CSCE 4603
Fundamentals of Computer Vision

Dr. Mahmoud Khalil
Fall 2019

Course Team

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Text Books

- Rafael C. Gonzalez and Richard E. Woods, **Digital Image Processing**, 4th Edition, Pearson Education, Inc. 2018., ISBN: 978-9353062989

- Richard Sceliski, **Computer Vision Algorithms and Applications**, Springer, 2011 (available online for free at: http://szeliski.org/Book/), ISBN: 978-1848829343

- Rafael C. Gonzalez , Richard E. Woods and Steven L. Eddins, **Digital Image Processing Using Matlab**, Second edition,, Pearson Education, Inc. 2009., ISBN: 978-0070702622

- **OpenCV**: https://opencv.org/

Grading Scheme

- Assignments: 20%
- Midterm Exams (2): 40%
- Final Exam: 20%
- Project: 20%

General Policies

- More than 6 absence days without an official excuse will result you an "F" in this course.

- Any plagiarism case will result you 0 in the corresponding component and possibly an "F" in this course.

- Late Assignments will NOT be accepted.

- An assignment is an individual effort while the project can be done individually or in groups of up to 3 students (with individual tasks validation).

Course Contents

Image acquisition, image transformations, gray level operations, histogram equalization, spatial filtering, edge detection, line and circle detection, generalized Hough transform, connected components labelling. Haar features, object detection with Adaboost, applications: face detection, open CV programming.

Visual Sciences
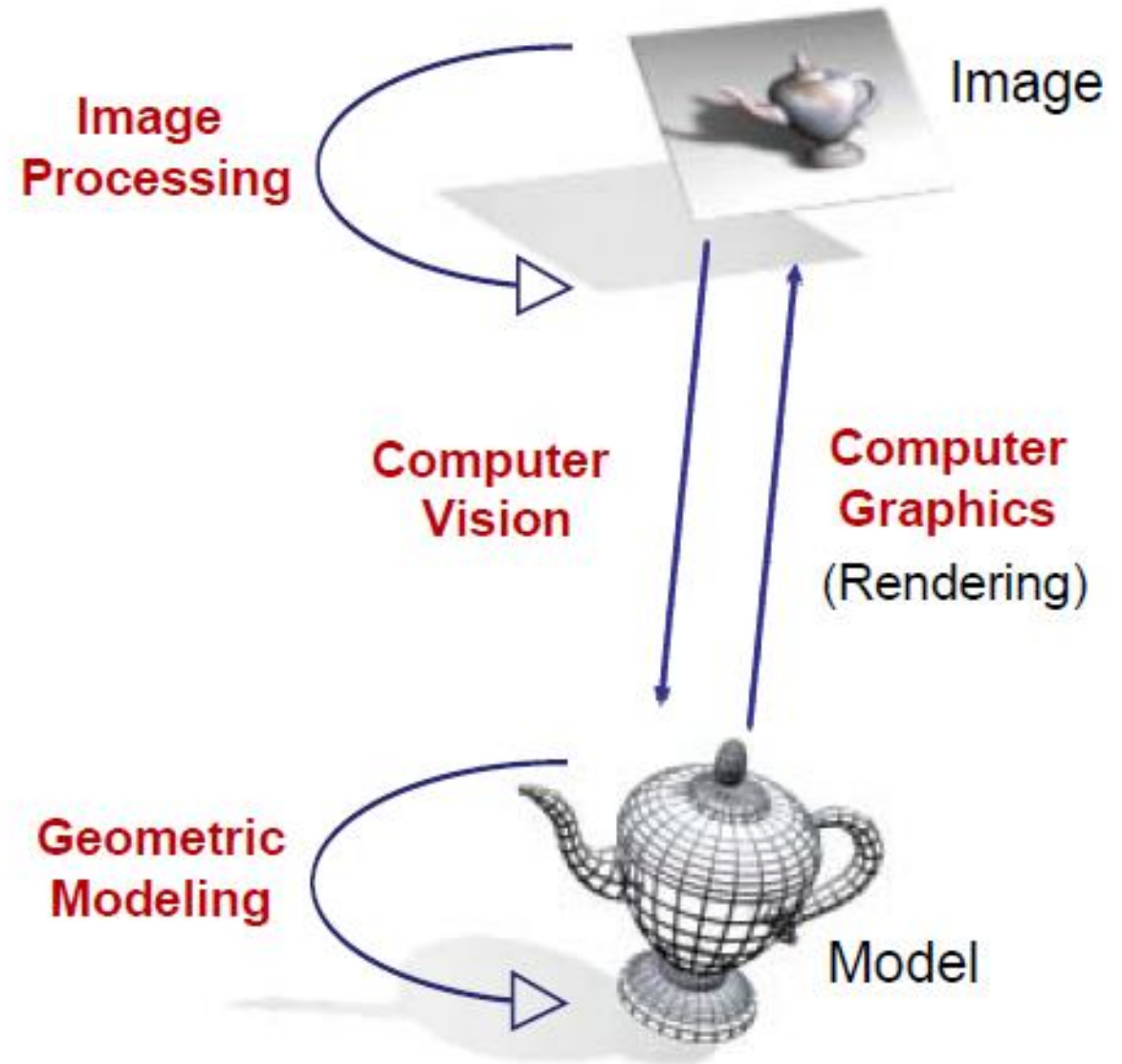
Image Processing - Computer Vision

Low Level

Image Processing

Acquisition, representation, compression, transmission

image enhancement

edge/feature extraction

Pattern matching

image "understanding" (Recognition, 3D)

Computer Vision

High Level
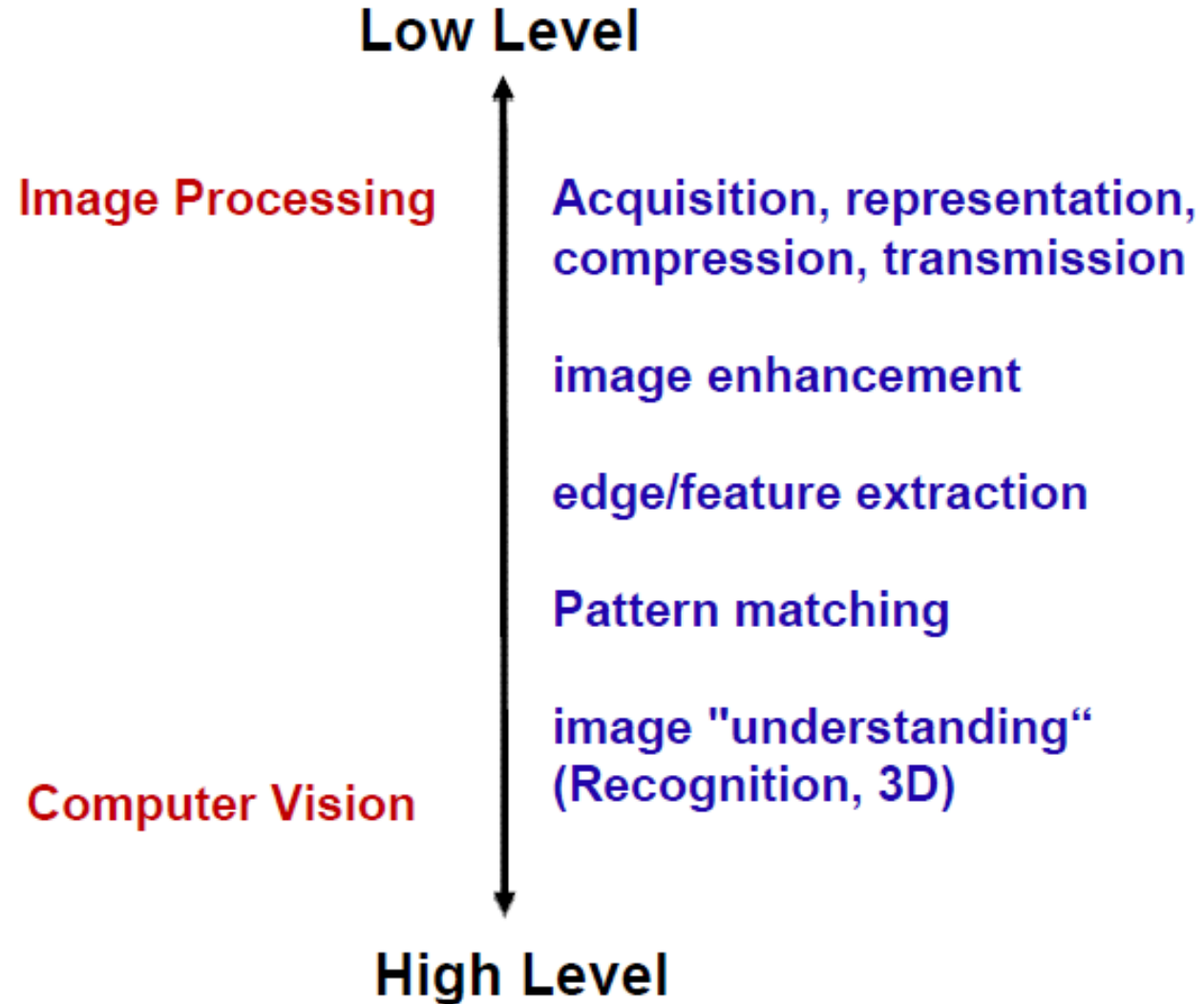
Course Outlines

FIGURE 1.23
Fundamental steps in digital image processing.

Outputs of these processes generally are images

CHAPTER 6	CHAPTER 7	CHAPTER 8	CHAPTER 9
Color image processing	Wavelets and multiresolution processing	Compression	Morphological processing

CHAPTER 5		CHAPTER 10
Image restoration	Knowledge base	Segmentation

CHAPTERS 3 & 4		CHAPTER 11
Image enhancement		Representation & description

CHAPTER 2		CHAPTER 12
Image acquisition		Object recognition

Problem domain

Outputs of these processes generally are image attributes

Image Enhancement

Image Denoising

Salt & Pepper Noise   3 X 3 Average   Median
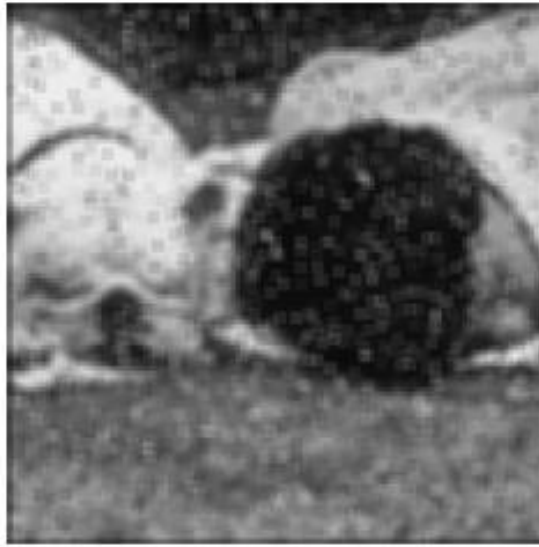
Image Enhancement - Frequency Domain

Original Noisy image   Fourier Spectrum
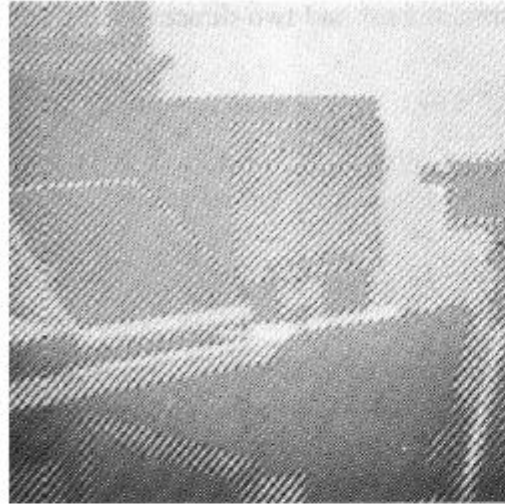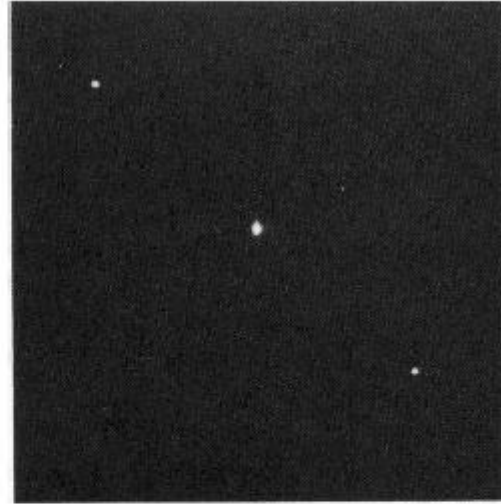
Edge Detection
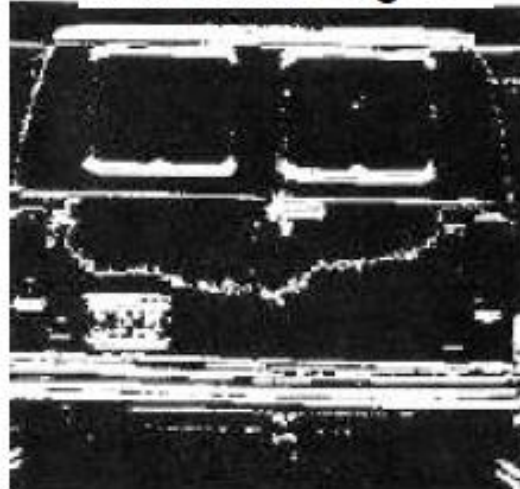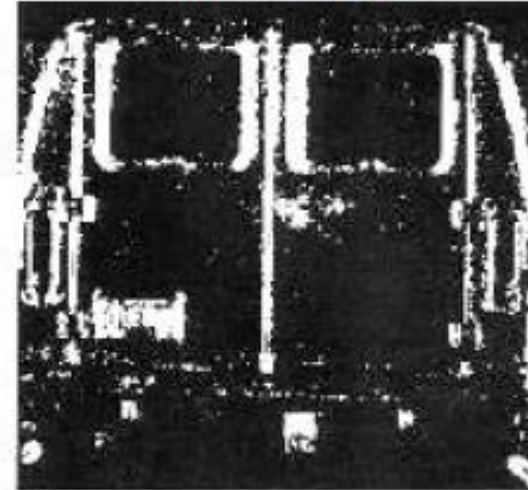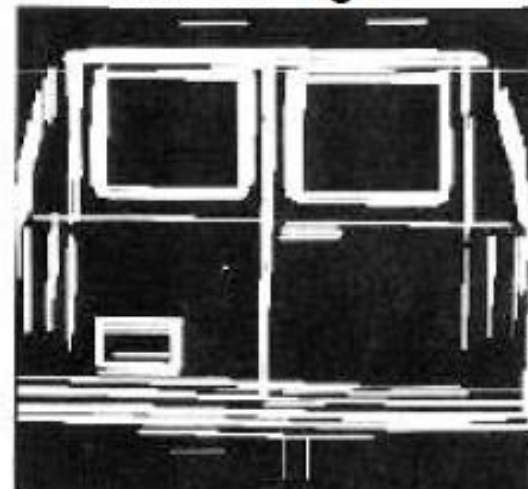
Image Segmentation

Goal: identify groups of pixels that go together
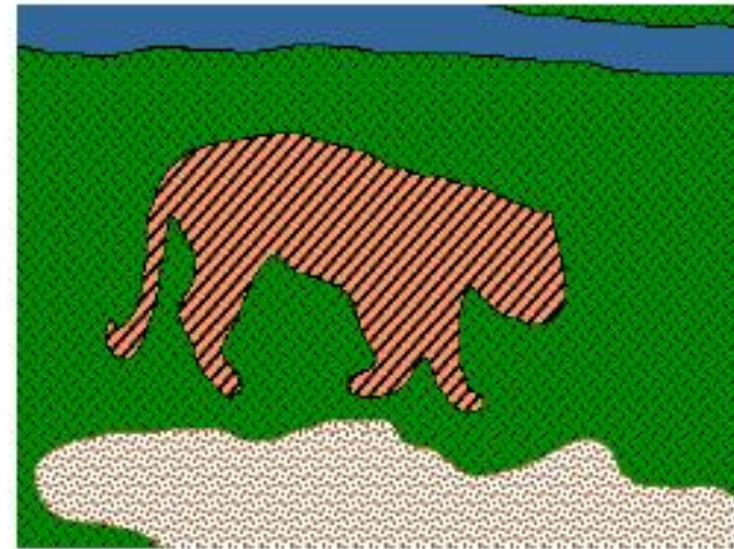
Optical character recognition (OCR)

Technology to convert scanned docs to text

- If you have a scanner, it probably came with OCR software
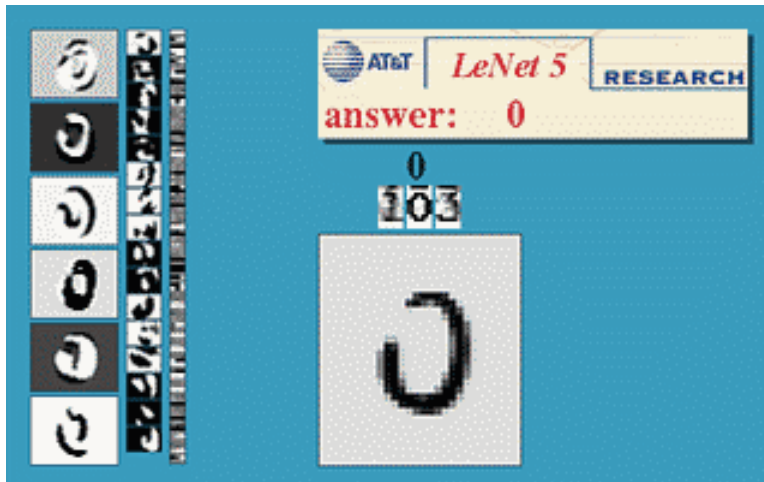
Digit recognition, AT&T labs
http://www.research.att.com/

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

Face detection

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

Smile detection
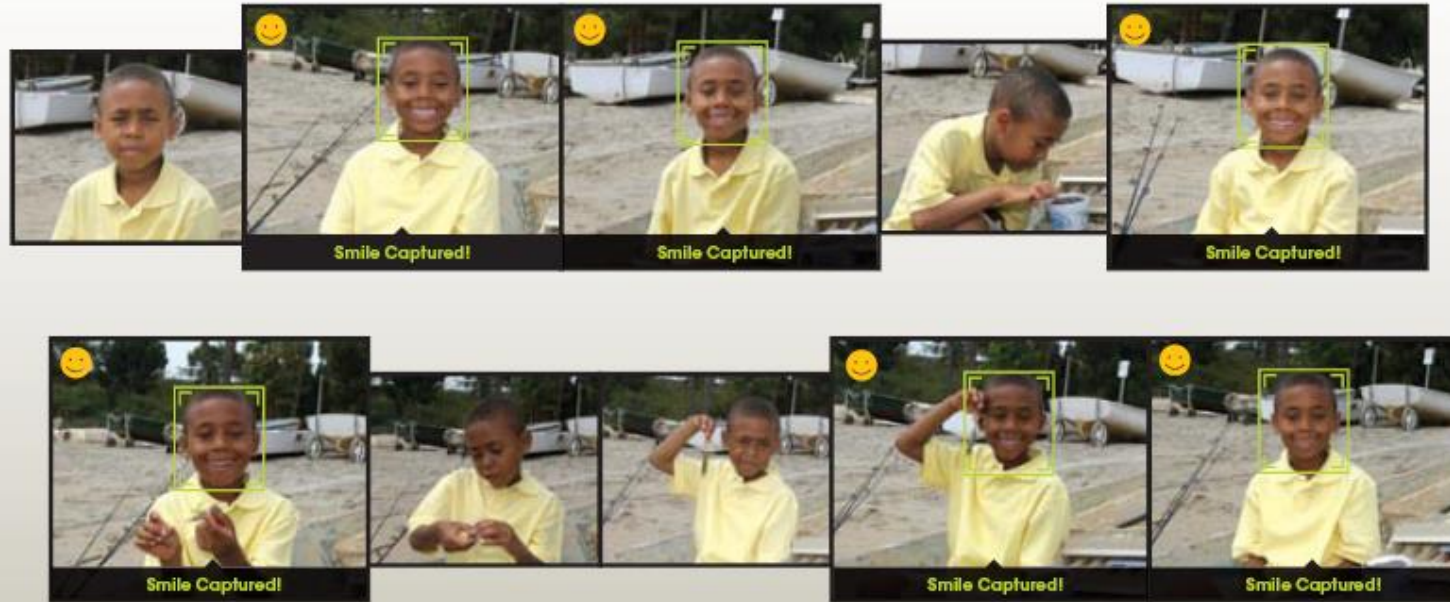
Sony Cyber-shot® T70 Digital Still Camera

Biometrics
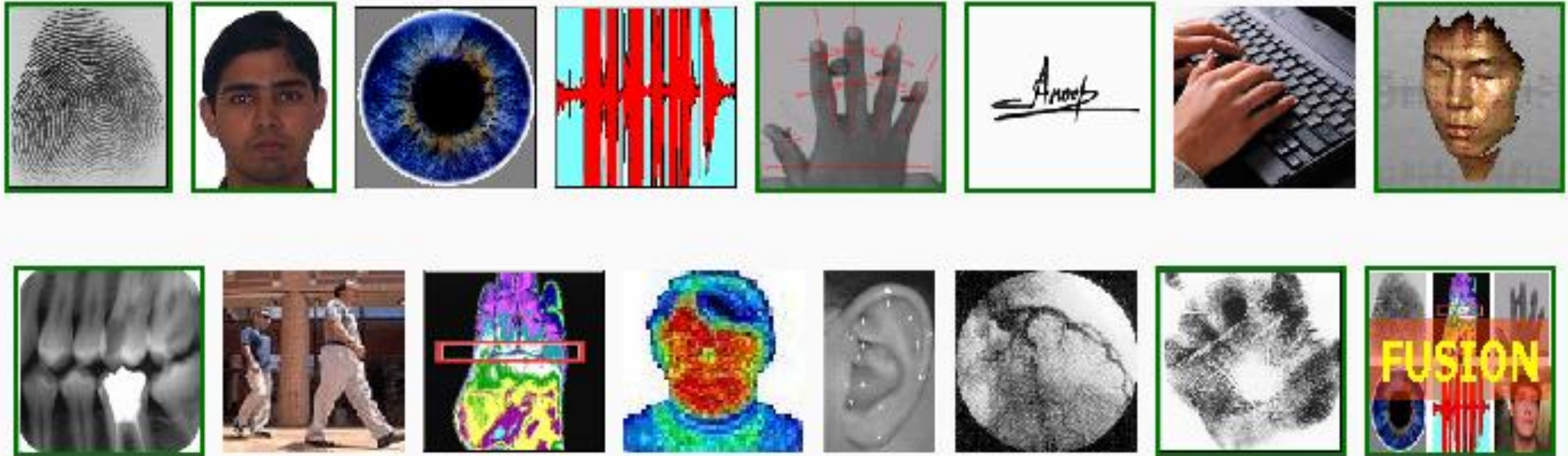
Vision-based biometrics
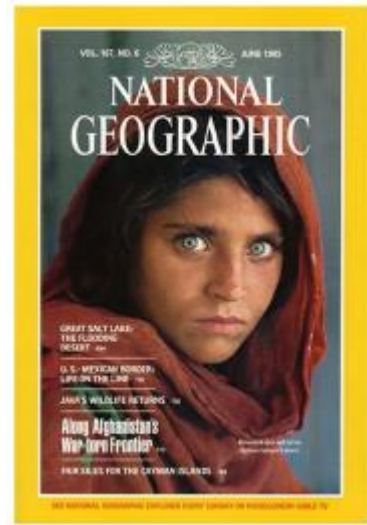
"*How the Afghan Girl was Identified by Her Iris Patterns*"
Read the story
wikipedia
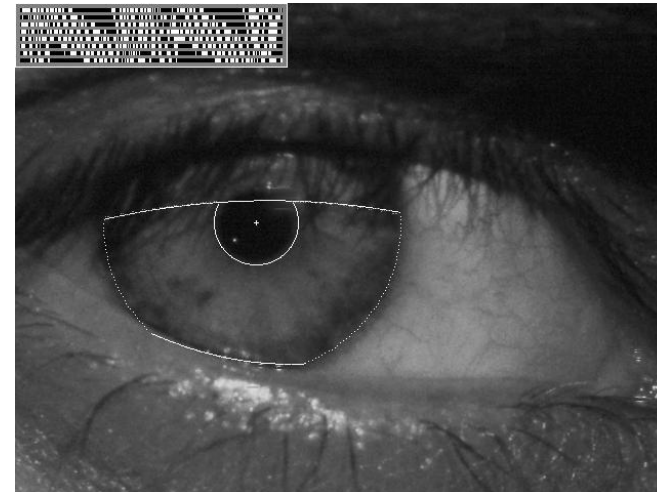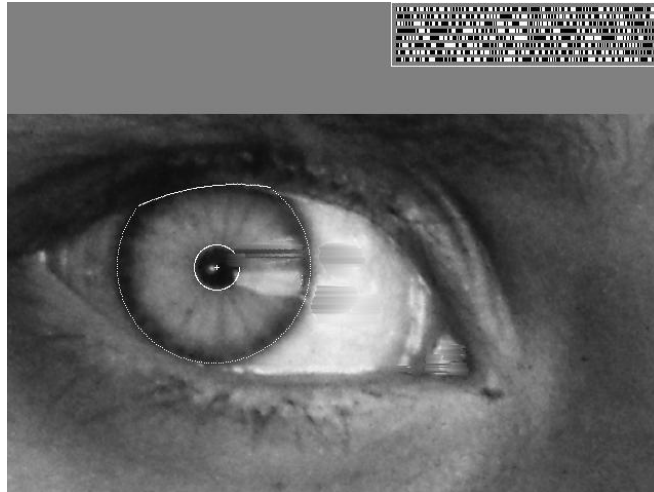
Login without a password…

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, Google Goggles

Building a Panorama

M. Brown and D. G. Lowe. Recognising Panoramas. ICCV 2003

Feature descriptors

- Extraordinarily robust matching technique
  - Can handle changes in viewpoint
    - Up to about 60 degree out of plane rotation
  - Can handle significant changes in illumination
    - Sometimes even day vs. night (below)
  - Fast and efficient—can run in real time

Steve Seitz
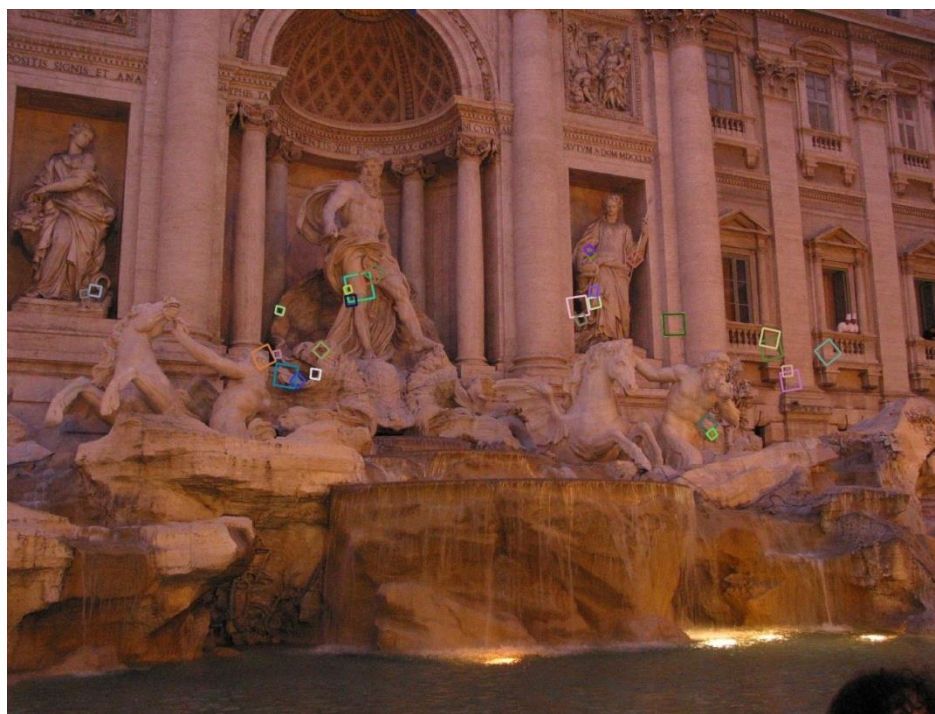
Interactive Games: Kinect

- 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
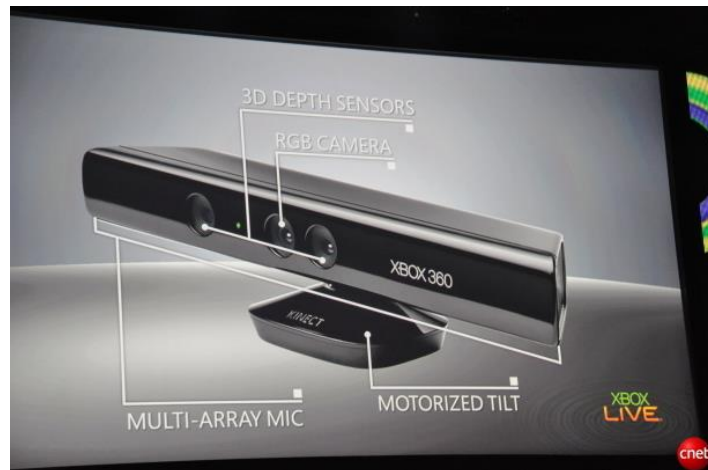
Medical imaging
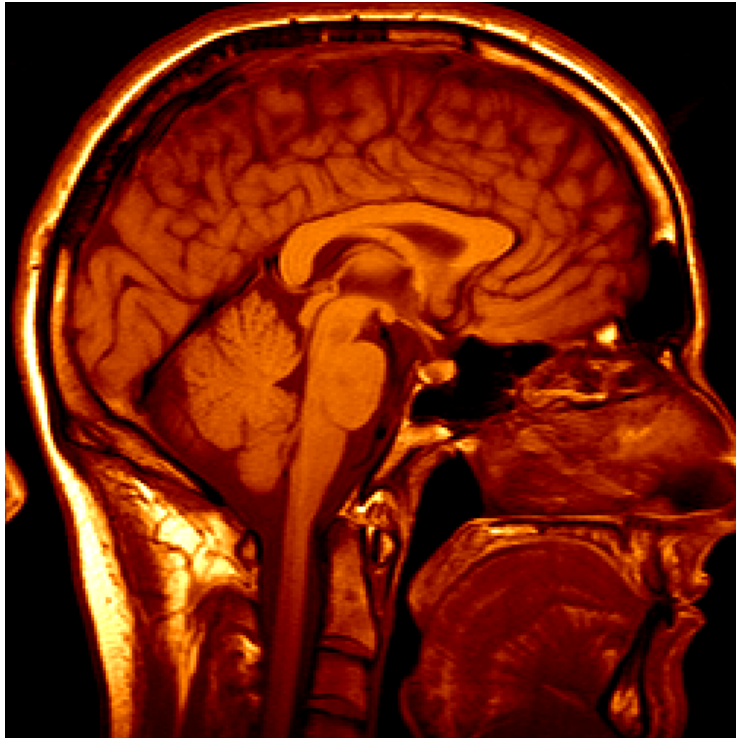
3D imaging
MRI, CT

Image guided surgery
Grimson et al., MIT

Smart cars

- https://www.mobileye.com/
- Vision systems currently in high-end BMW, GM, Volvo models

Google cars

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

AutoCars - Uber bought CMU's lab

Car Detection and Depth Estimation
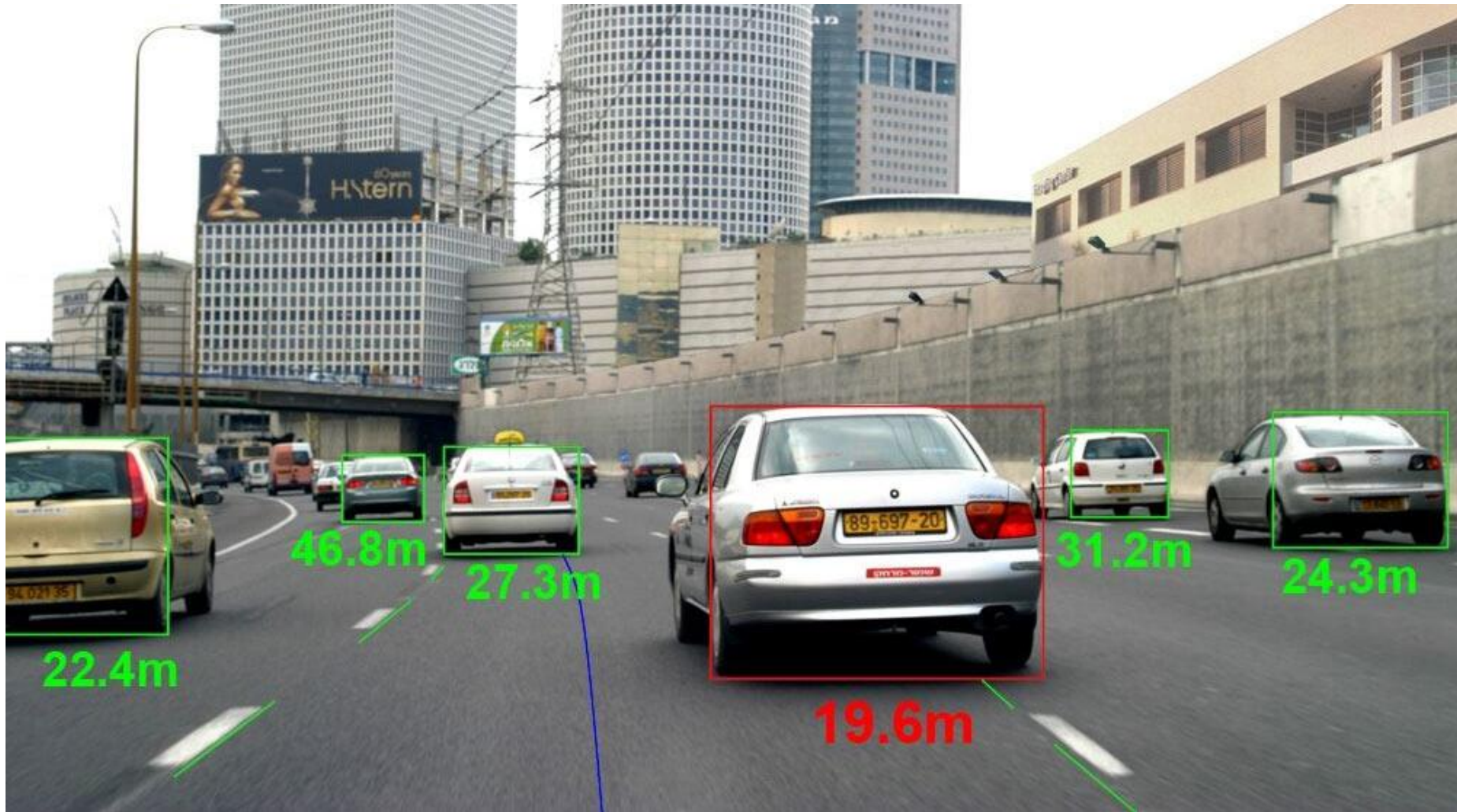
Vision as a Source of Semantic Information

Sports video analysis
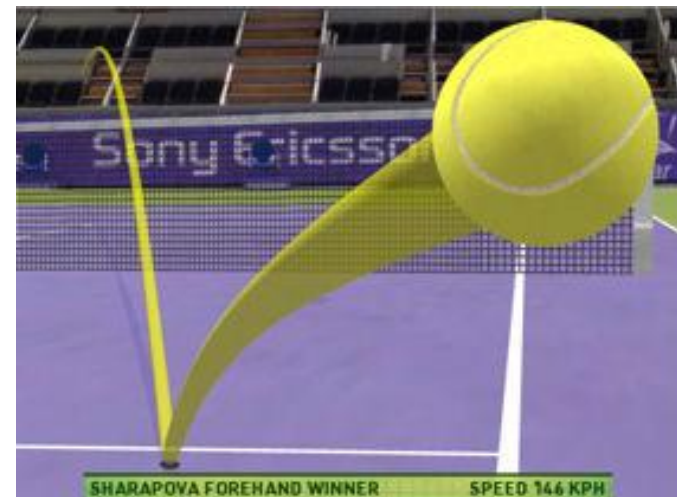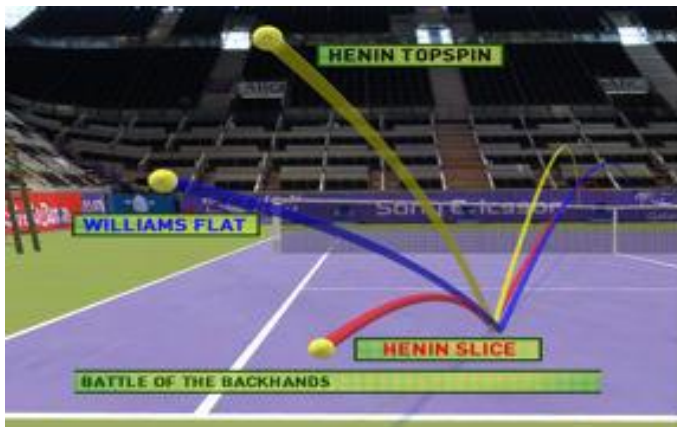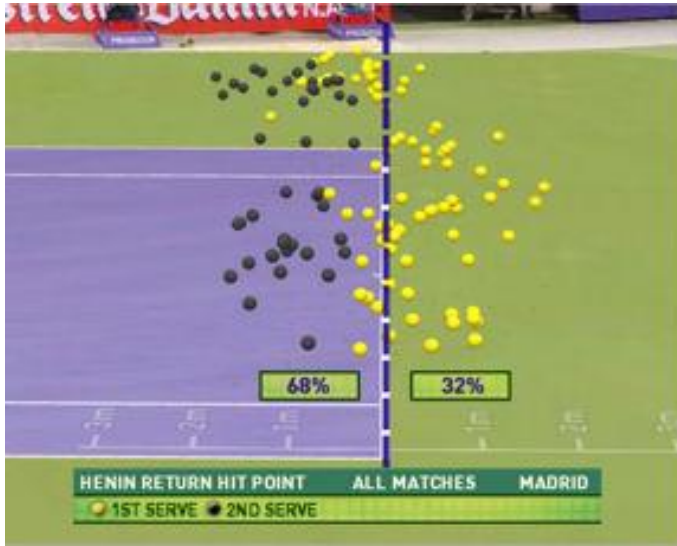
Tennis review system

Why is vision so hard?
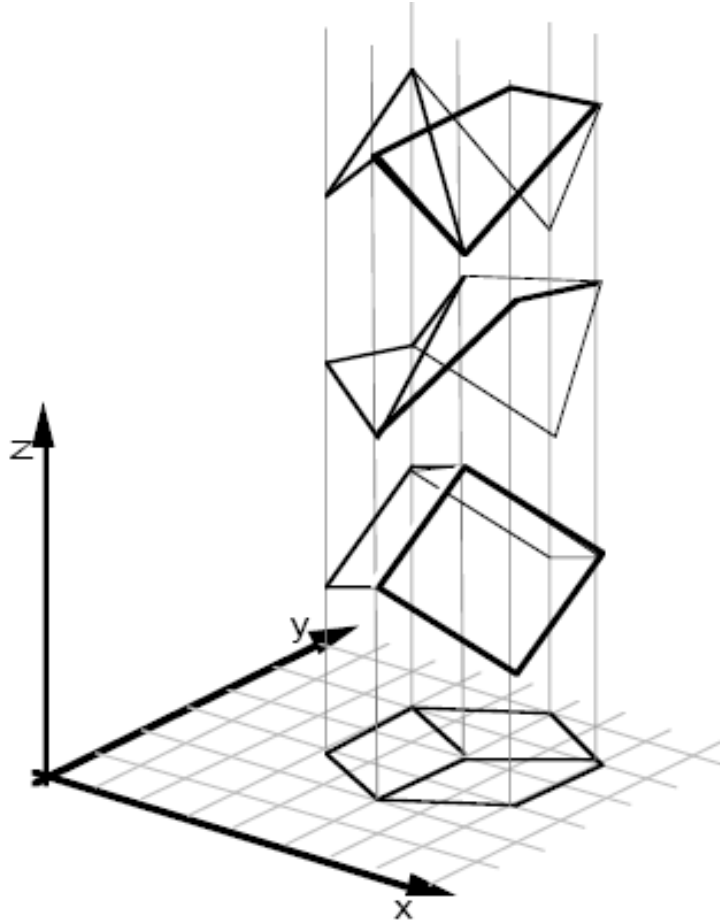
posed problem

[Sinha and Adelson 1993]

Challenges 1: view point variation

Michelangelo 1475-1564

Challenges 2: illumination
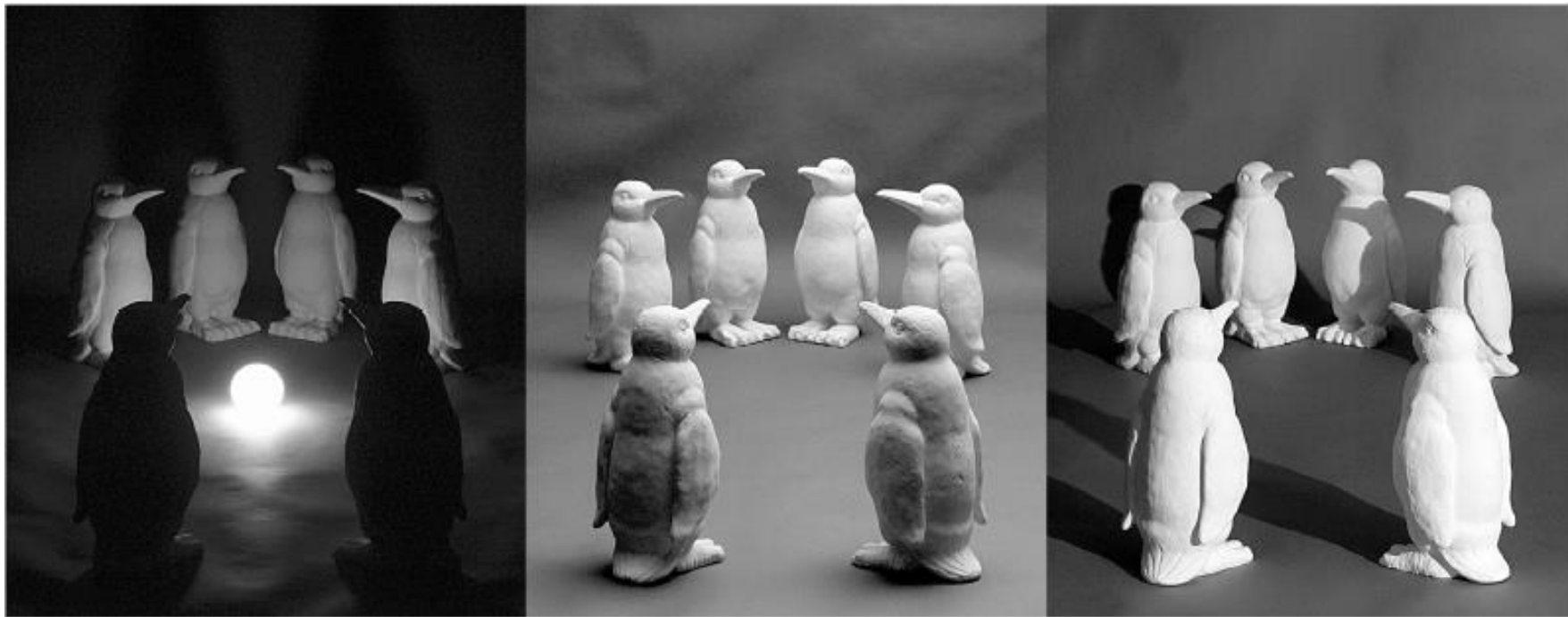
Adapted from Fei-Fei Li

Challenges 3: occlusion

Magritte, 1957

Adapted from L. Fei-Fei,
R. Fergus, A. Torralba
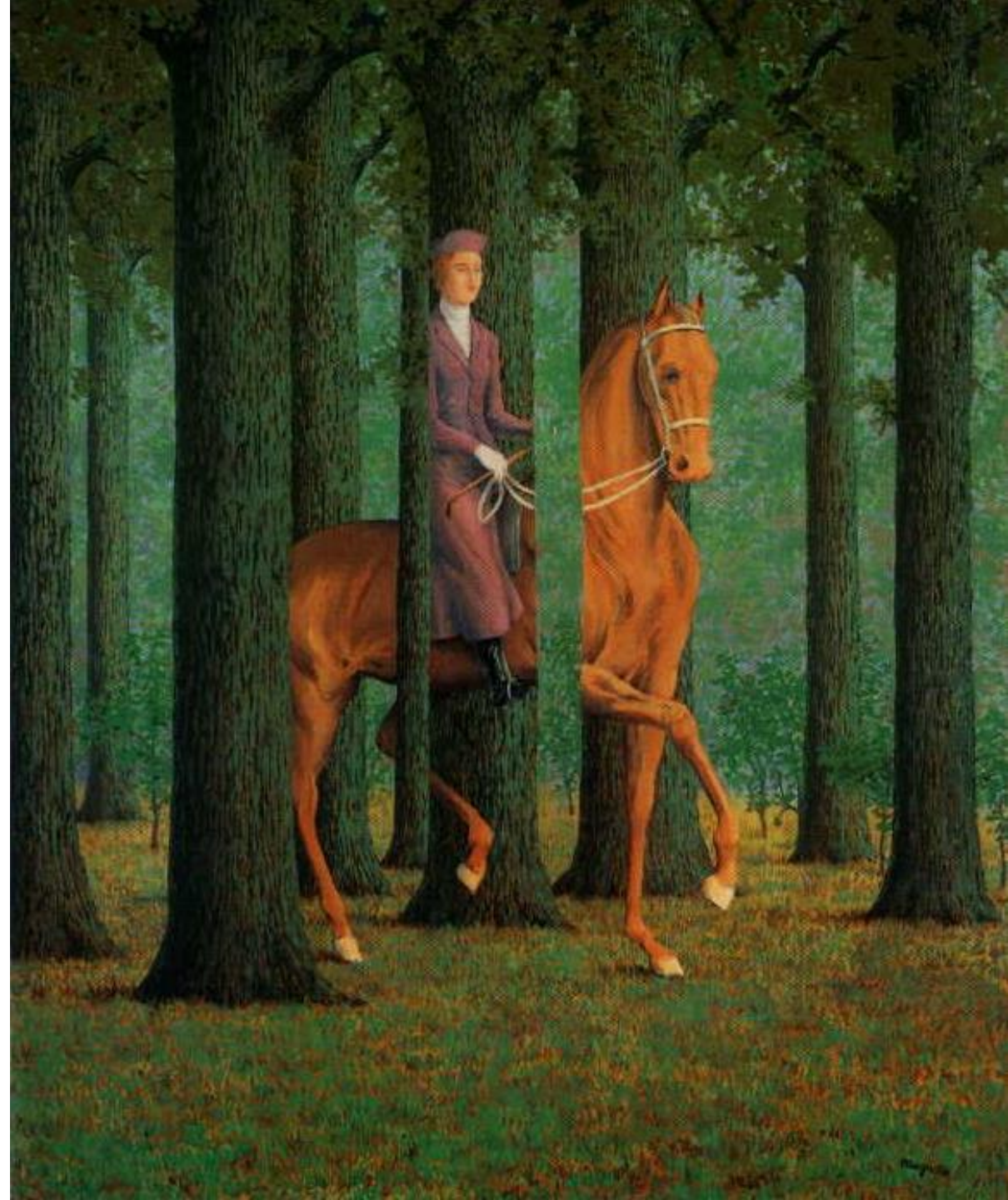
Challenges 4: scale

Adapted from L. Fei-Fei,
R. Fergus, A. Torralba

Challenges 5: deformation
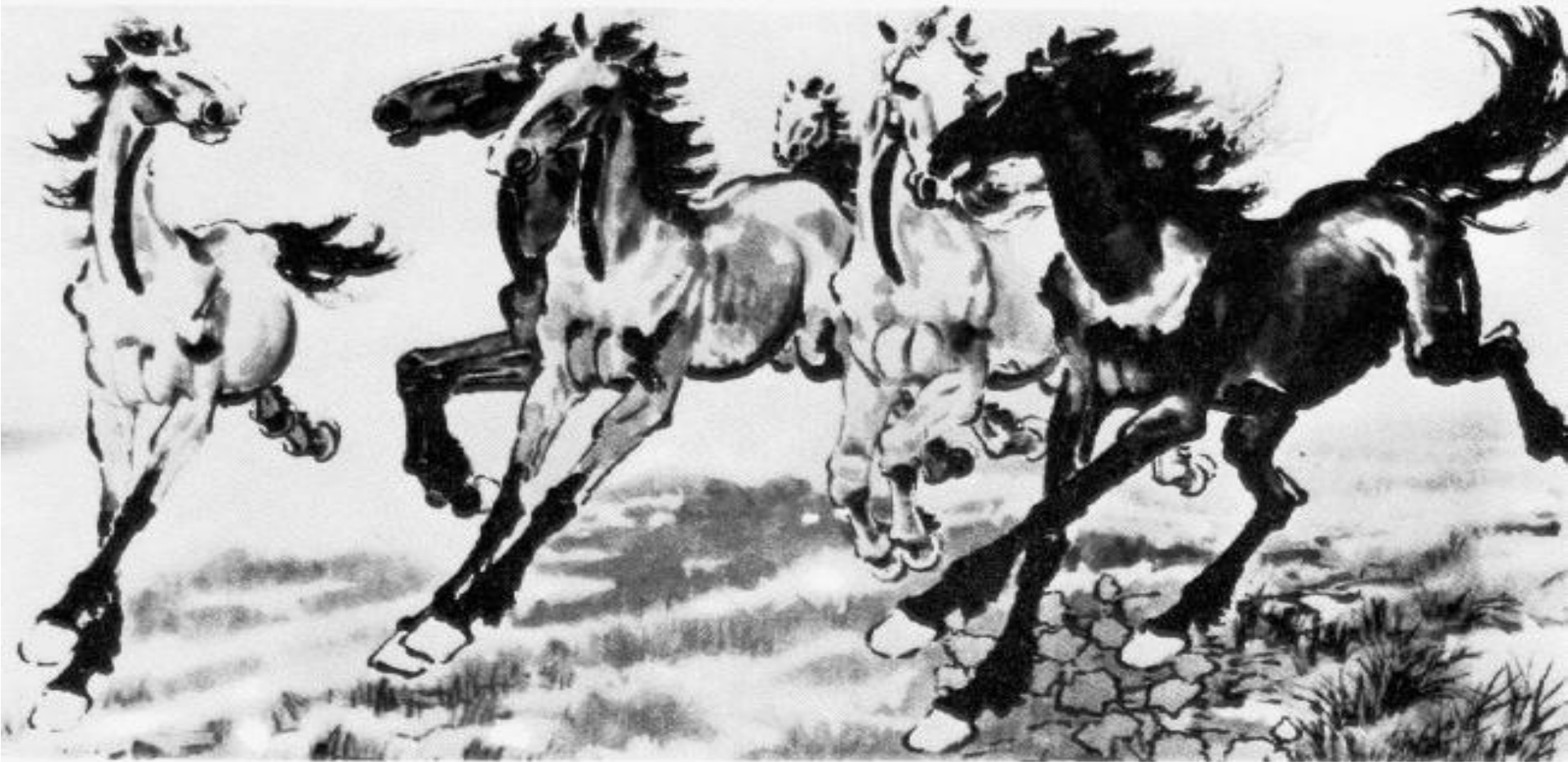
Xu, Beihong 1943

Challenges 6: background clutter

Adapted from Fei-Fei Li

Challenges 7: intra-class variation
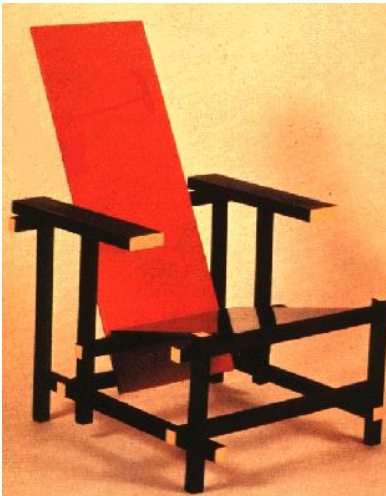
Adapted from L. Fei-Fei, R. Fergus, A. Torralba

What do computers see?

Stages of computer vision

- Low-level

  image → image

- Mid-level

  image → features / attributes

- High-level

  features → "making sense", recognition

Low-level

sharpening →
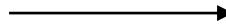
← blurring

Low-level

original image

Canny →

edge image

Mid-level

edge image
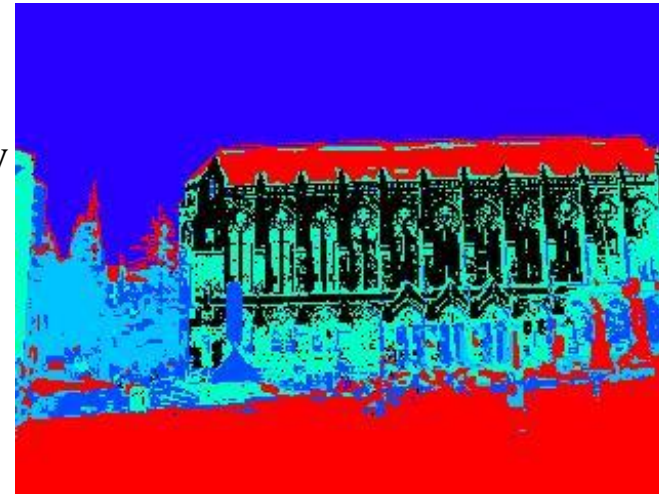
ORT →

data structure

circular arcs and line segments

Adapted from Linda Shapiro, U of Washington

Mid-level

K-means clustering

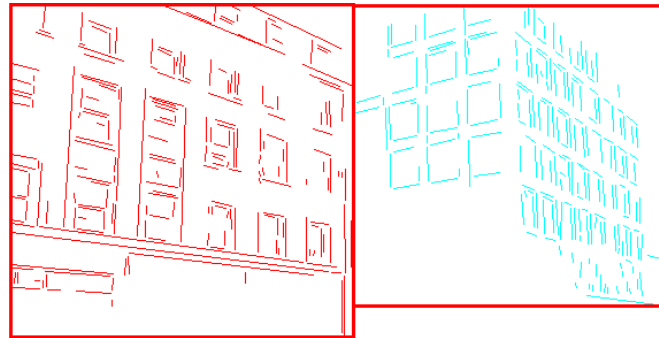(followed by connected component analysis)
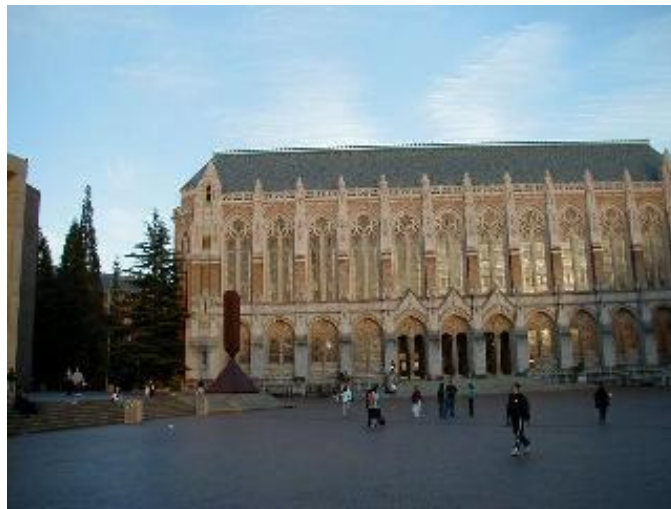
data structure
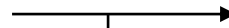
original color image

regions of homogeneous color

Low-level to high-level

low-level →
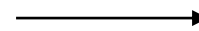
| edge image |

↓ mid-level

| consistent line clusters |

← high-level

Adapted from Linda Shapiro, U of Washington
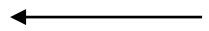
Visual recognition

Verification

Is this a car?

Credit: Selim Aksoy

Visual recognition

Classification
.
Is there a car in this picture?

Credit: Selim Aksoy

Visual recognition

Detection
- **Where is the car in this picture?**
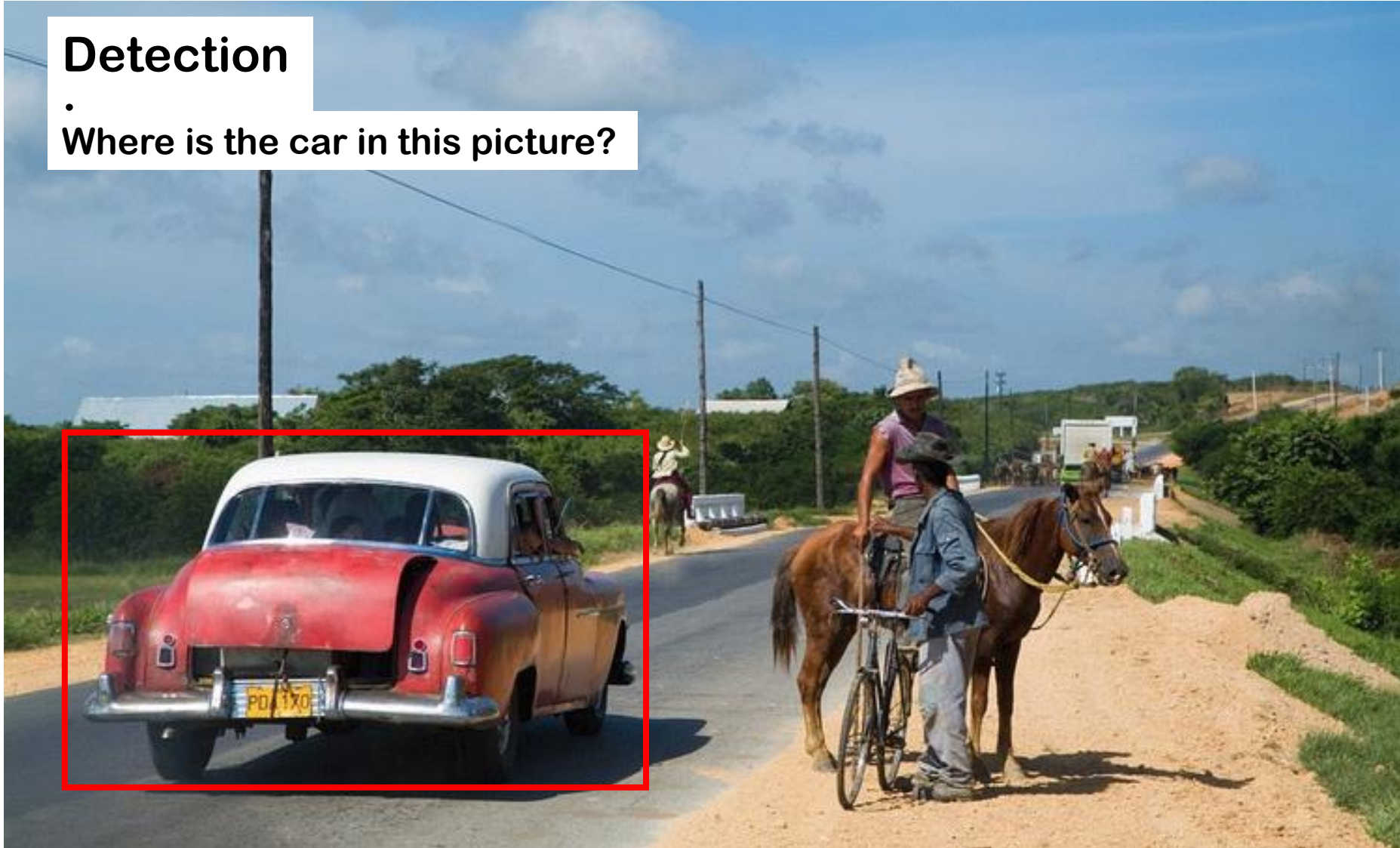
Visual recognition

Pose Estimation:

Credit: Selim Aksoy

Visual recognition

Activity Recognition:

What is he doing?

What is he doing?

Credit: Selim Aksoy

Visual recognition

Object Categorization:

Sky

Person

Tree

Car

Horse

Person

Bicycle

Road

Credit: Selim Aksoy

Visual recognition

Segmentation

Sky

Tree

Car

Person

Credit: Selim Aksoy