CAP 5415: Computer Vision

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Computer Vision:

Various definitions. Some common definitions are:

- Study of visual data.
  - Examples for visual data: Images, Videos

- A scientific field that extracts meaning (information) from images or videos. Examples are:
  - Visual recognition,
  - Look for a particular and a local activity occurring in videos,
  - Track the objects over time in videos, etc.

- A field that builds algorithms to understand & extract the content of images (or videos) and to use it for other applications. Examples are:
  - Robotics,
  - Medical field,
  - Surveillance,
  - Entertainment, etc.

Logistics:

Exams:

- See Syllabus for details.
- 1 Midterm

Hands-on Experience:

- Final Project
- Programming assignments (PA)

Presentation Experience:

- Research paper presentation
- Final project presentation

Office hours:

- Tuesday/Thursday 4:30pm-5:30pm
  - (after the class)
- Office: HEC 214

Notes:

- Follow the slides

Special thanks to:

- Dr. Mubarak Shah
- Dr. Ulas Bagci
- Dr. Yogesh Singh Rawat

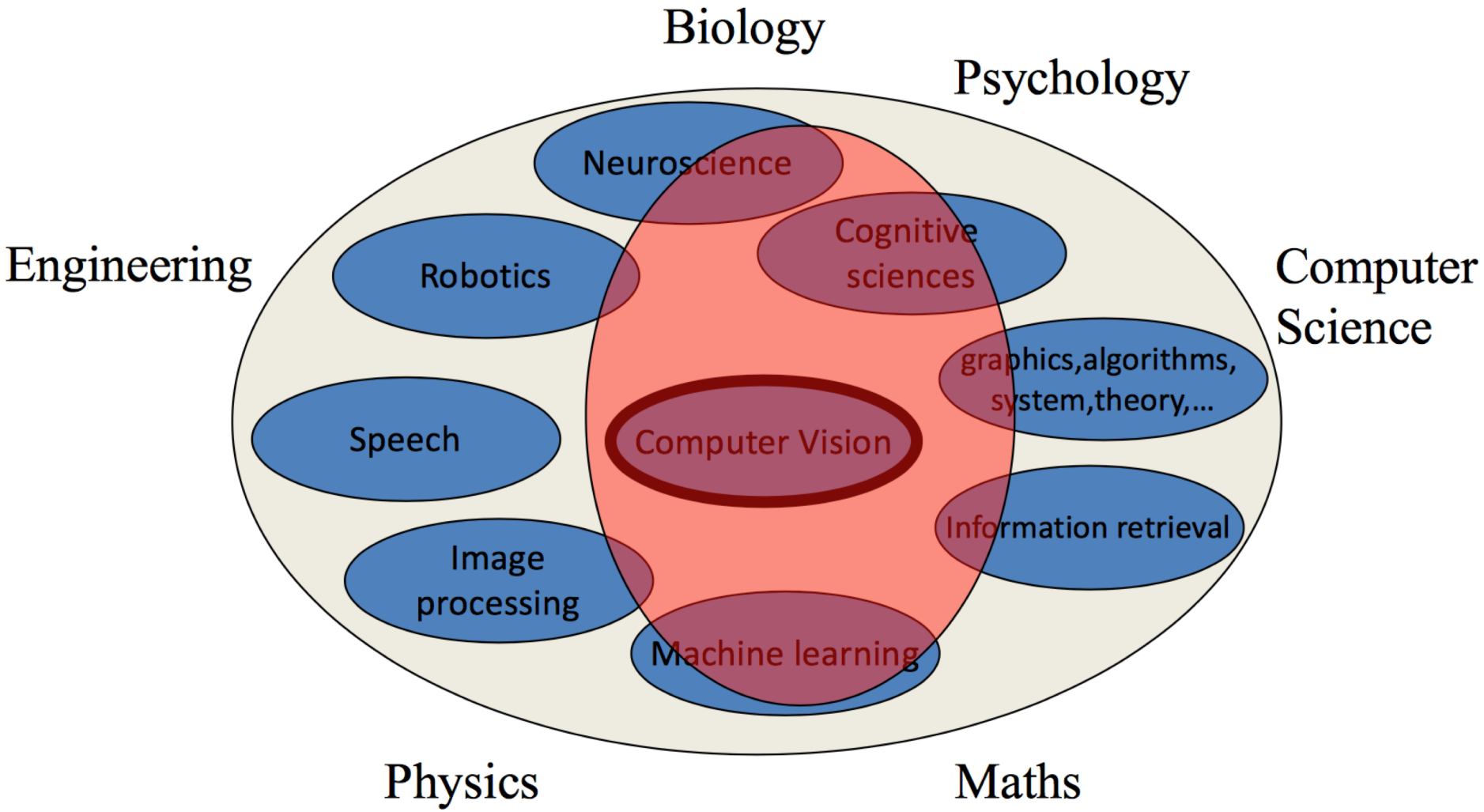
Teaching Assistants:

- Google
- Bing
- TBA

- No text book is required!
  - There are many online resources available.
- Attend the class (mandatory), follow the lecture notes and in-class material.
- Python is the required language for PA.

Computer Vision

What is it related to?



Computer vision: introduction

Visual recognition: Classification

Problem:
Are there any human in this image?

Answer: Yes / No

Problem:
Are there any cars in this image?

Answer: Yes / **No**

⋮

Visual recognition: Detection (localization)

Problem:
Tell me if there is any person in this image and if there is, where in image?

Answer: in the form of bounding boxes on the image.

Visual recognition: Object Categorization

Problem:
Detect all the objects in this image and give me a list of their type.

Answer: Building, Tree, Sky, People, Human, Grass

Semantic Segmentation: What we want

Image source: Antonio Torralba

Segmentation

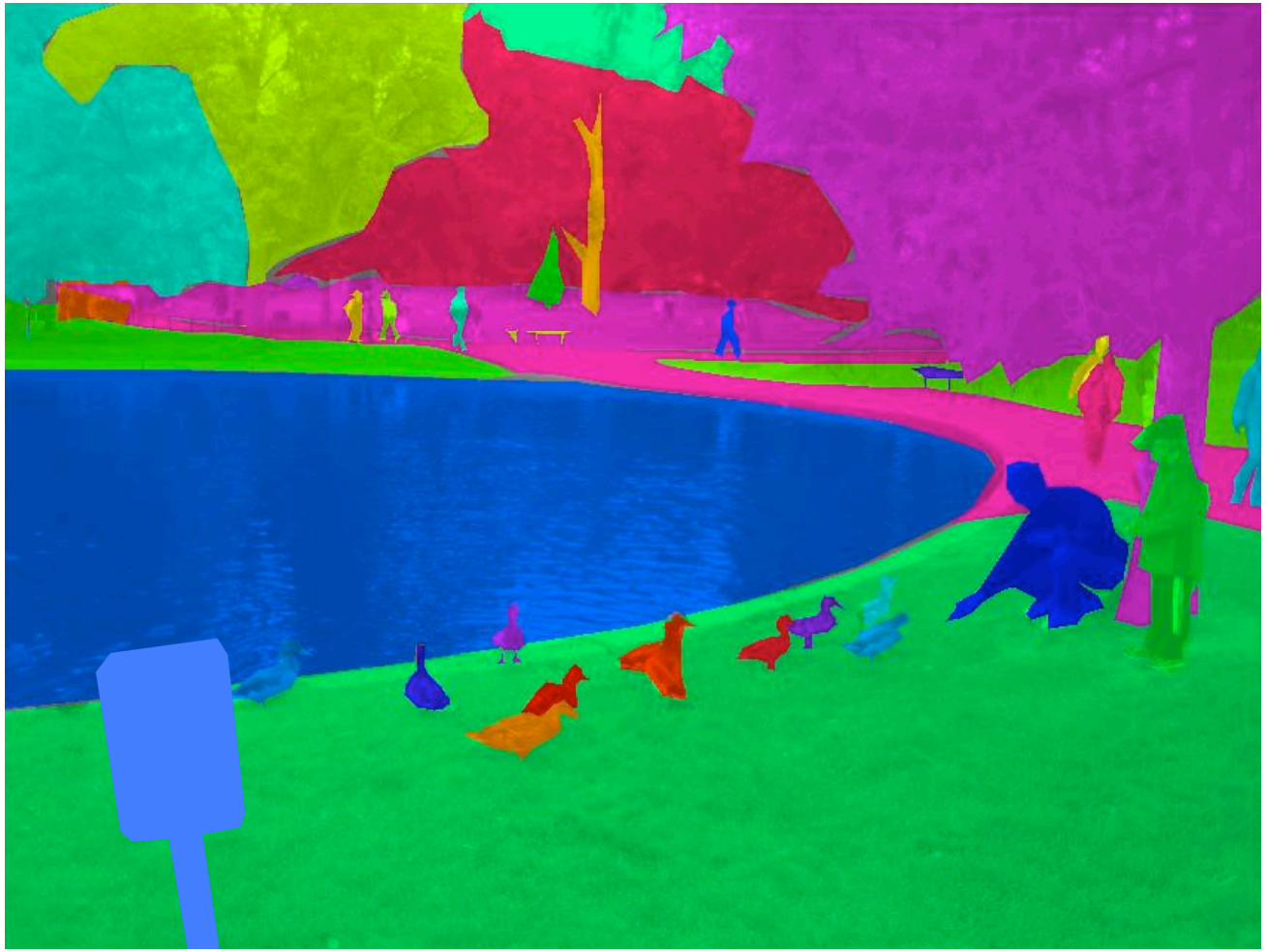


Image source: Antonio Torralba

Segmentation

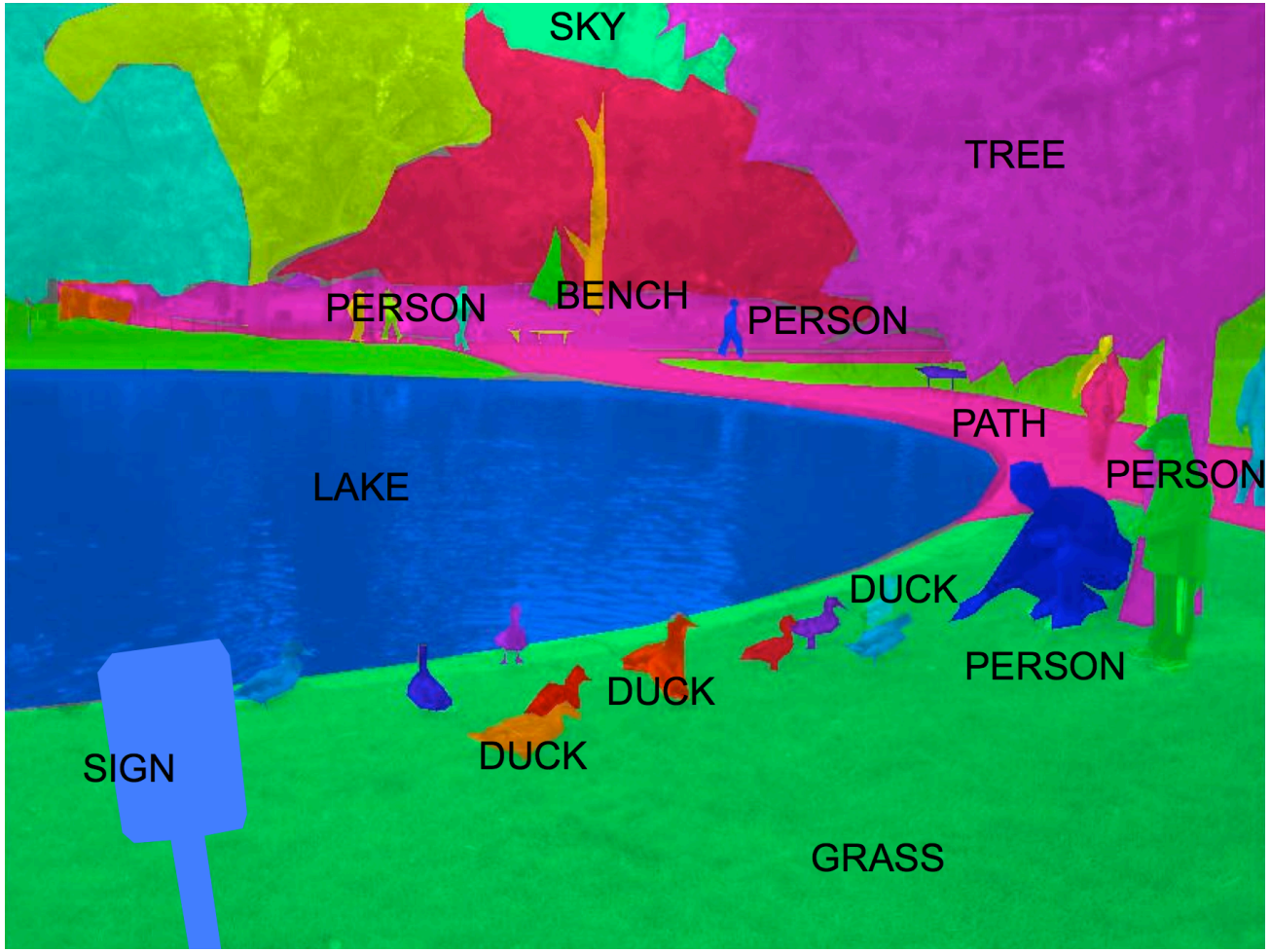
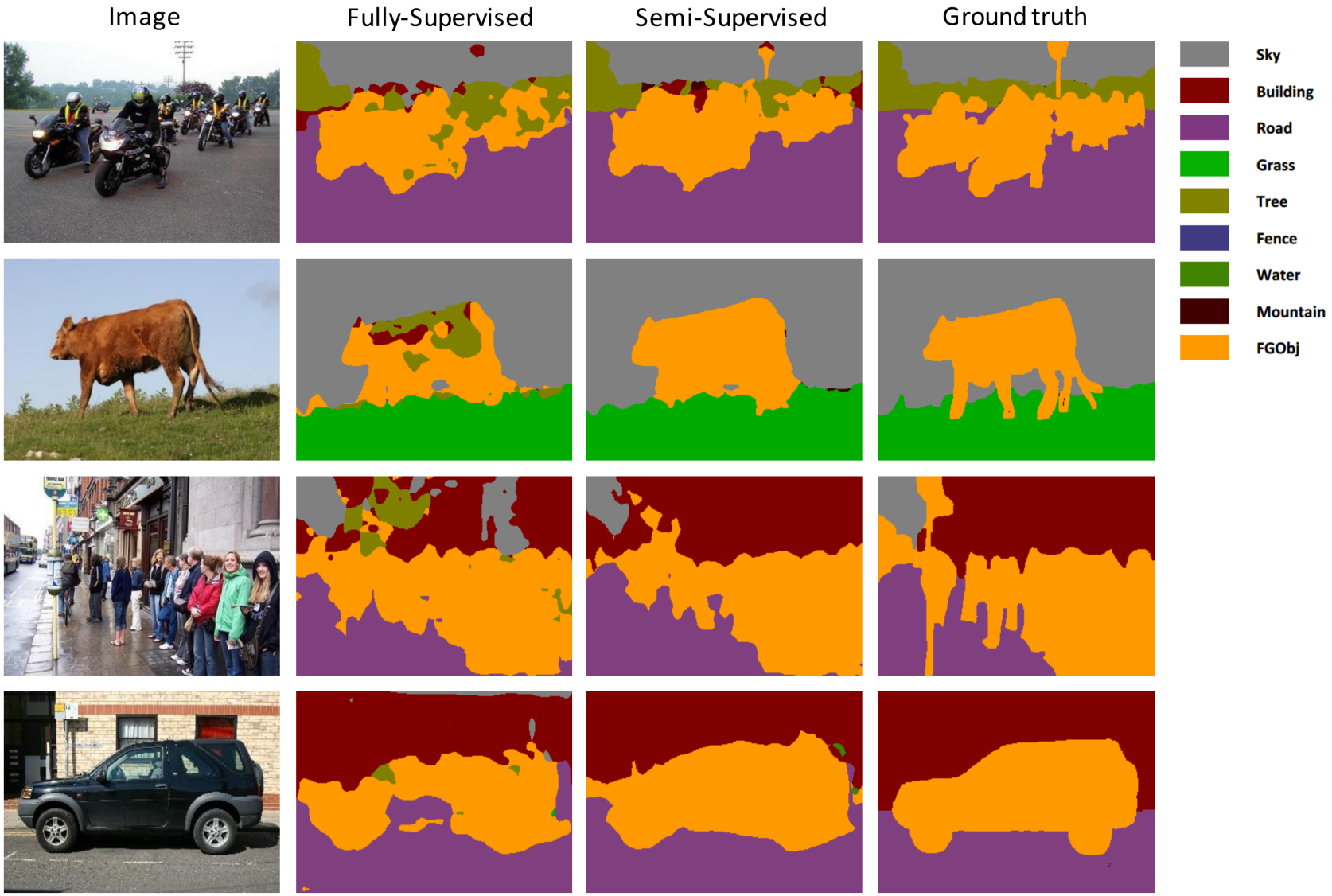


Image source: Antonio Torralba

Segmentation

Image source: Antonio Torralba

Semantic Segmentation: Results



Semantic Segmentation Using GAN, Nasim, Concetto, and Mubarak, 2017.

Computer Vision Applications

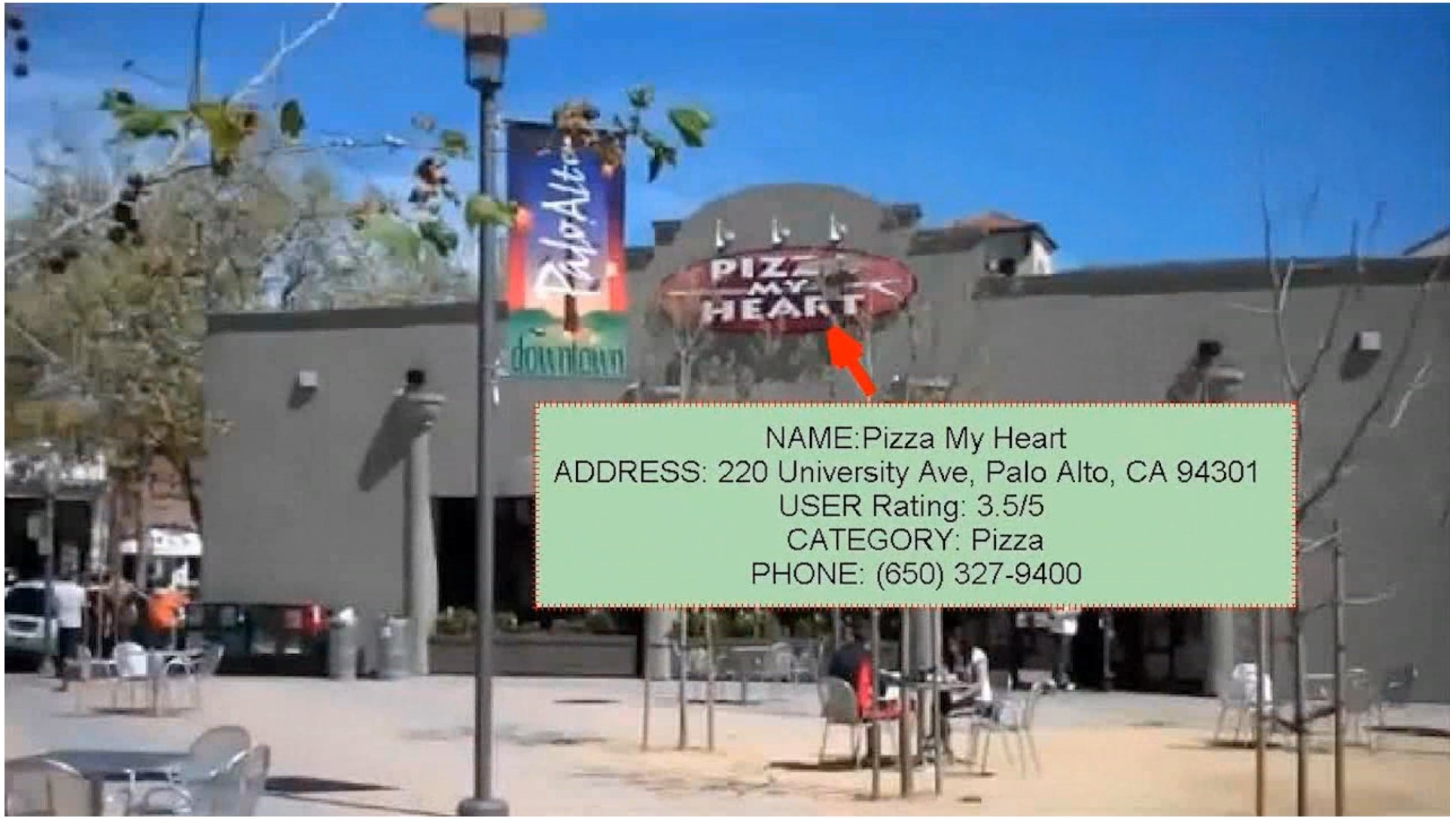
Counting in Extremely Dense Crowd Images

Ground truth=634 Proposed Method by Idrees and Shah=640

Ground truth=1428 Proposed Method=1468

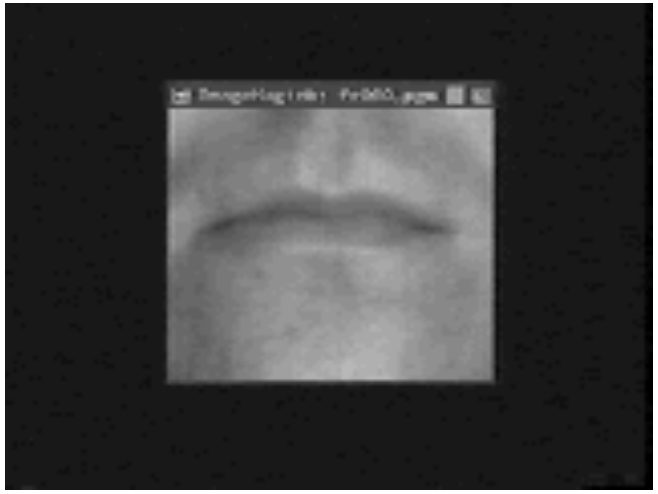
Ground truth=2319 Proposed Method=2496

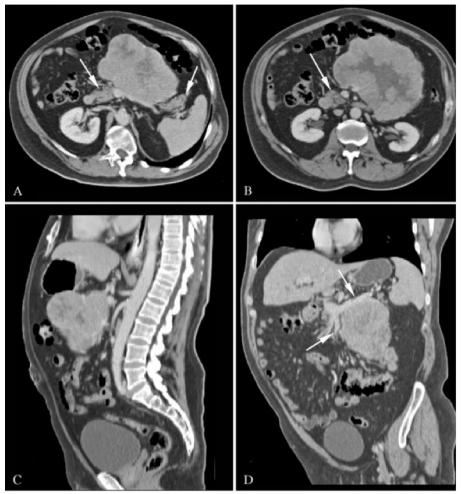
Visual Business Recognition

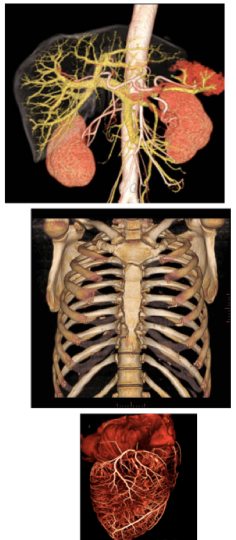


So many other applications…

- Face identification,
- Lip reading,
- Emotion detection,
- Medical Computer Vision / Analysis,



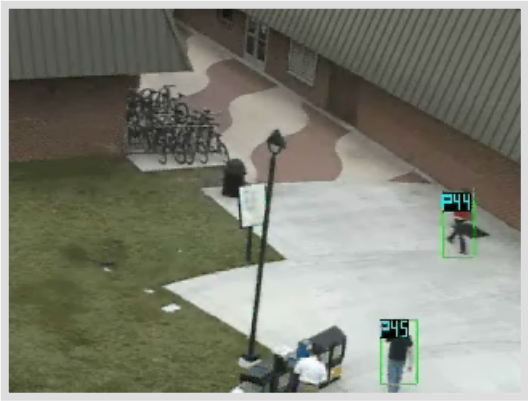


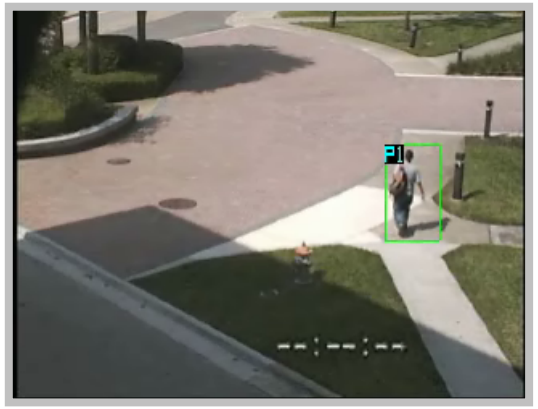


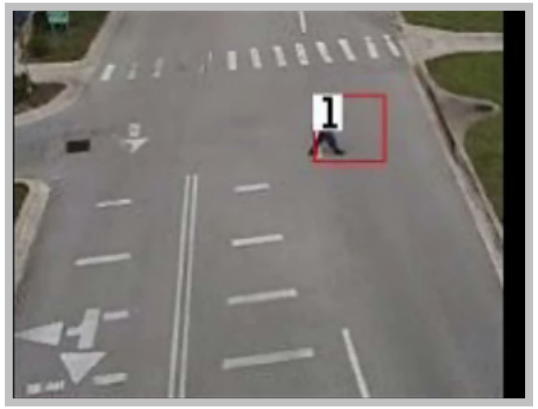
Video Analysis

Video: image sequence (over time)

Object detection → Object tracking → Event, Action or Activity Recognition

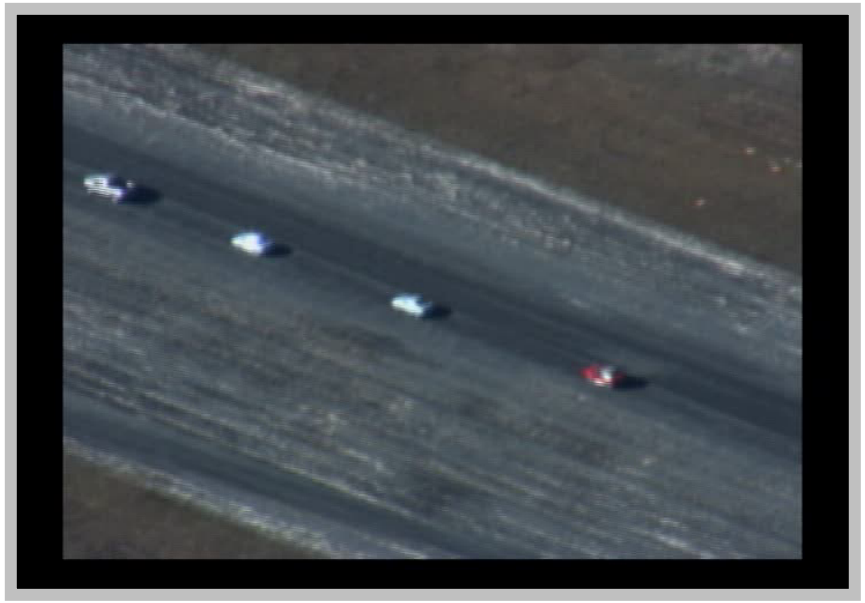






Object detection in videos

(Object) Tracking



- Deals with data association problem
  - (Correspondence problem)
- Correlates objects over time

Human Action Recognition

Action: A spatial and temporal pattern

9 actions, 142 videos (UCF database, Shah).

Bench Swing

Dive

Swing

Run

Kick

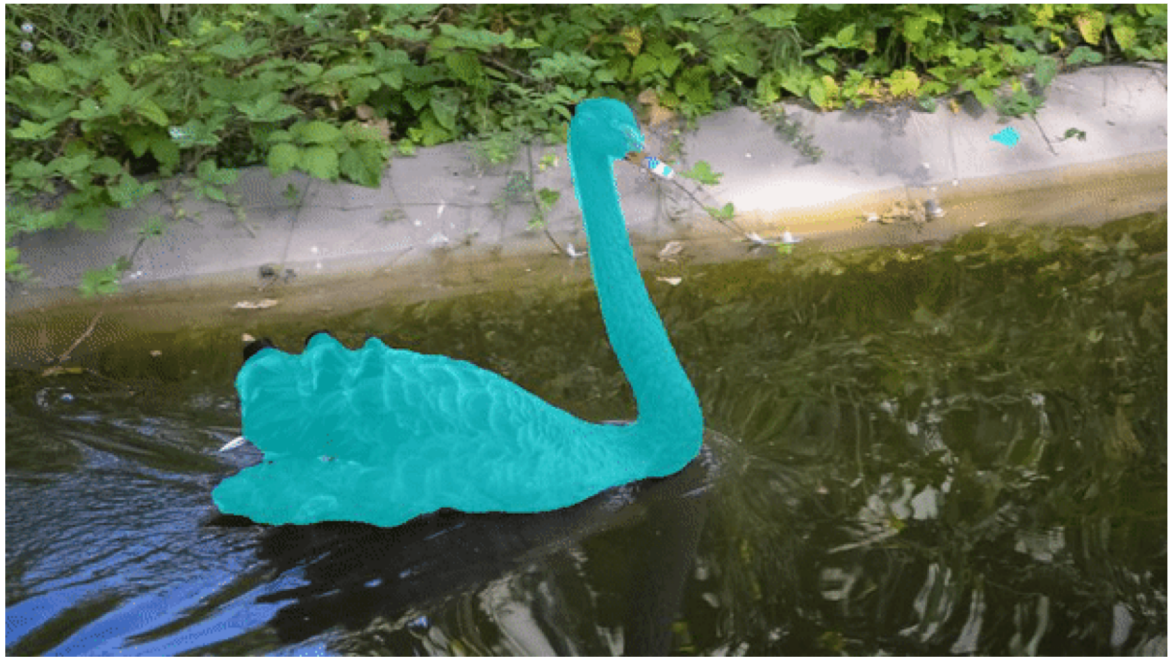
Lift

Ride

Golf Swing

Skate

Actor – action segmentation



R. Hou, C. Chen, and M. Shah, 2017

Test: what do you see in this image?

Image source: Antonio Torralba

What do you see in this image?

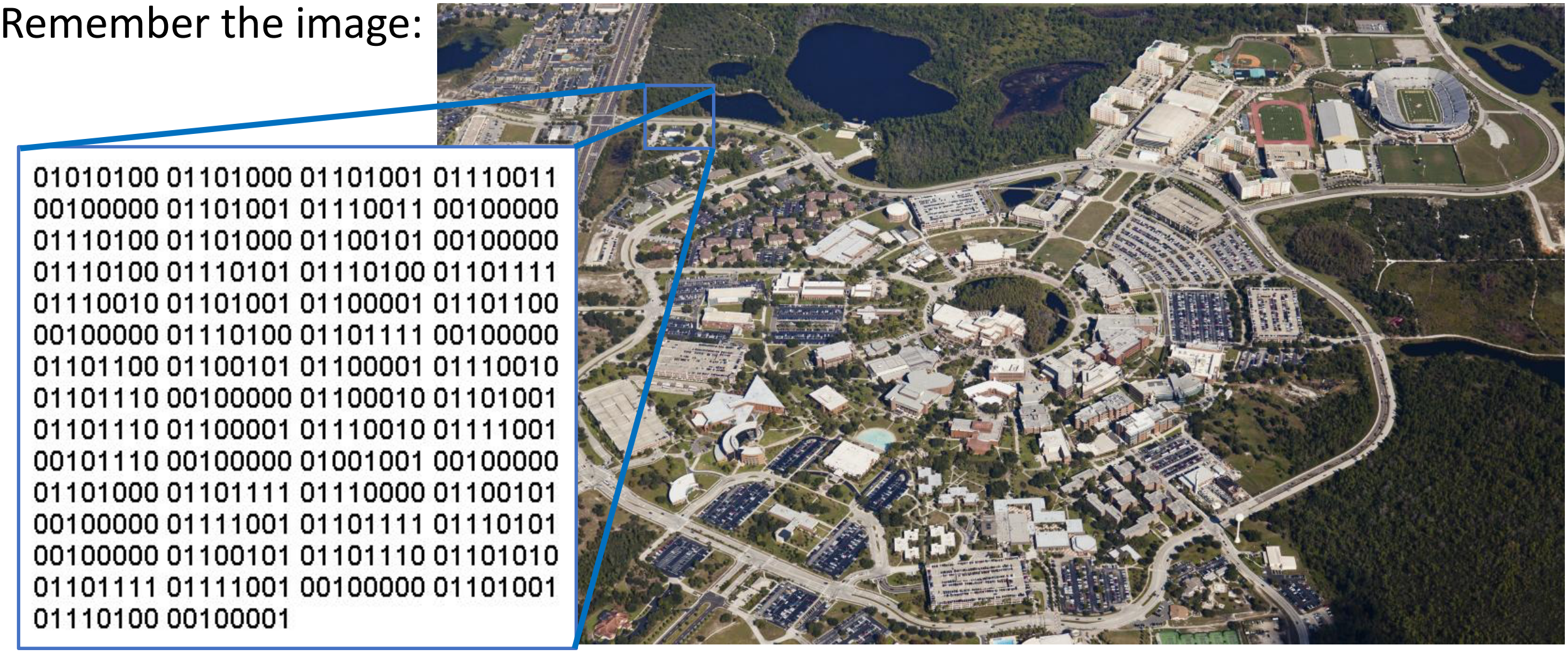
Now can you see it?

Credit: Thompson, Basic Vision, Oxford Press, 2012.

Question:

How would you model (represent) an object in visual recognition? Ideas?

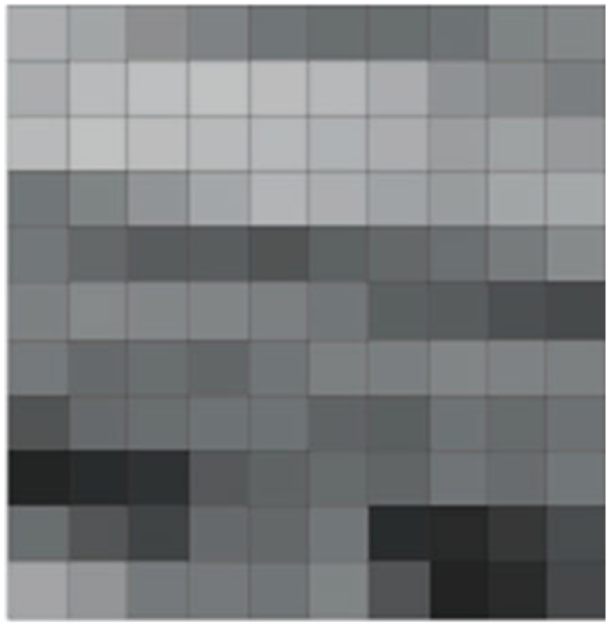
Remember the image:

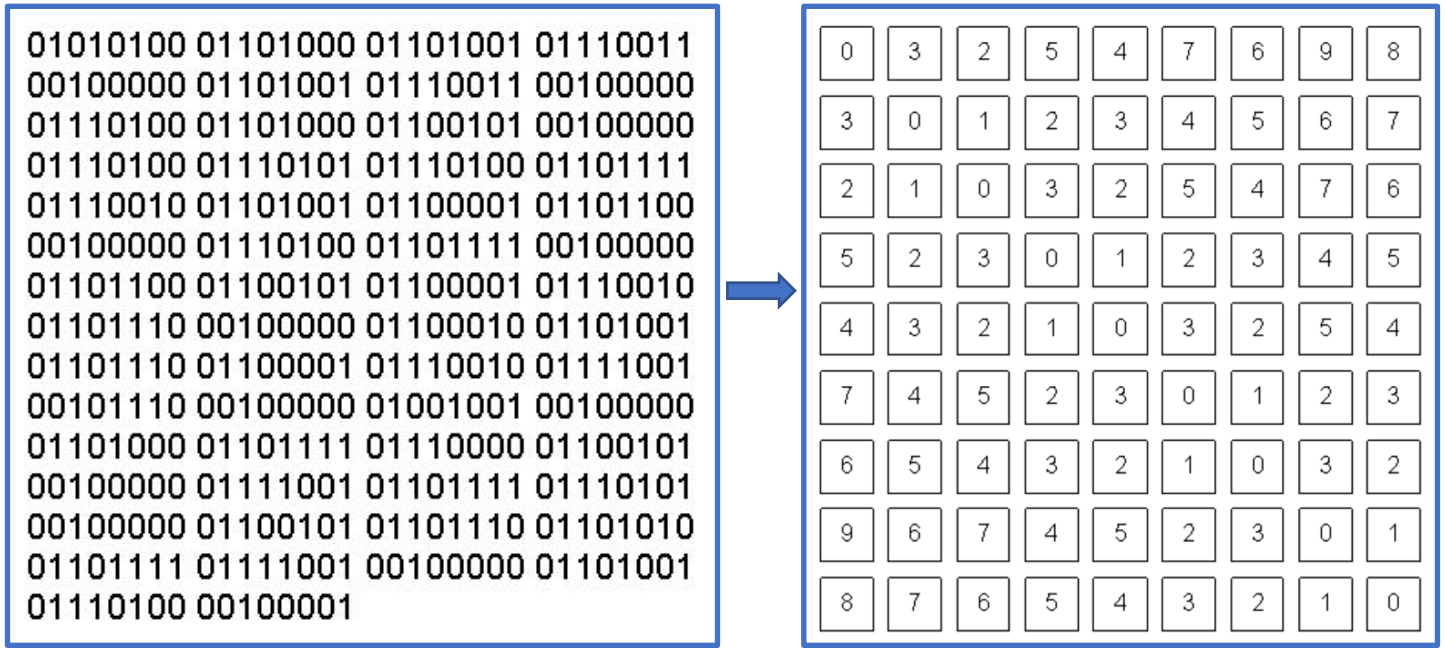


This is what computers get (see?)!

This is what you see…

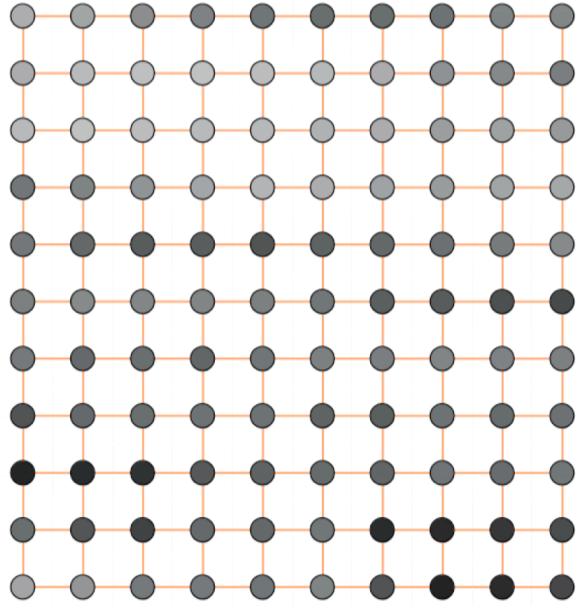
Our common units: Pixels





Binary

Decimal - grid



Grayscale image

Image Types: (Gray)Scalar and Binary

- A scalar image has integer values

$$u \in \{0, 1, ..., 2^a - 1\}$$

a: level (bit)

Ex. If 8 bit (a=8), image spans from 0 to 255

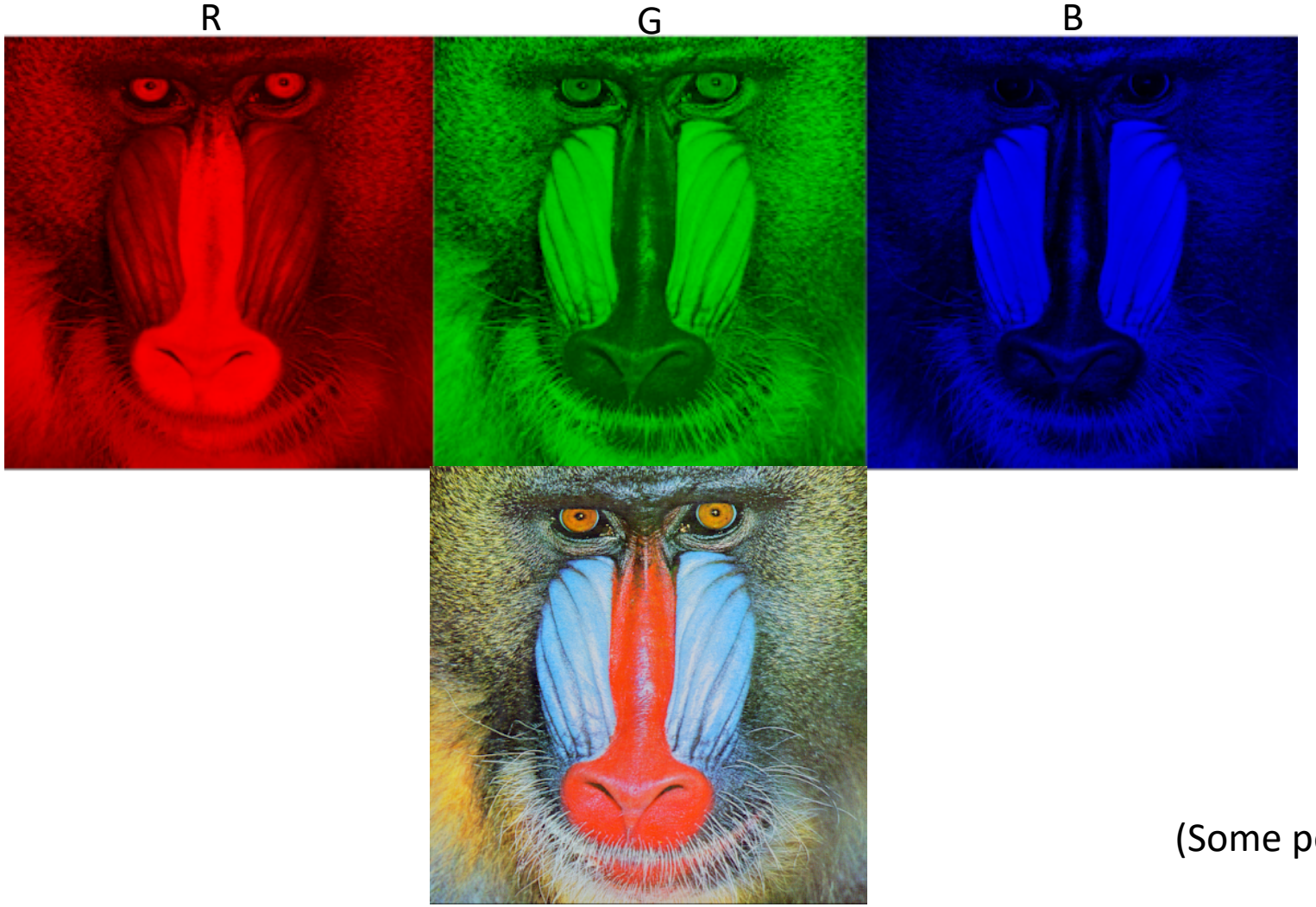
0 black

255 white

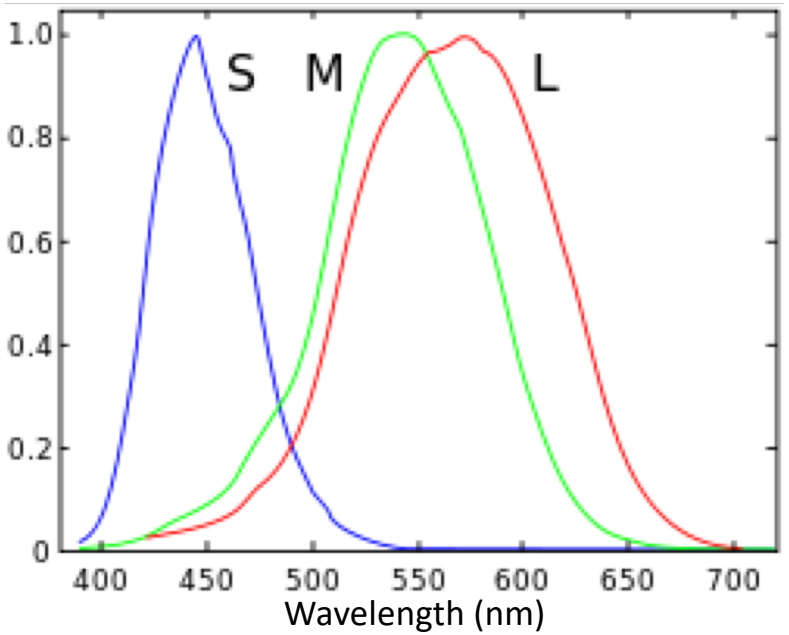
Ex. If 1 bit (a=1), it is binary image, 0 and 1 only.

Image Type: RGB (red, green, blue)

- Image has three channels (bands), each channel spans a-bit values.



Human Cone-cells (normalized) responsivity spectra

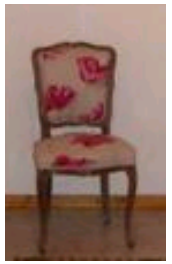


(Some people might have 4 cone-types!)

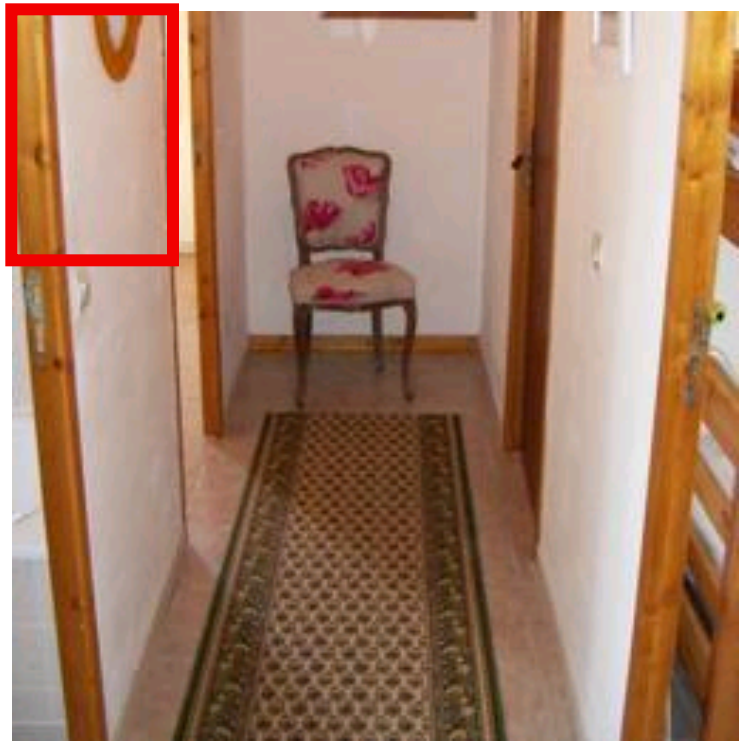
So…. How do we detect an object in an image?

Naïve approach: Template Matching

This is a chair



Find the chair in this image



Output of correlation

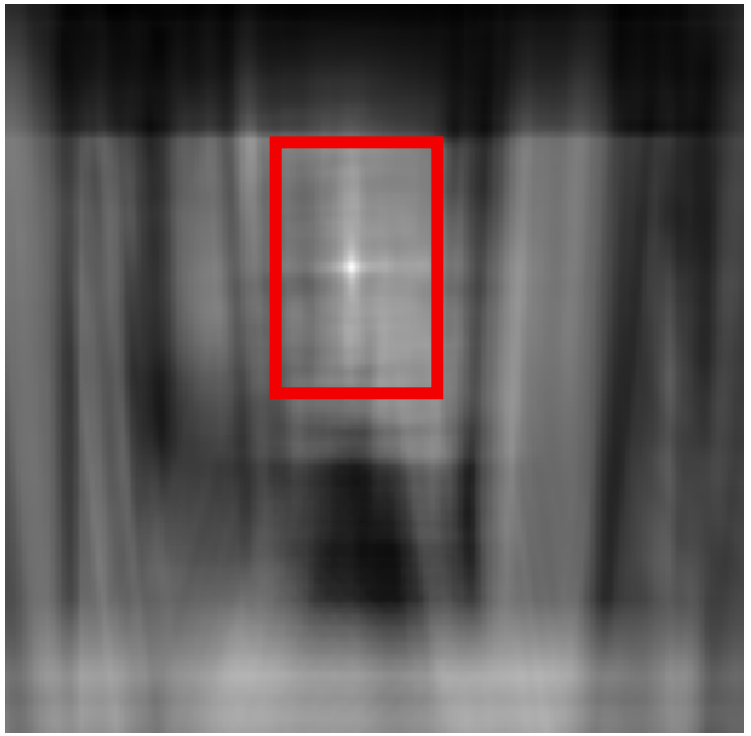
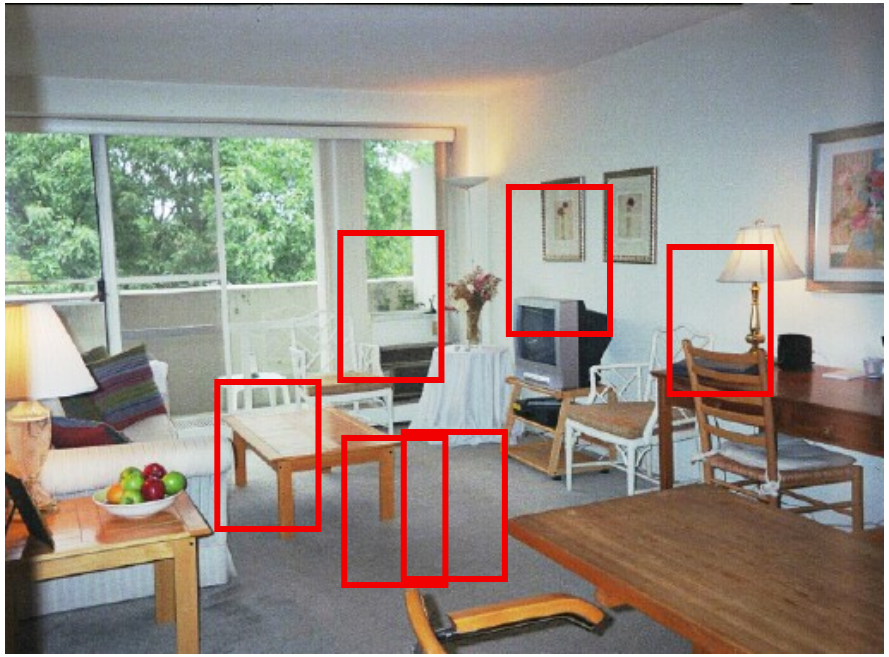
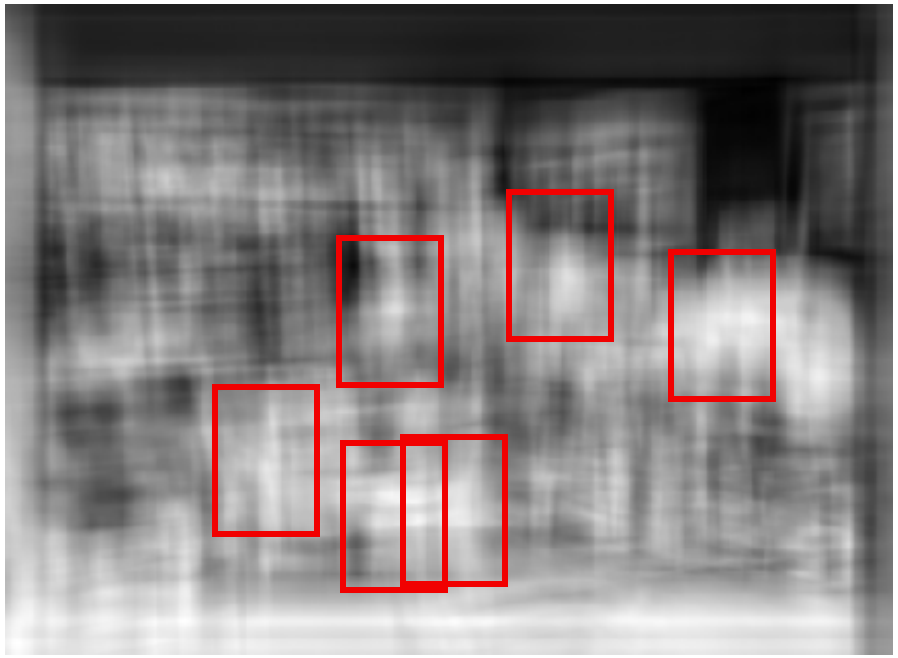


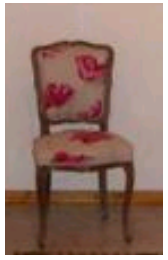
Image source: Antonio Torralba

Template Matching

Find the chair in this image







Epic fail!
Simple template matching is not going to make it

Image source: Antonio Torralba

Idea:

- Instead of comparing raw image pixels:
  - first map those pixels into another (more robust) form,
  - and then compare those mapped forms.
  - Finally, select the closest image map (how do you define “closest”? Metrics).
- Features
  - Examples: compute edges, compute color histograms, Gradients, HOG, SIFT, …

“Bag-of-Words” Representation

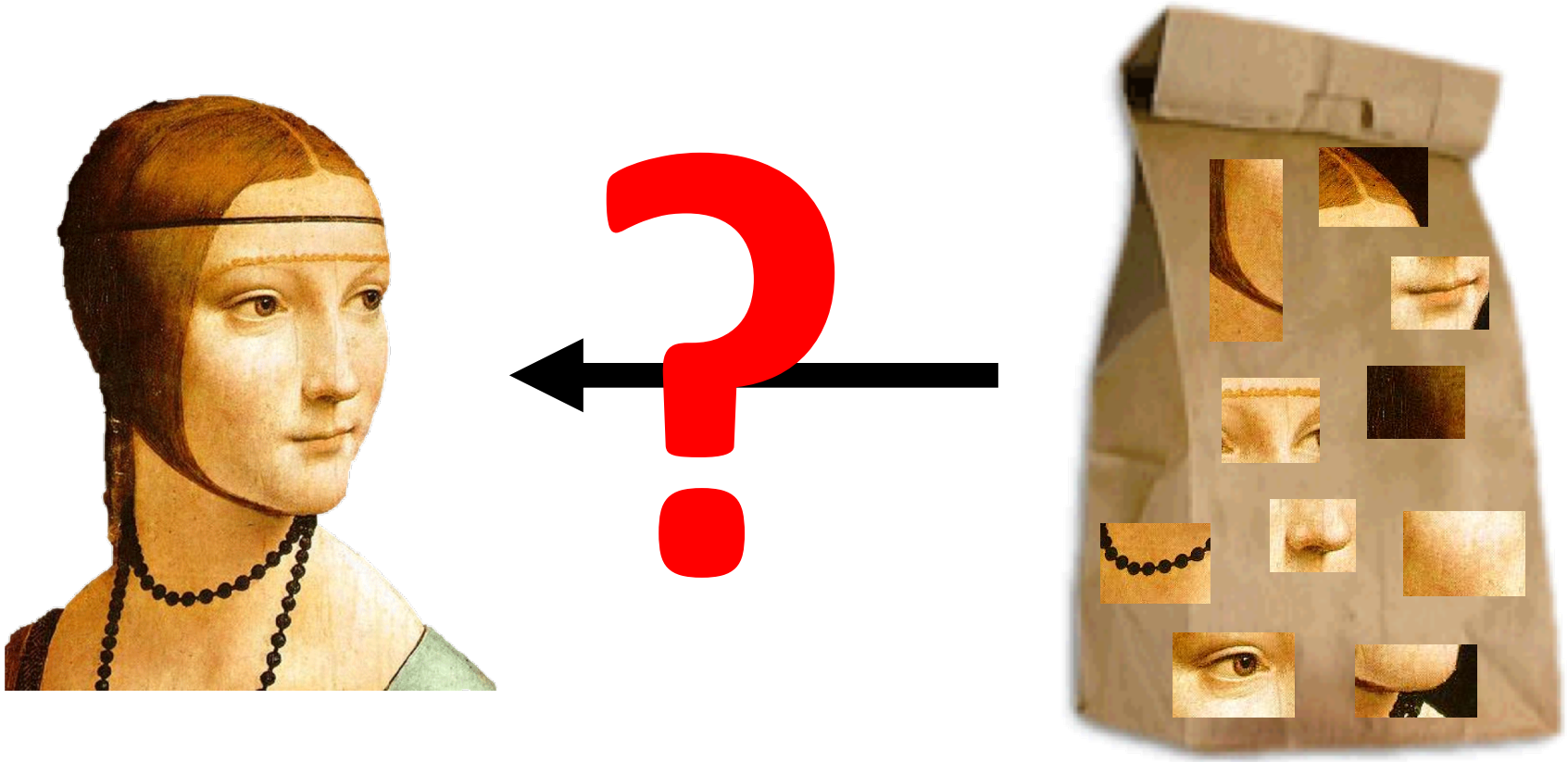
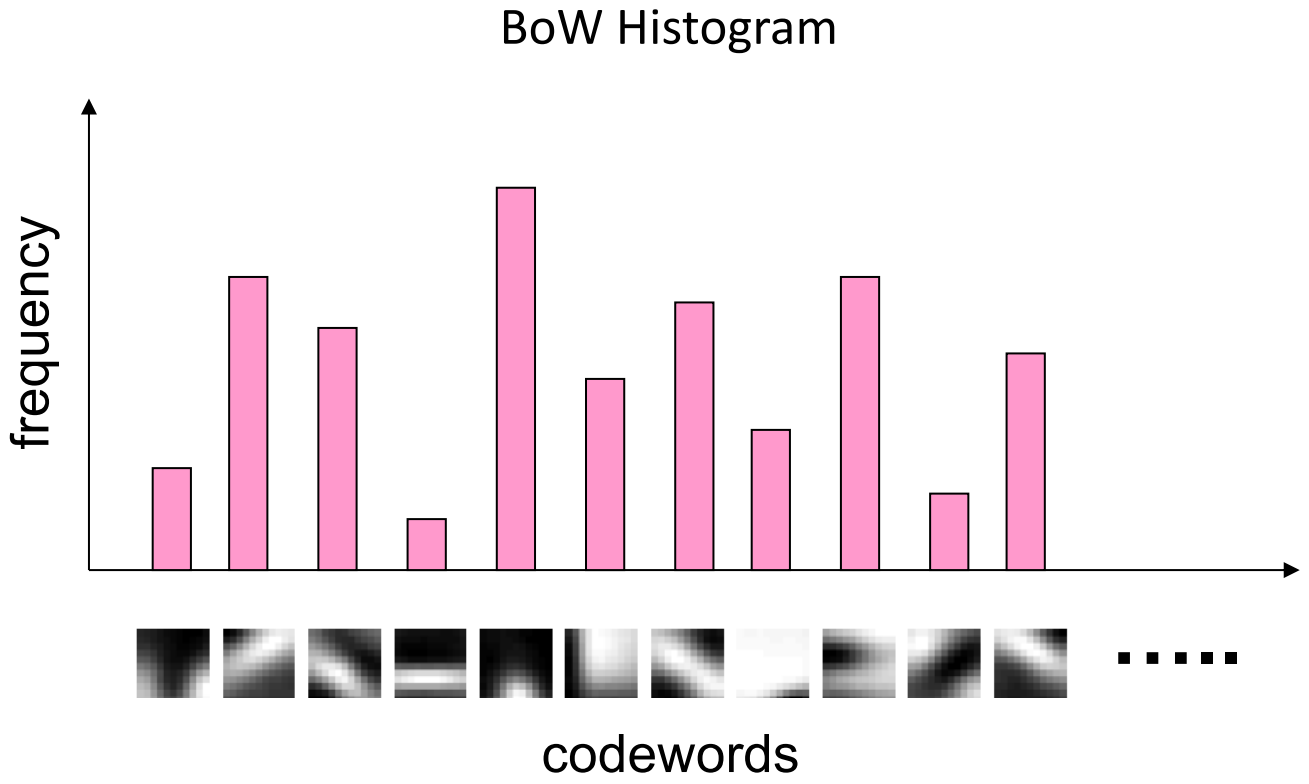
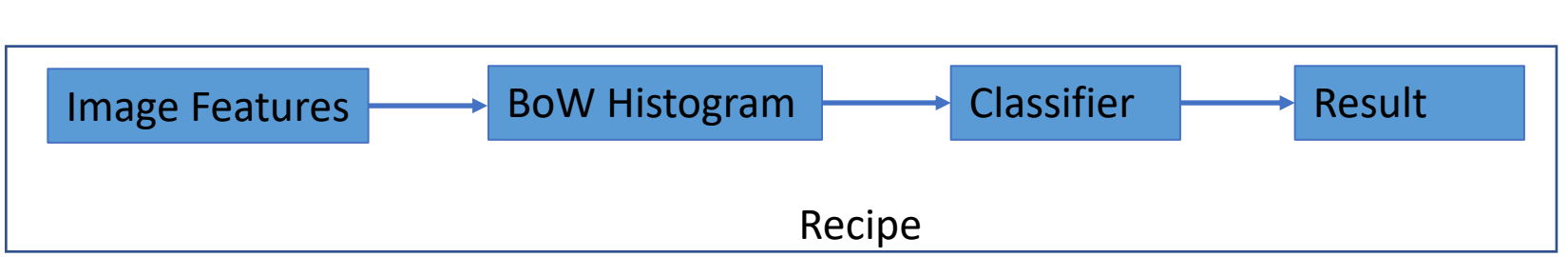


Image source: Antonio Torralba

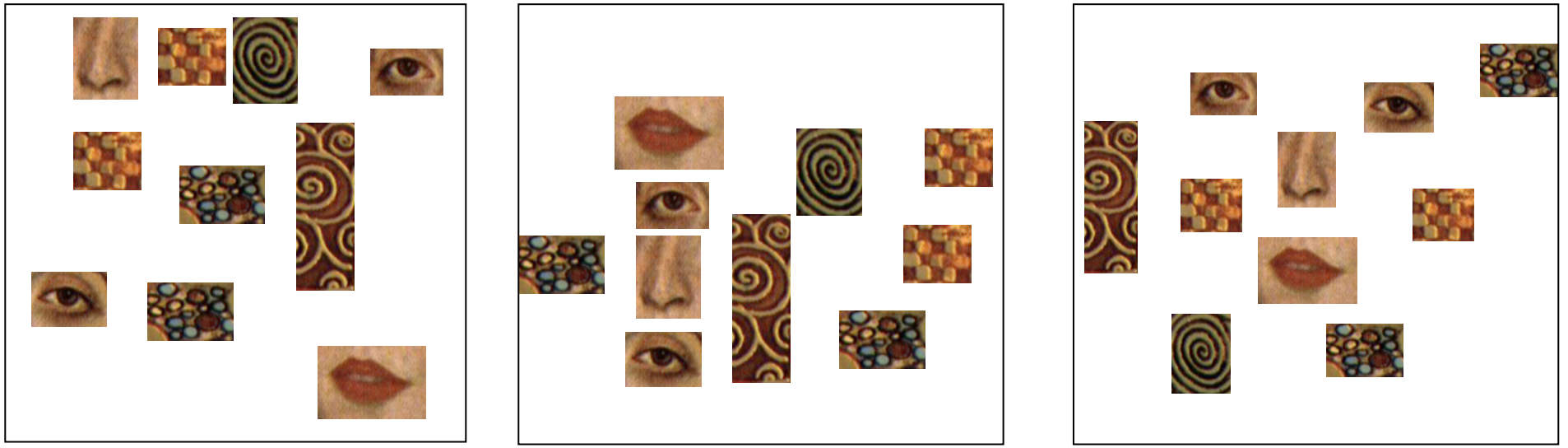
“Bag-of-Words” (BoW) Histograms

Image





BoW Representation



- All have equal probability for bag-of-words methods,
- Location (spatial) information is important but lost.

Image source: Antonio Torralba

A Brief History

The early optimism (1960-1970)

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

PROJECT MAC

Artificial Intelligence Group — July 7, 1966
Vision Memo. No. 100.

THE SUMMER VISION PROJECT

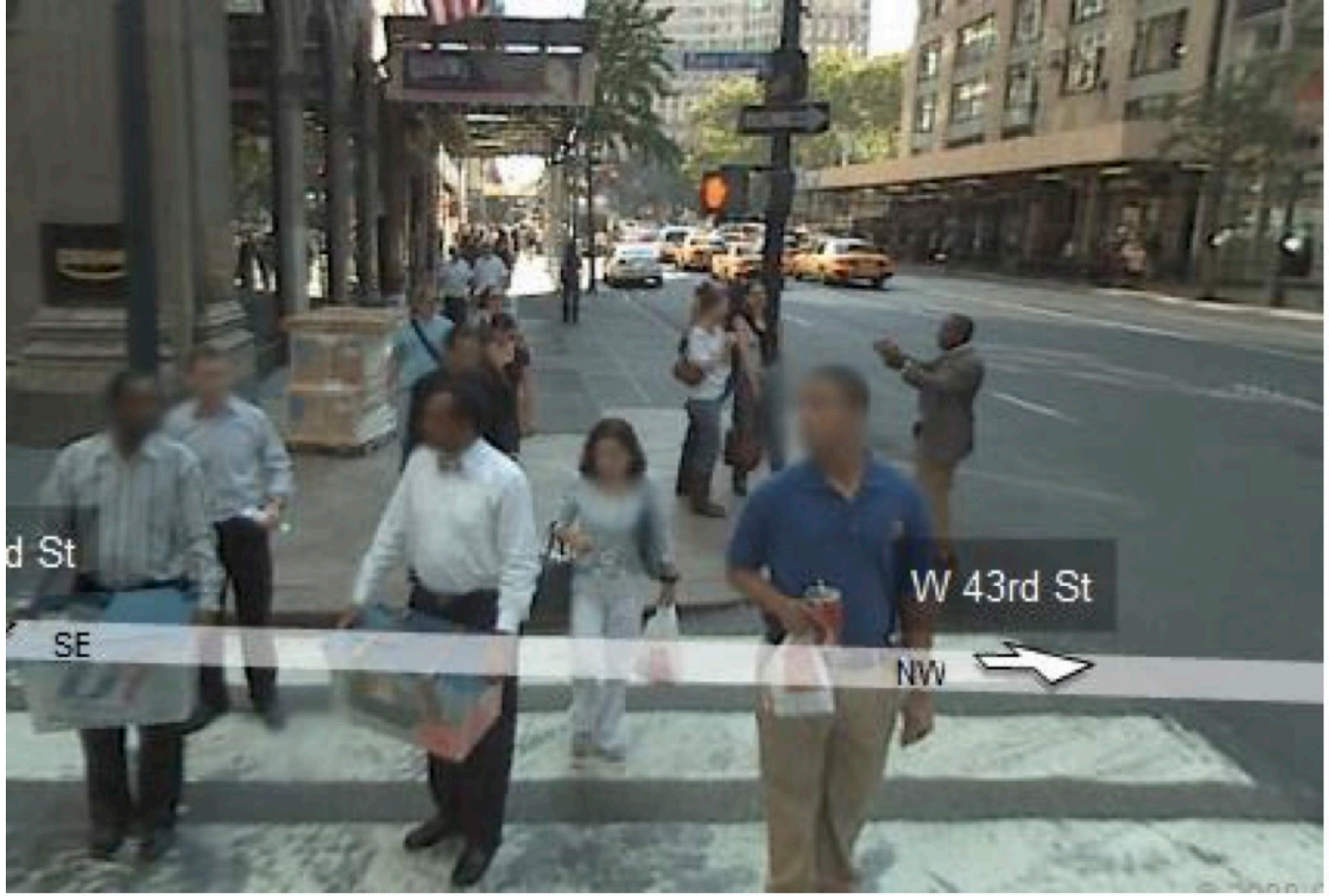
Seymour Papert

The summer vision project is an attempt to use our summer workers effectively in the construction of a significant part of a visual system. The particular task was chosen partly because it can be segmented into sub-problems which will allow individuals to work independently and yet participate in the construction of a system complex enough to be a real landmark in the development of "pattern recognition".

50 Years Ago

25 Years ago

15 Years ago



- The representation and matching of pictorial structures Fischler, Elschlager (1973).
- Face recognition using eigenfaces M. Turk and A. Pentland (1991).
- Human Face Detection in Visual Scenes - Rowley, Baluja, Kanade (1995)
- Graded Learning for Object Detection - Fleuret, Geman (1999)
- Robust Real-time Object Detection - Viola, Jones (2001)
- Feature Reduction and Hierarchy of Classifiers for Fast Object Detection in Video Images - Heisele, Serre, Mukherjee, Poggio (2001)
- ….

Image source: Antonio Torralba

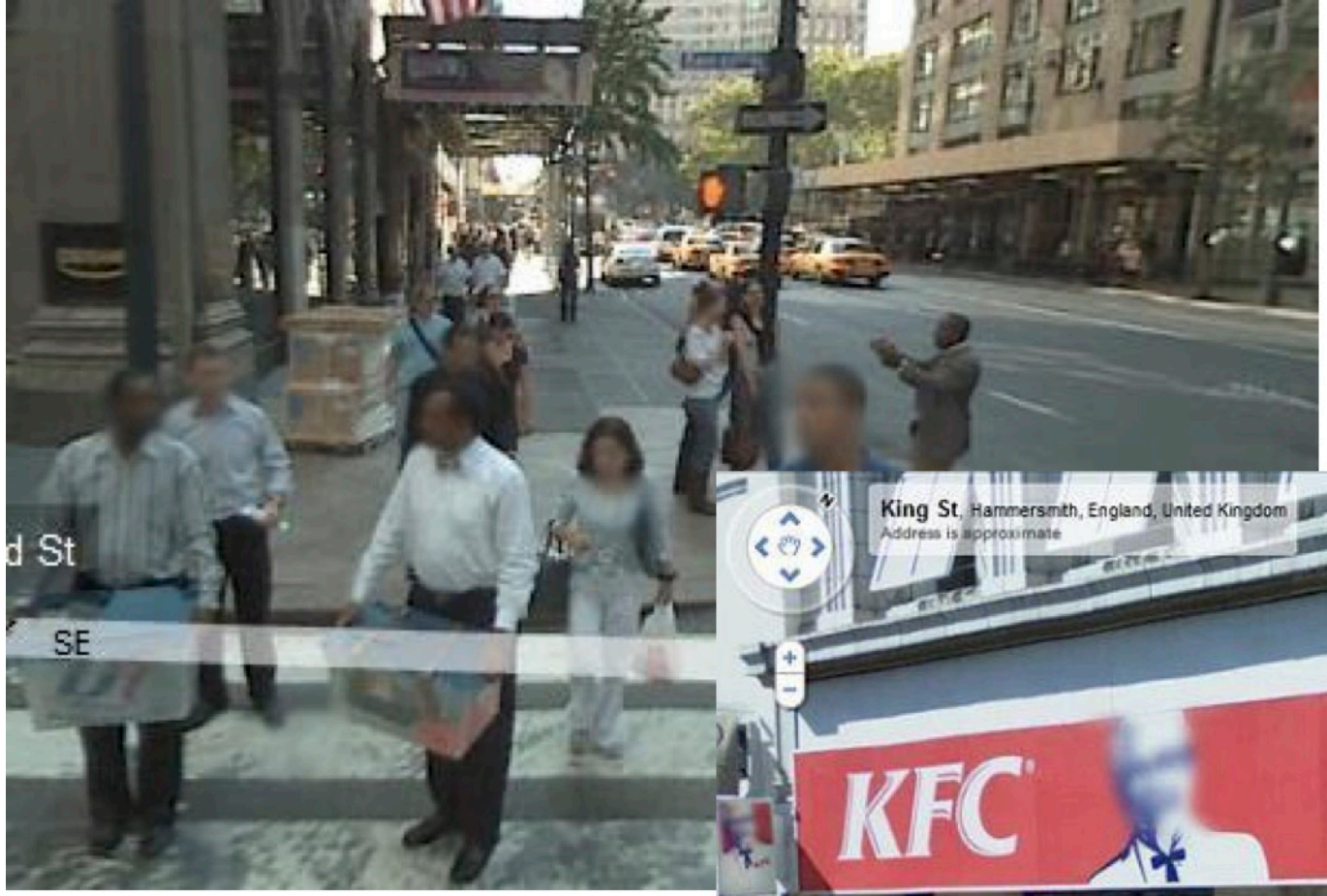


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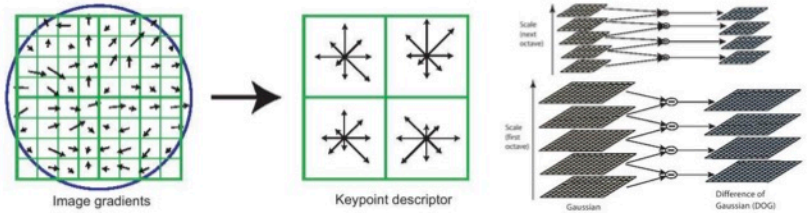
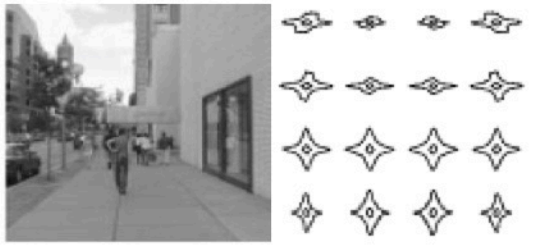
Image source: Antonio Torralba

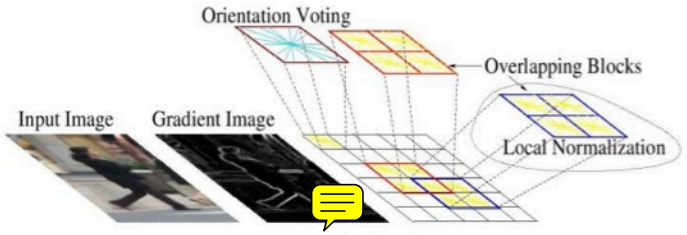
Advances in computer vision



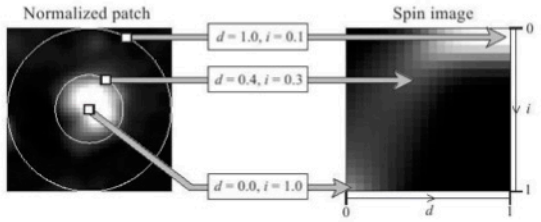
SIFT



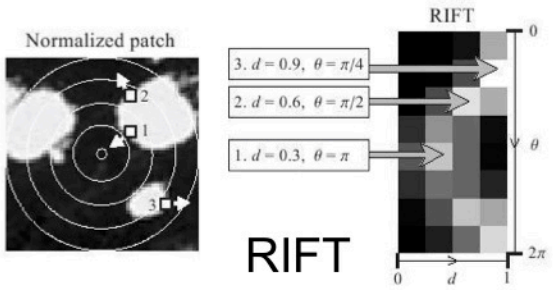
GIST



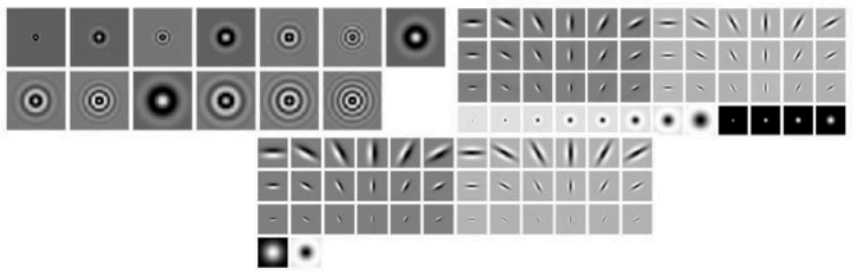
HoG



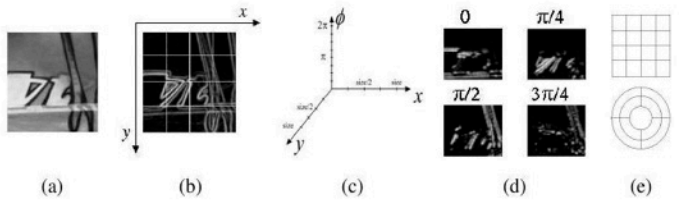
Spin image



RIFT



Textons



GLOH

Image source: Antonio Torralba

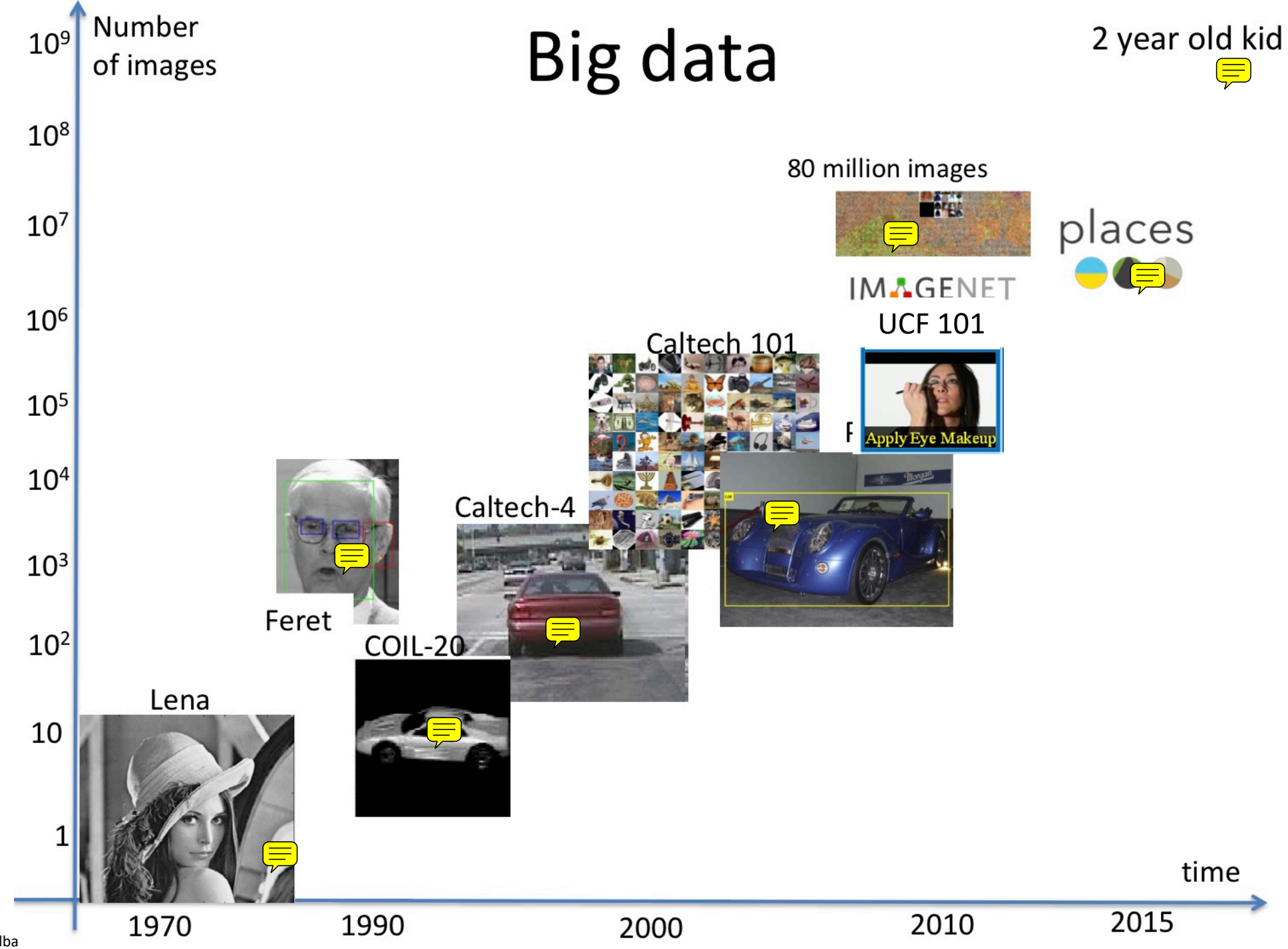


Image source: Antonio Torralba

The time of big data

Image source: Antonio Torralba

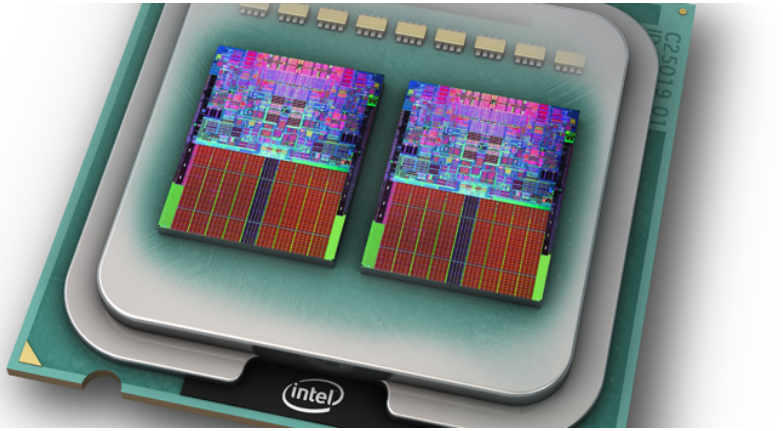
Distributed / GPU / Cloud Computing

amazon web services™

Google Cloud

Microsoft Azure

NVIDIA GPU CLOUD



QUESTIONS?

This lecture contains content from:

- Antonio Torralba (MIT),
- Ulas Bagci (UCF),