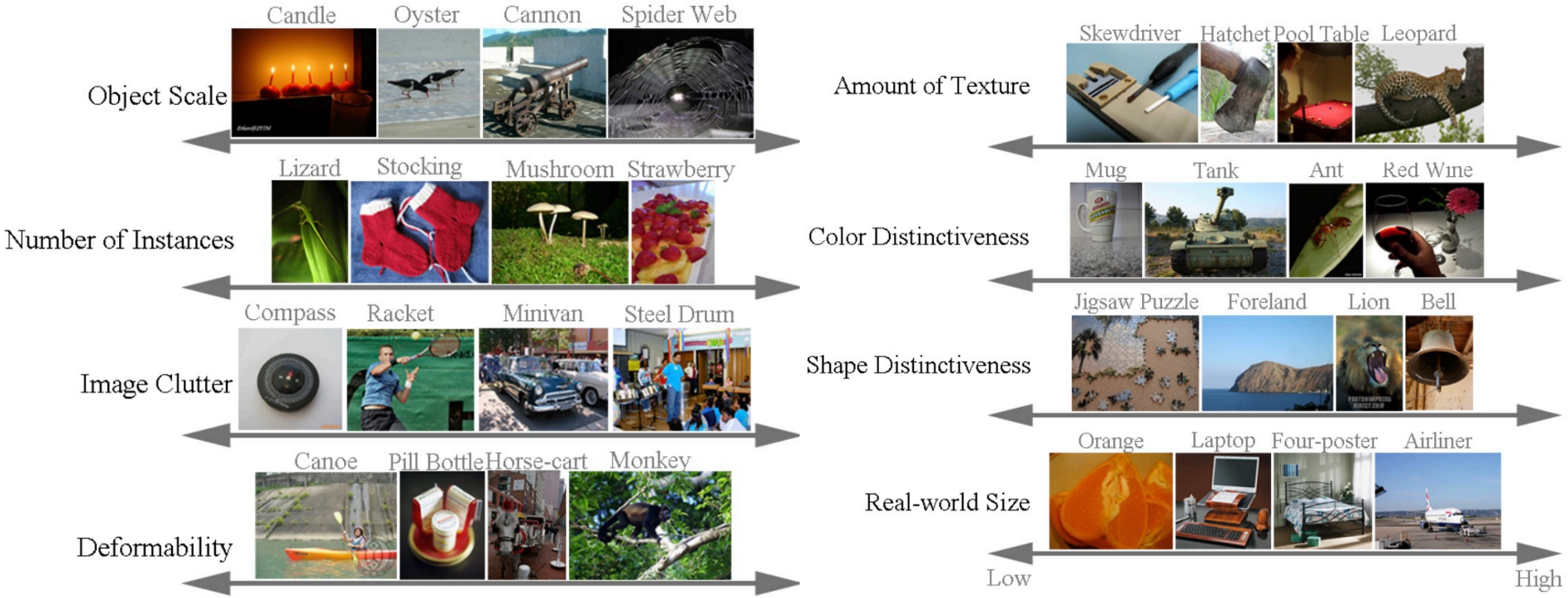






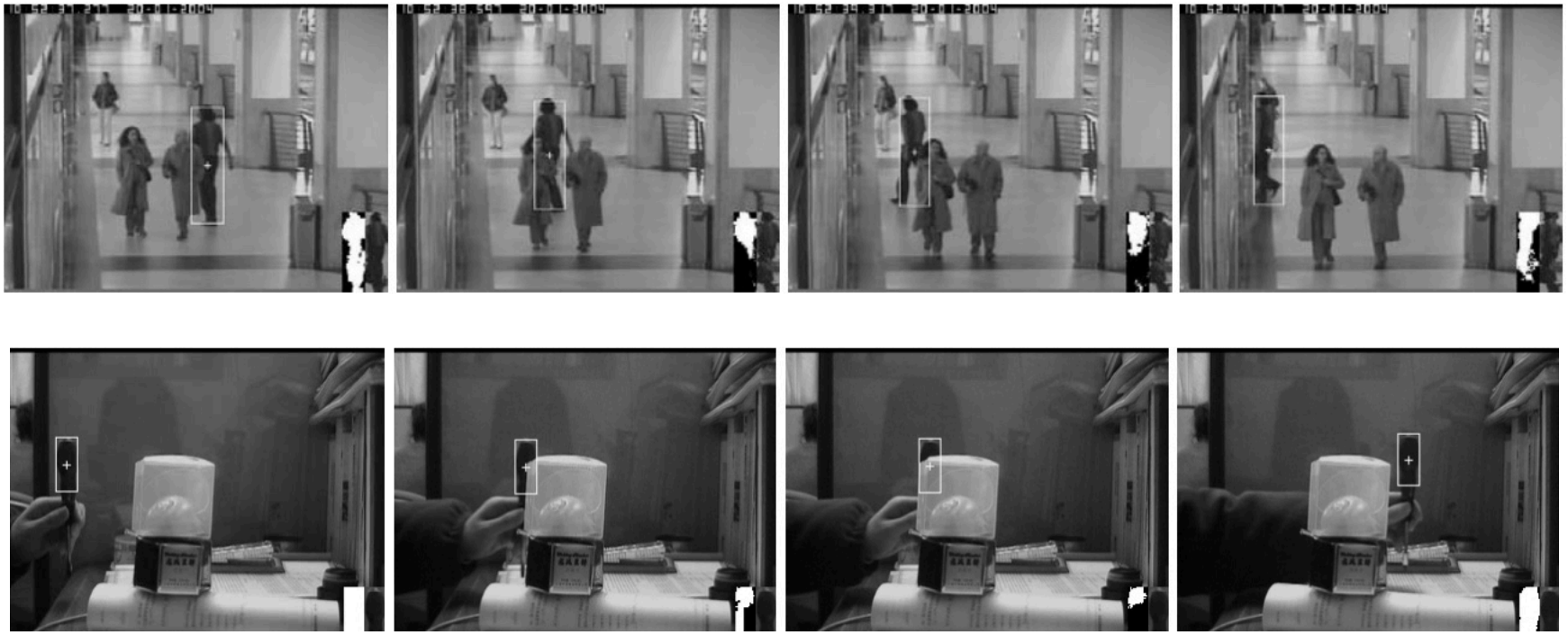
Source: S.Geffray et al./Journal ofcMultivariate Analysis 150(2016)191–213

Challenges: Diversity of Data and scale



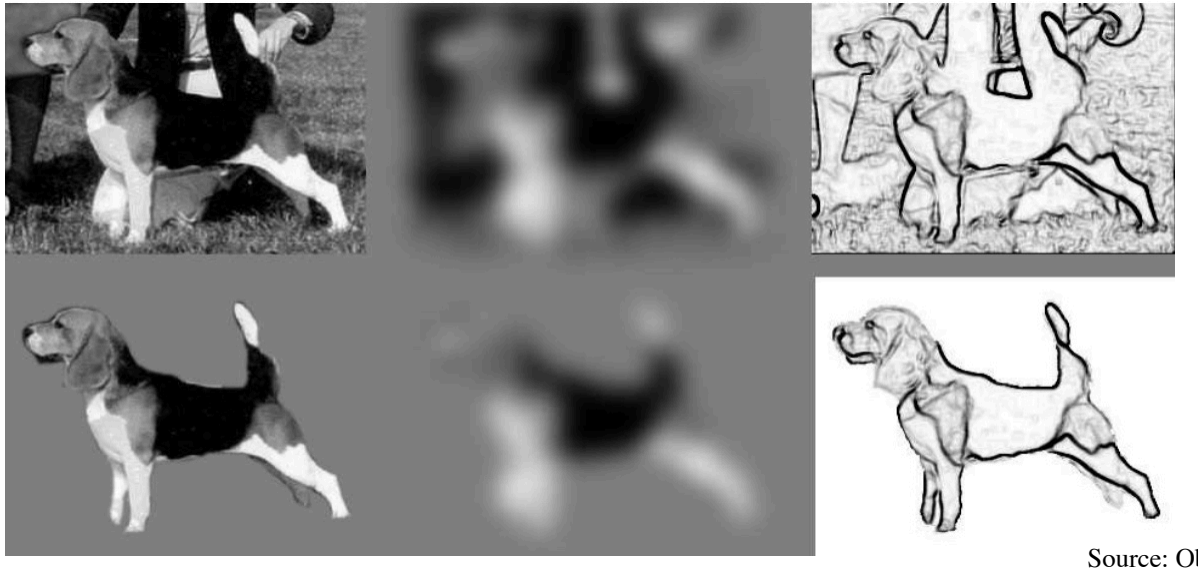
Source: ImageNet Large Scale Visual Recognition Challenge

Challenges: occlusion



Source: Robust Occlusion Handling in Object Tracking, pan & Hu

Challenges: background clutter



Source: Object Recognition in Dense Clutter, Bravo & Farid

Challenges: Motion

Challenges: object intra-class variation

slide credit: Fei-Fei, Fergus & Torralba

Levels of complexity

- Early vision – local operations, compute maps, or statistics of individual pixels (edges, motion fields, depth maps)
- Midlevel vision – assembly of local information (segmentation, contour completions, grouping)
- Scene analysis – recognition of objects, scenes
- Active vision – how to control and use the resources to adjust the sensor to gather additional information
- Goal directed vision – control behaviors based on visual information

Contents of the Class

Image Processing, Low-level and Mid-level Vision :

- Image sensing, lenses
- Non-traditional sensors & perceptual coordinate systems
- Photometry and Color
- Filtering, correlation, convolution, noise
- Fourier transform
- Edge detection, Boundary detection
- Hough transforms
- Features, Corners, SIFT features
- Image and Motion
- Segmentation
- Texture Analysis

Multiple view Geometry for Robotics:

- Geometric transforms
- Projective geometry
- Camera Calibration
- Epipolar geometry
- Stereopsis
- Optical flow
- Tracking

Image Recognition

- Recognition of specific objects
- Recognition using Machine Learning, SVM, HOG features
- Recognition using Neural Networks
- Applications of Recognition

Homework 1

- Review of estimation
- LS estimation TLS estimation , LS with Regularization and RANSAC, applied to the problem of line fitting