CAP5415-Computer Vision
Lecture 1-Introduction

Ulas Bagci

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About Me (Short Bio)

- **2003:** Graduated from EE/Bilkent University (Turkey).
- **2005:** MSc EECS/Koc University (Turkey).
- **2006-2010:** Marie Curie Fellow, University of Nottingham (UK) and University of Pennsylvania (USA), Computer Science and Radiology Departments.
- **2010-2012:** ISTP Research Fellow, Radiology, NIH.
- **2012-2013:** Senior Research Fellow, Radiology, NIH.
- **2013-now:** Staff scientist and Lab Manager (CIDI), Radiology, NIH.
- **2013-2014:** Leading image analysis scientist of Bio-terrorism/bio-defense studies in the USA (NIH, Integrated Research Facility).
- **2015-Now:** Assist. Prof. at CRCV, UCF

- **Research Interests:** Medical computer vision, image processing and analysis, biomedical and clinical imaging applications, pattern analysis, statistical machine learning.

Course Syllabus

- Class time: Tuesday/Thursday 3pm-4.15pm
- Office hours: HEC221/4.30pm-6pm

- 5 Programming assignments (PA) 50% (each 10%)
  - First programming assignment (PA-0) PA will be optional, it will be graded, and counted as BONUS.
- 2 mini projects 50% (each 25%)
- Python is the required language for PA.
  - Any IDE is fine, CANOPY is free to use.
- Processing, Matlab, C/C++, Java, Python,.. can be used for mini projects.

- No required books, but optional ones:
  - Szeliski, Computer Vision: Algorithms and Applications, Springer 2010 (online draft)
  - Shah, Fundamentals of Computer Vision (available from the course webpage)
  - Python for Computer Vision (available online)

Course Goals

- Introductory level computer vision course, suitable for graduate students.
  - Image filtering, edge detection
  - Motion and optical flow
  - Region/Shape Segmentation
  - Shape modeling and analysis
  - Deep Learning for Computer Vision
  - Imaging Geometry, Camera Modeling, Calibration

Computer Vision

Applications

Ex. Object Recognition

- Problem: Given an image I, does I contain an image of a person?

Ex. Object Recognition

- Problem: Given an image I, does I contain an image of a person?





YES

Ex. Object Recognition

- Problem: Given an image I, does I contain an image of a person?

NO

Ex. Object localization

Ex. Human Detection

Ex. Face Recognition

Ex. Image Search

Tons of applications, Big market, …

facebook

350 million photos uploaded daily

flickr

Picasa

YouTube

100 hours of movies uploaded per hour

amazon instant video

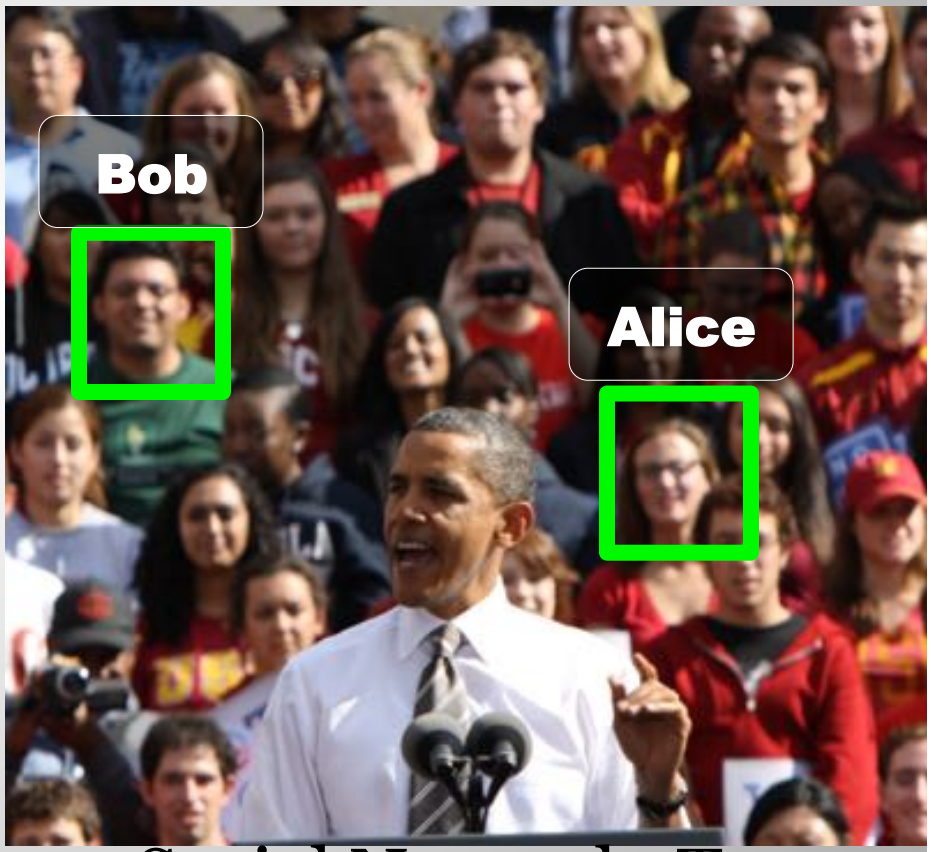
Google play

iTunes

60,000 movies

Open-Universe Face Identification

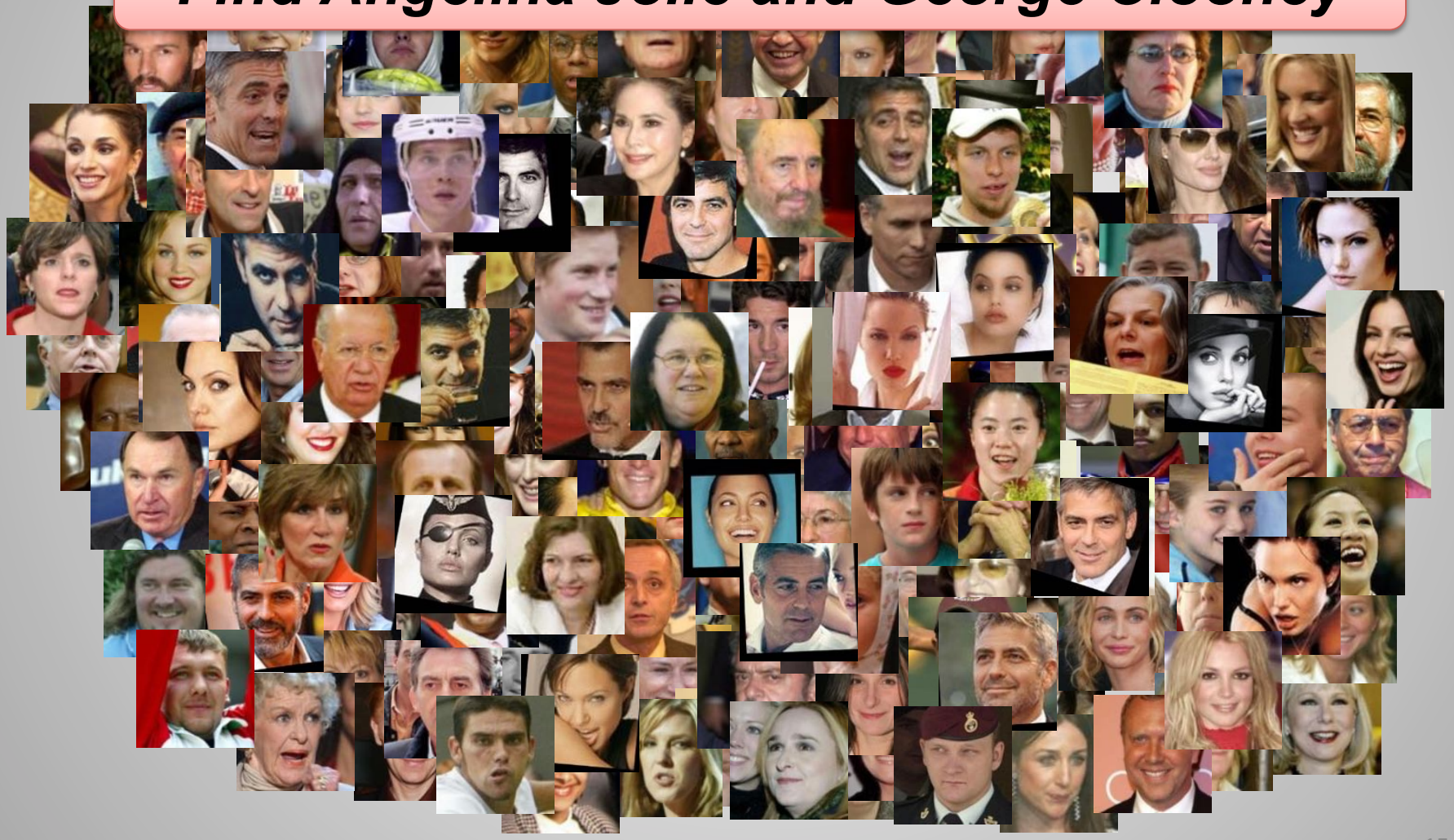
News Article: Label Important Figures



Social Network: Tag Facebook Friends

Open-Universe Face Identification

Find Angelina Jolie and George Clooney



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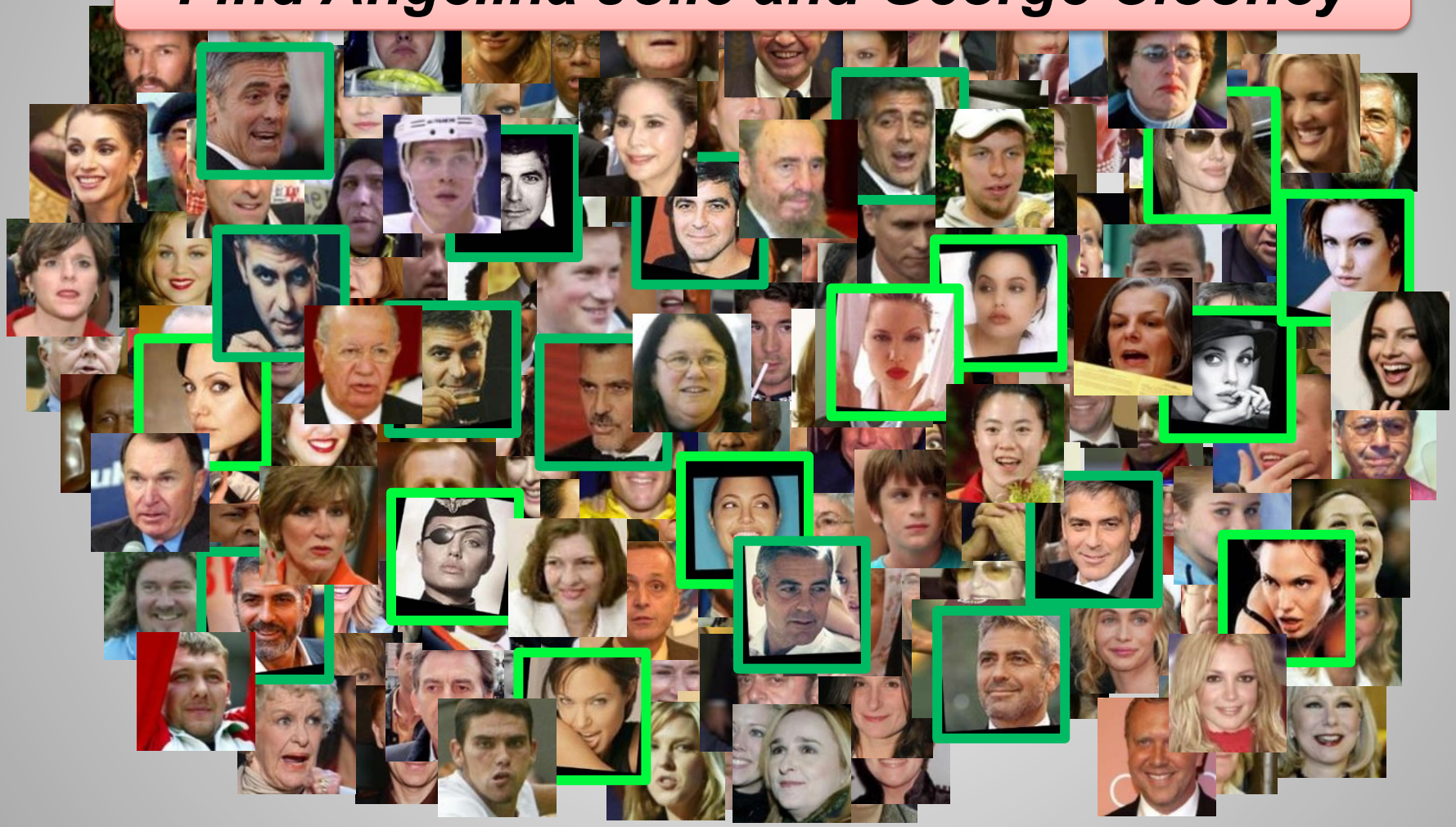
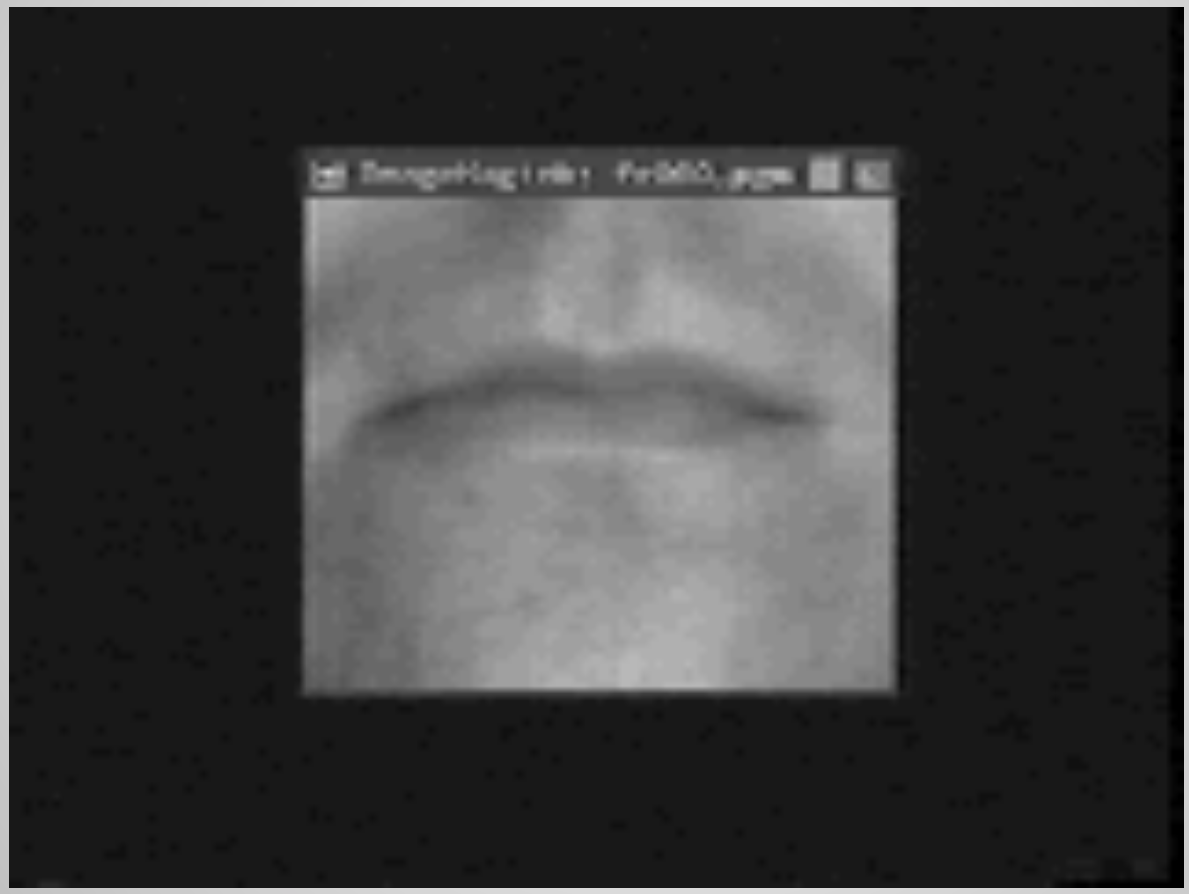


Ex. Facial expression

Ex. Fatigue detection

Ex. Lip-reading



Video Surveillance and Monitoring

Object detection → Object tracking → Object categorization and classification → Event or Activities Recognition

UAVs: Unmanned Aerial Vehicles (drones)

Global Hawk

Predator

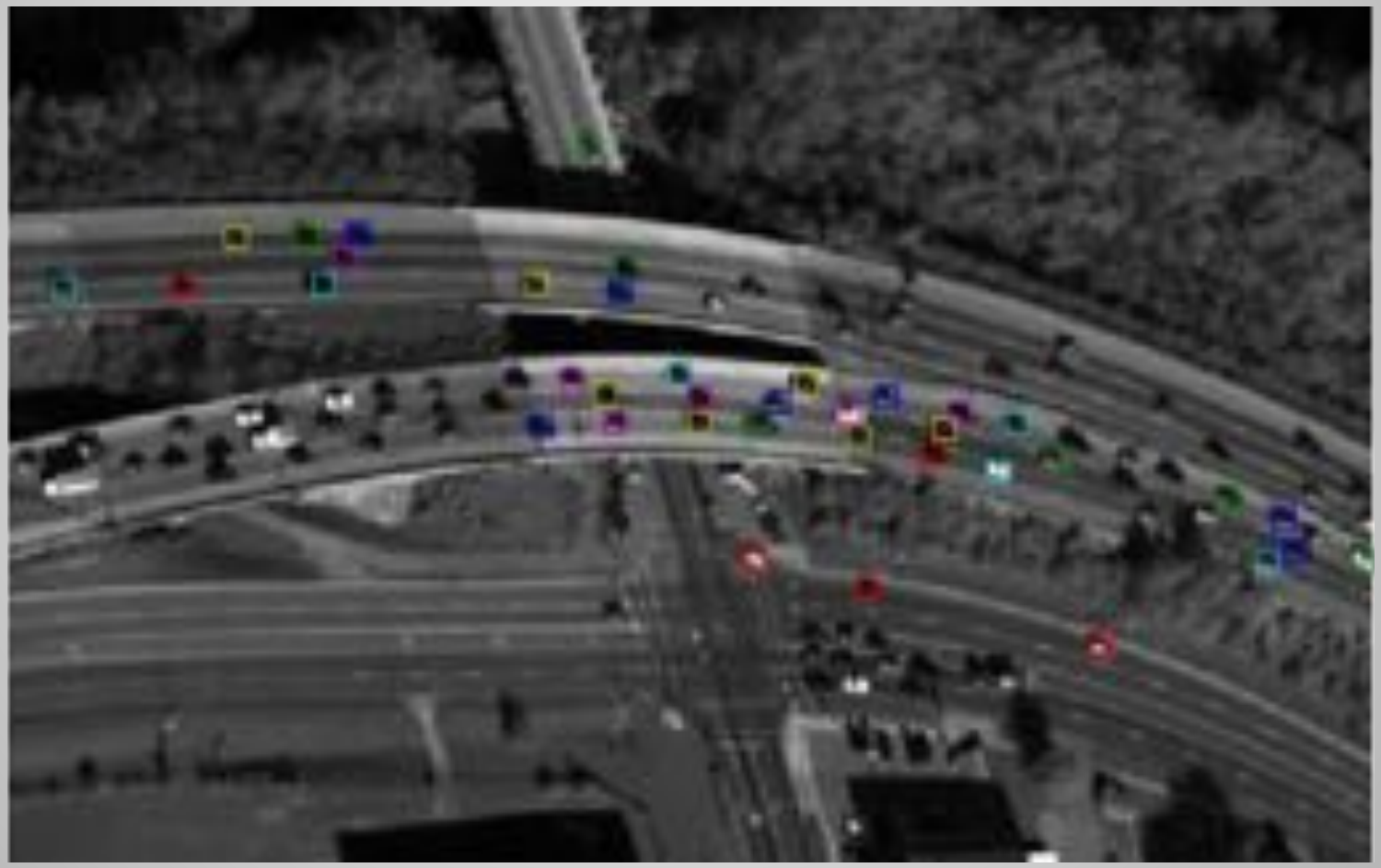
Microdrone

Ex. Detection in Videos

Ex. Object Tracking

Ex. Wide Area Surveillance

Ex. Tracking (multi-object)



Ex. Human Action Recognition

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

Bench Swing

Dive

Swing

Run

Kick

Lift

Ride

Golf Swing

Skate

Ex. UCF YouTube Action Dataset


Cycling


Diving


Golf Swinging


Riding


Juggling

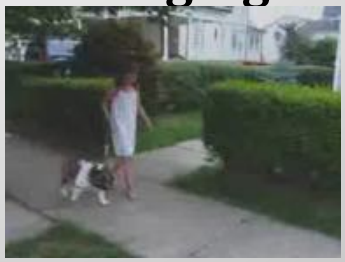

Basketball Shooting


Swinging


Tennis Swinging


Volleyball Spiking


Trampoline Jumping


Walking Dog

Ex. High Density Crowded Scenes

Political Rallies

Religious Festivals

Marathons

High Density
Moving Objects

Ex. Counting in Extremely Dense Crowd Images

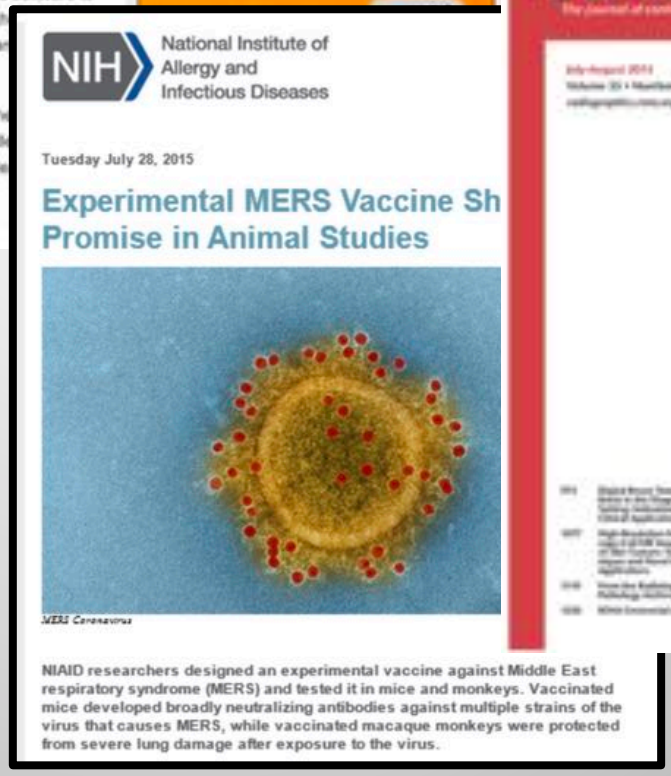
Ground truth=634 Proposed Method by Idrees and Shah=640

Ground truth=1428 Proposed Method=1468

Ground truth=2319 Proposed Method=2496

Ex. Visual Business Recognition

Ex. Medical Computer Vision

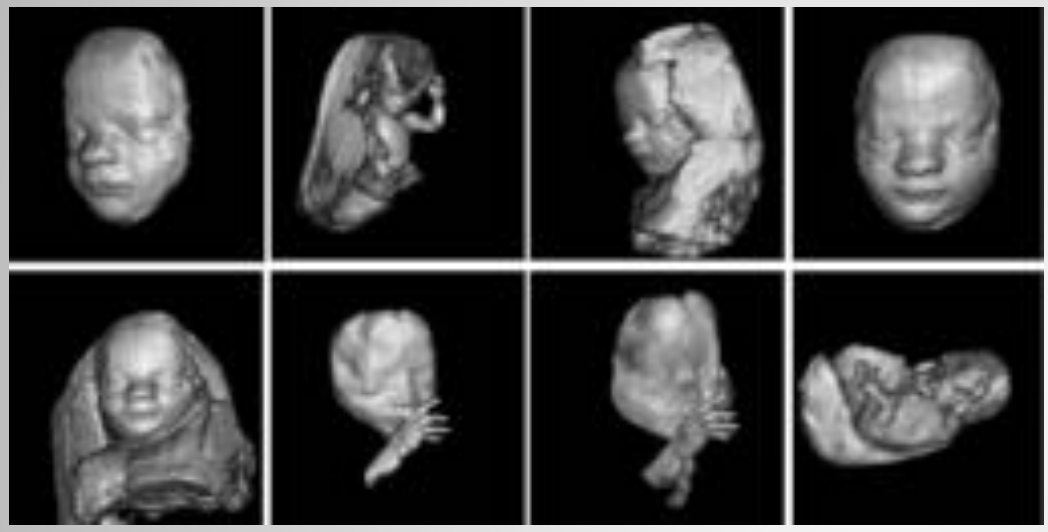


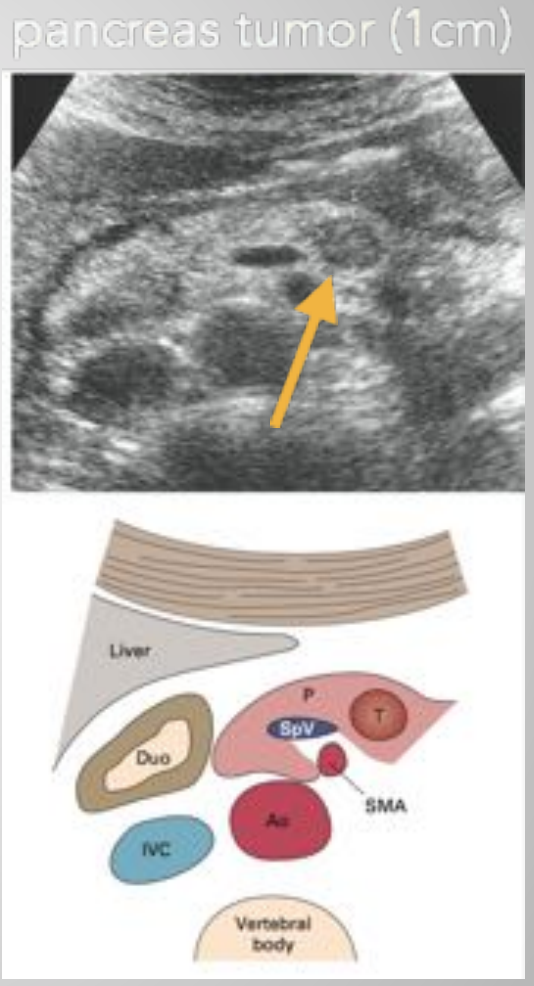
Ex. X-Ray Imaging/Radiography

The first published medical image was a radiograph of the hand of Wilhelm Conrad Roentgen's wife in 1895.

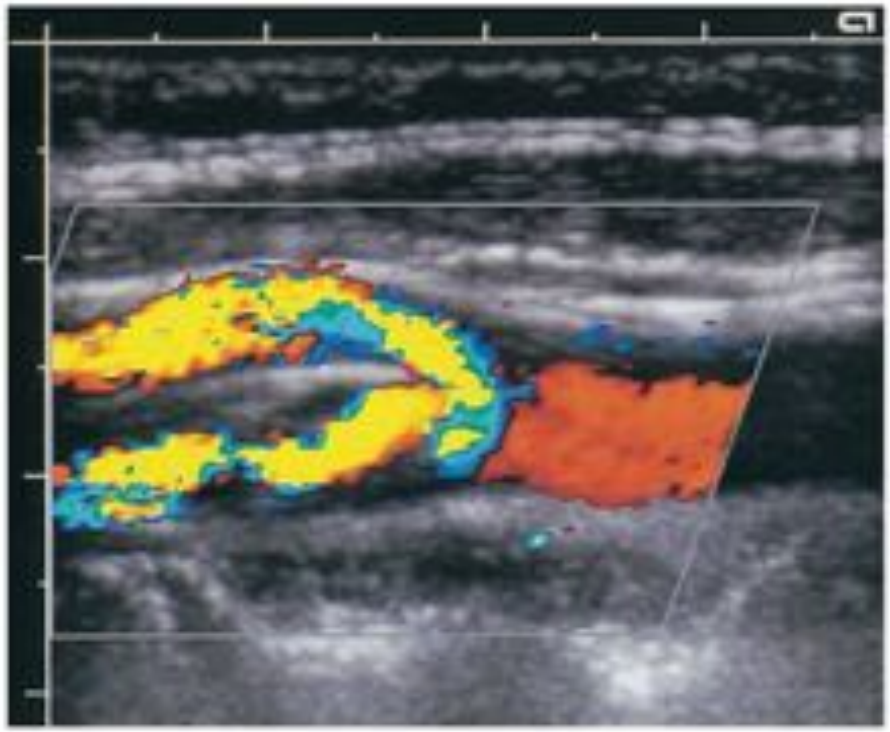
Nobel Prize in Physics 1901.

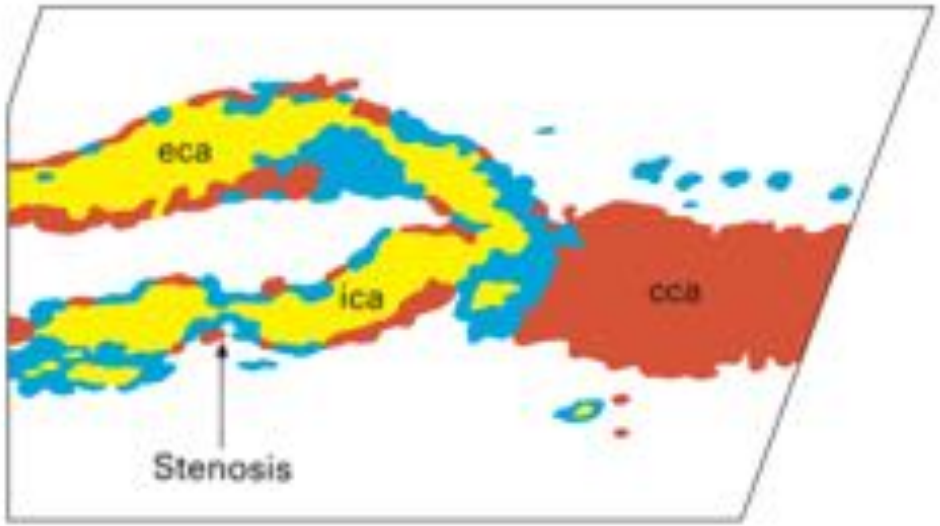
Ex. Ultrasound imaging and Analysis





Ex. Renal Artery Blood Flow Estimation by Computer Vision Techniques

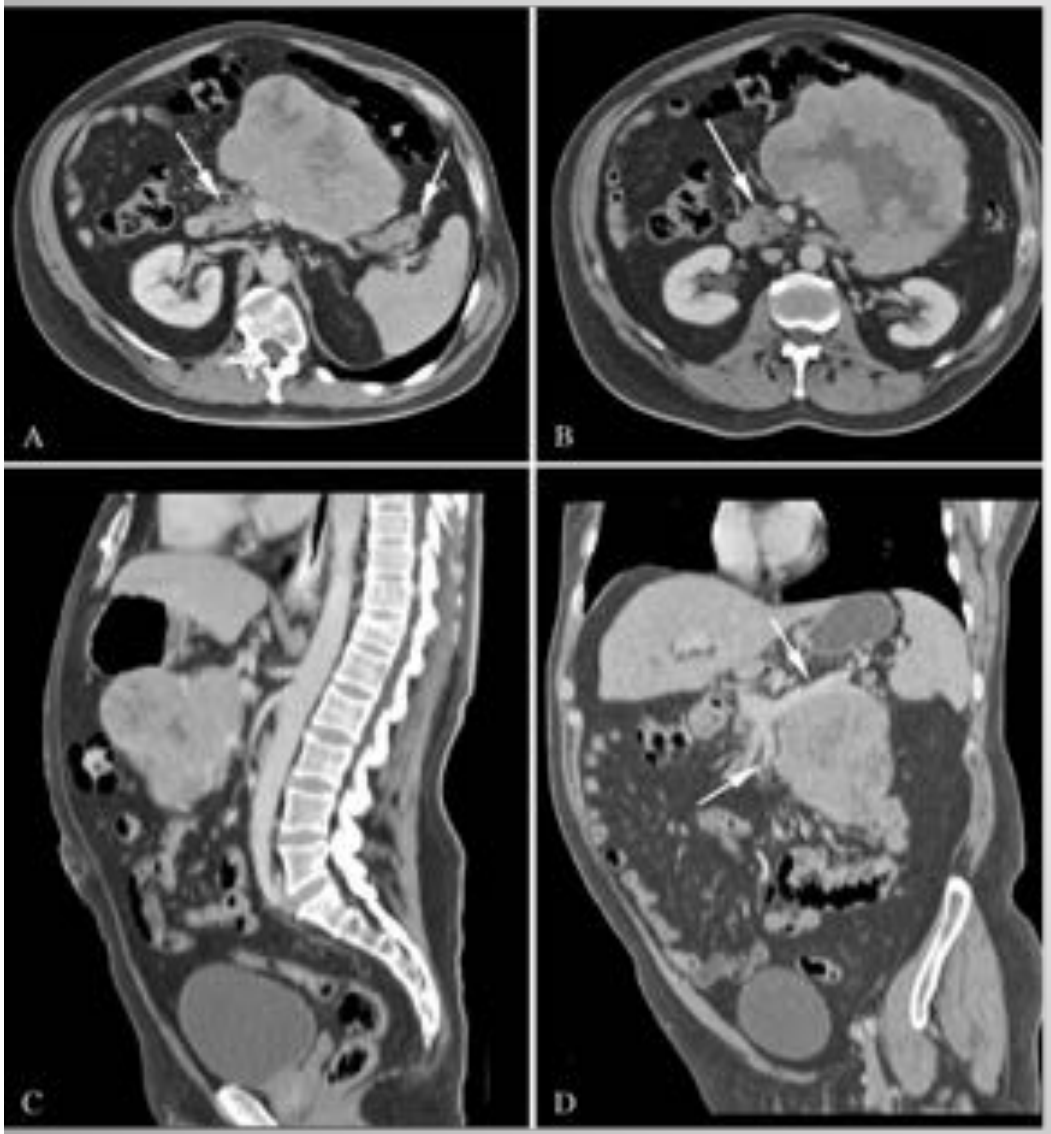




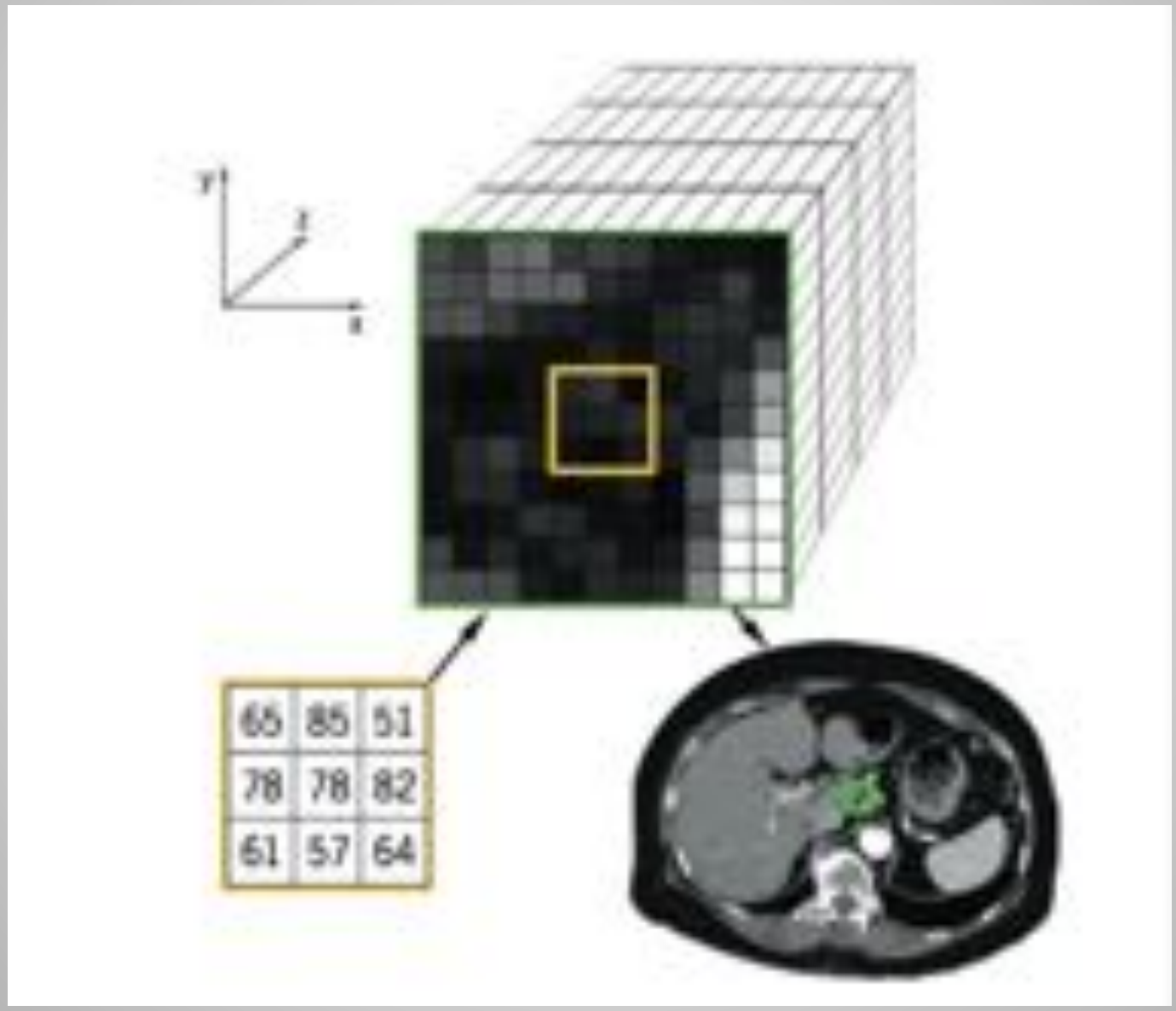
CV methods can help calculating
All blood flow and identify
Automatically the abnormal regions.

stenosis is seen
eca: external carotid artery
cca: common carotid artery
ica: internal carotid artery

Ex. Computer Vision for Graphics



Computed Tomography / Auto-detection of tumors

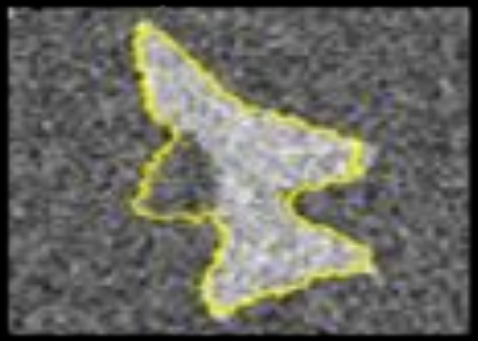


Computer vs. Human Vision?

- In which task computers are superior to humans?
- In which task humans are superior to humans?

Human > Computer

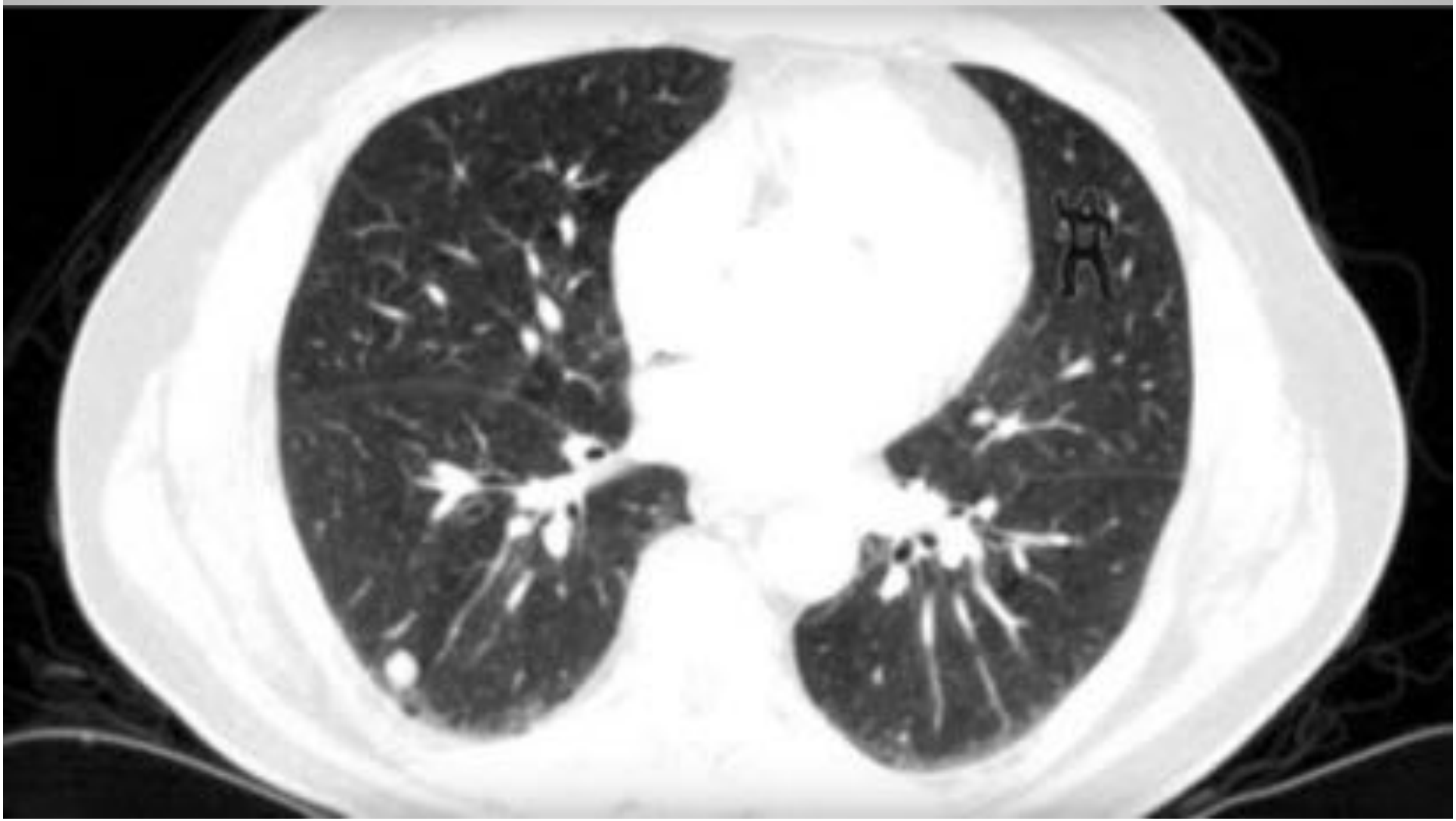
Recognition, detection, etc …global tasks



Computer > Human

Delineation, local analysis, etc …local tasks

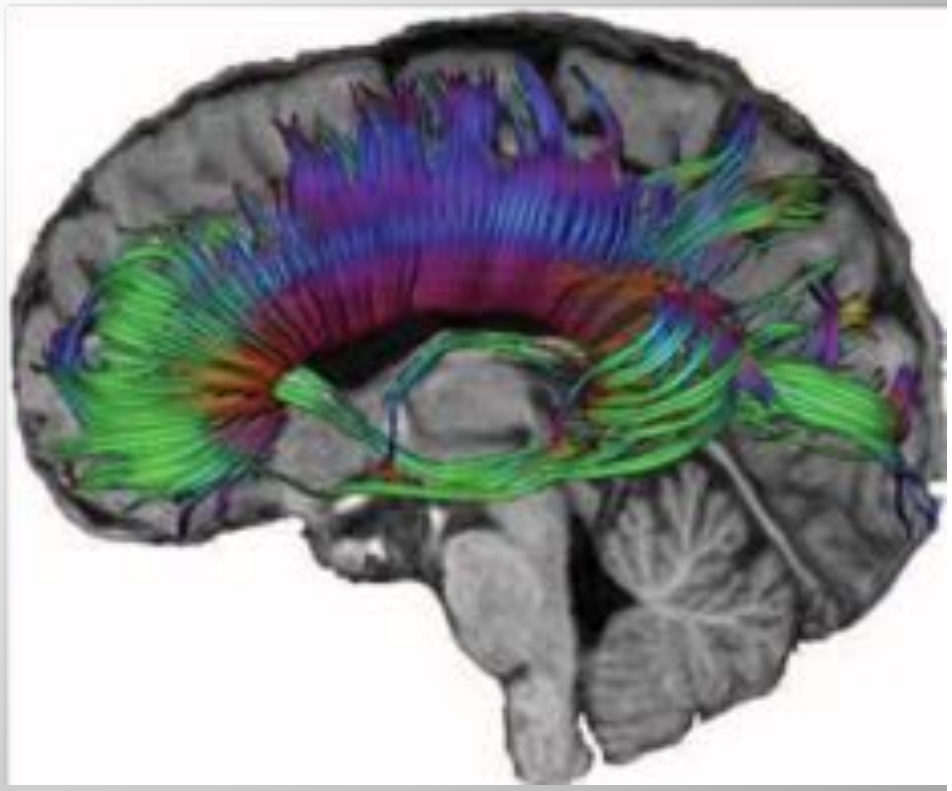
Anything interesting in this scan?



Now?

Ex. DWI and DTI

Tracking water/oxygen molecules characterize tumors, and provide connectivity Information on neural tracks

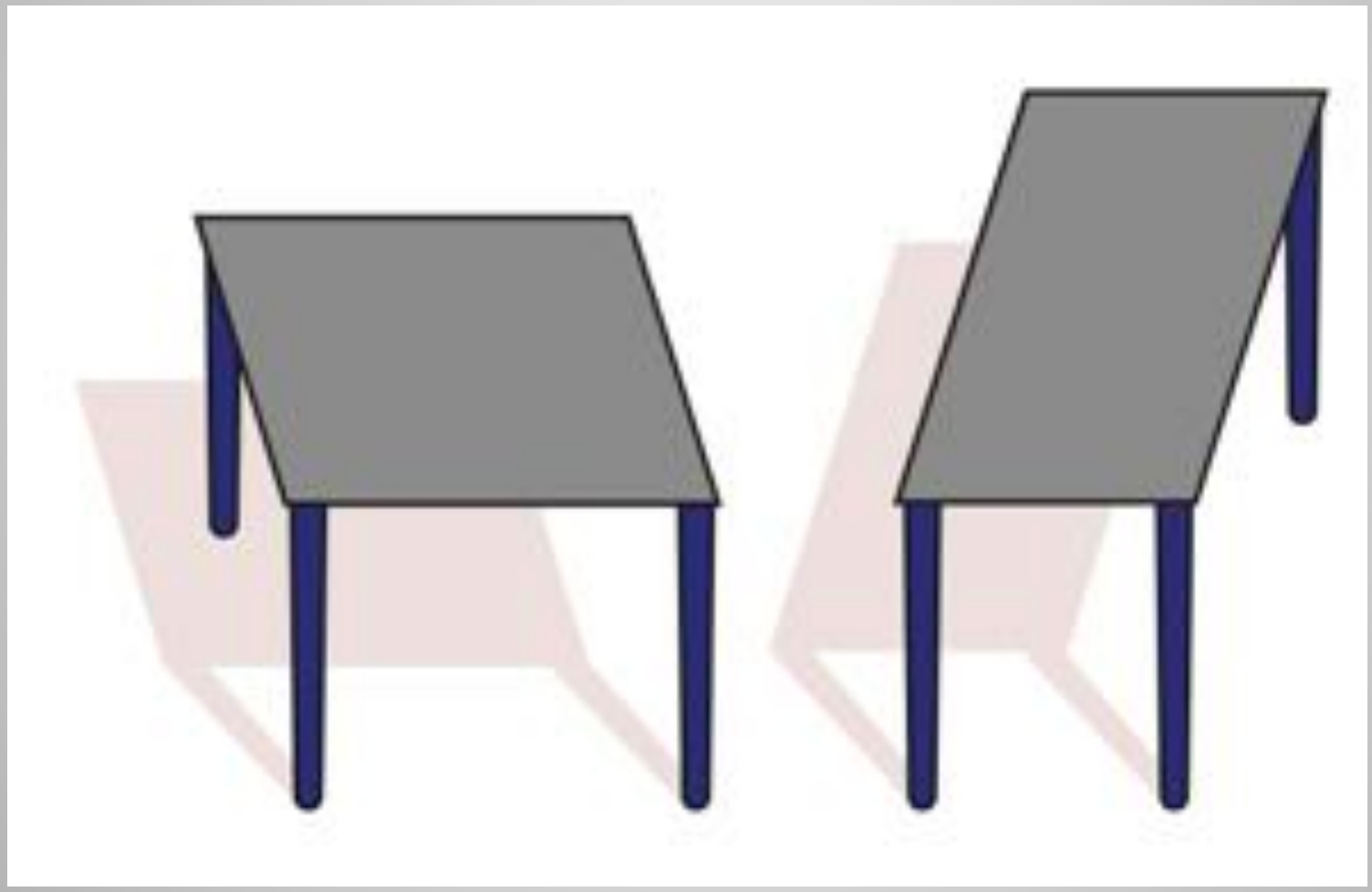


What can you see in this picture?

Now can you see what the picture is?

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

Do they look the same?



Visual Perception

- How do we know that the objects that we see are for?

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- Can people "see" without being aware of what they see?

Visual Perception

- How do we know that the objects that we see are for?
- Can people "see" without being *aware* of what they see?
- Why do objects appear colored?

Visual Perception

- Definition: *Process of acquiring knowledge about environmental objects and events by extracting information from the light they emit or reflect [Palmer, 2012].*

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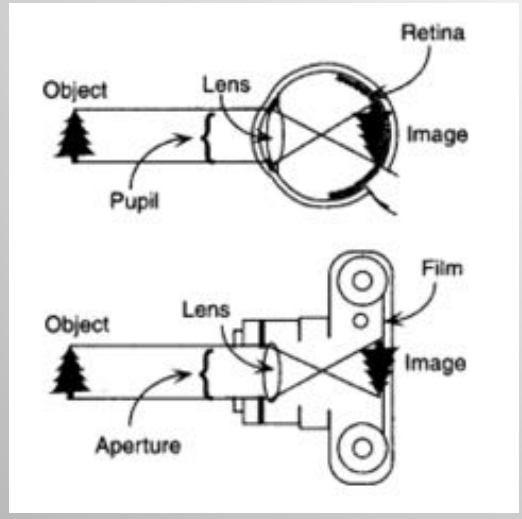
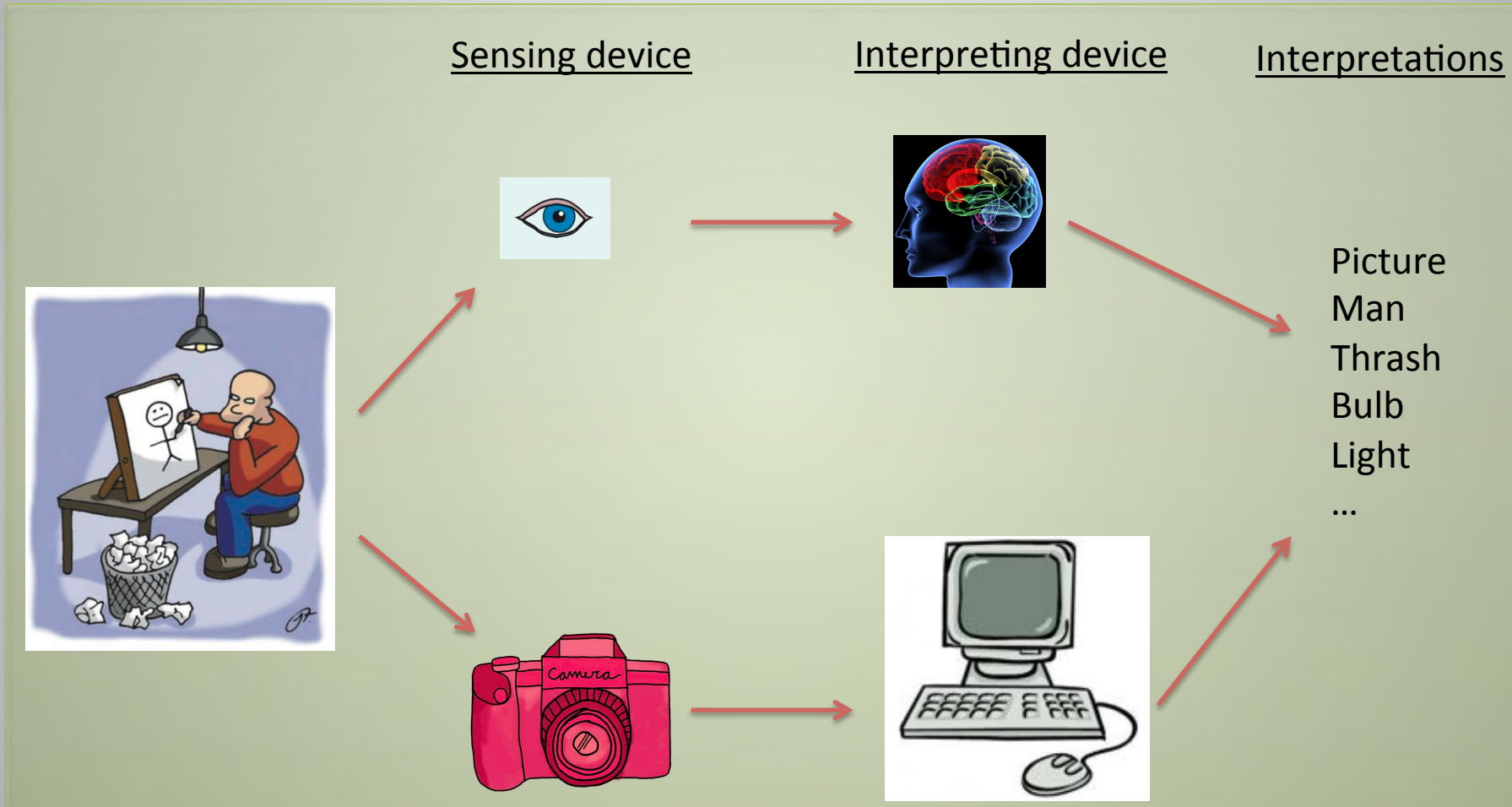


Perception is analogous to taking a picture!
(credit: Palmer, 2012)

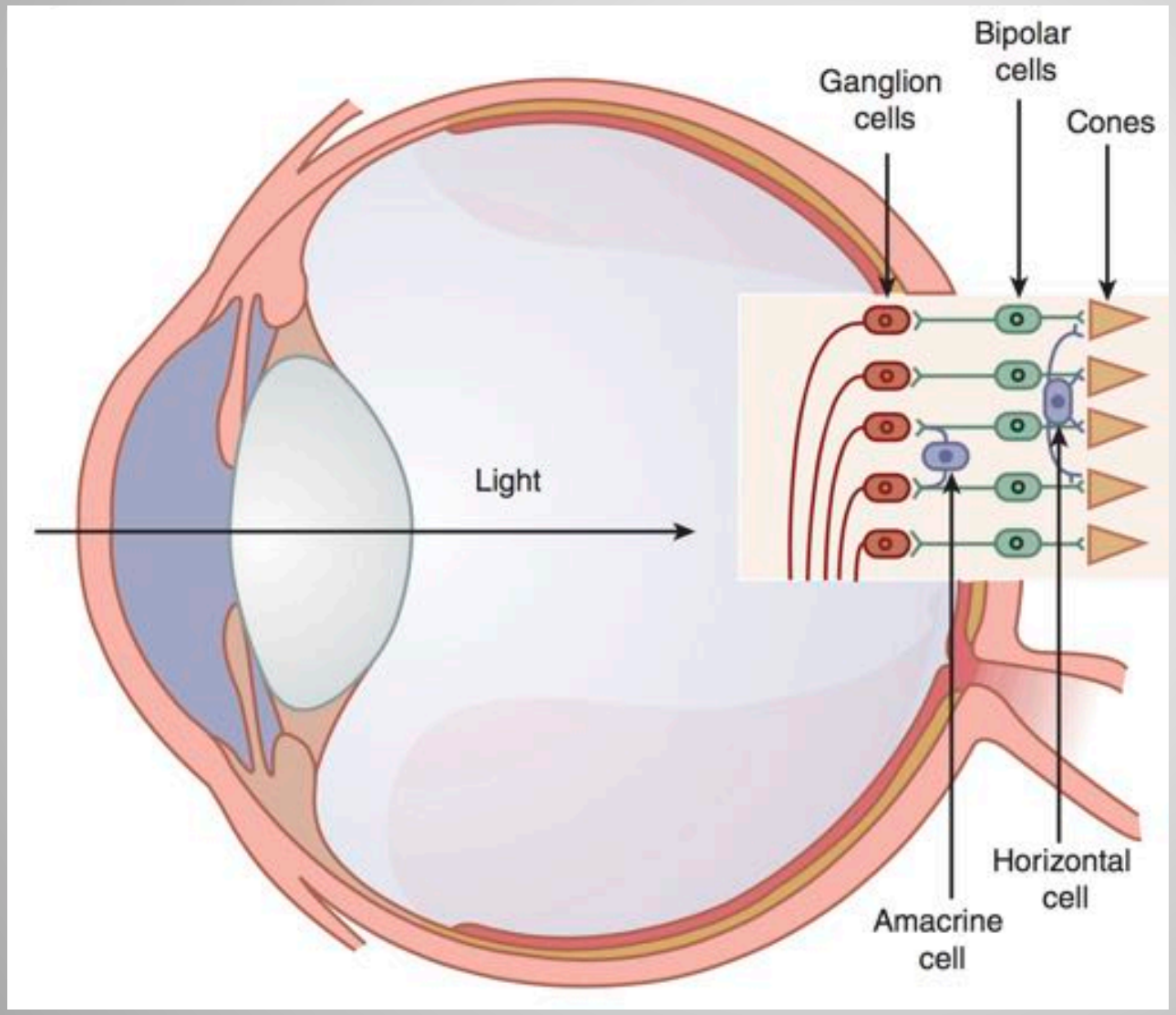
Visual Perception

Vision is a process in which temporally changing intensity and color values in the image plane have to be interpreted as processes in the real world that happen in 3D space over time

Vision vs. Computer Vision ?



Vision-Eye-Light



<u>Retinal Processing:</u>

Photoreceptors absorb Light quanta and convert This radiant energy into Electrical activity.

They synapse on bipolar cells, which in turn, can stimulate ganglion cells, thereby sending action potentials along the optic nerve to the LGN(lateral Geniculte nucleus).

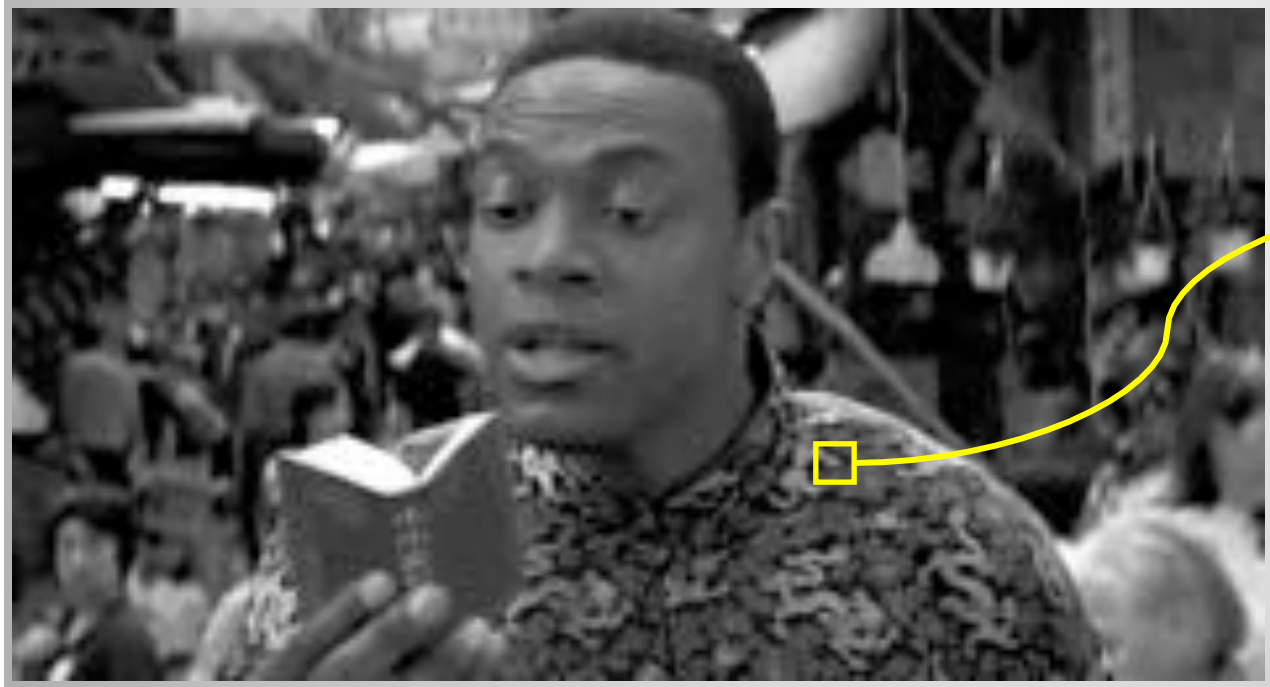
Credit: Schwarts, 2009.

Vision and Image Understanding

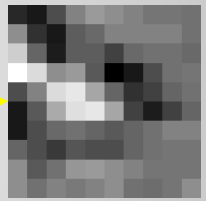
- Visual tasks: We use vision to interact with environments and survive – to navigate and avoid obstacles, to recognize and pick up objects, to identify food and danger, friends and enemies, …

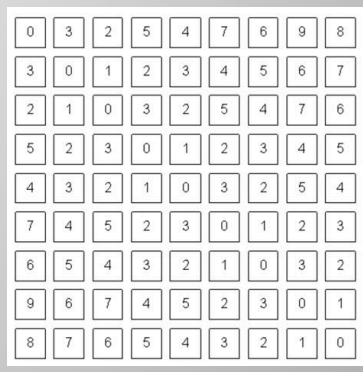
Goal of Computer Vision?

- To bridge the gap between image pixels and "meaning" (semantic)!



What we see!

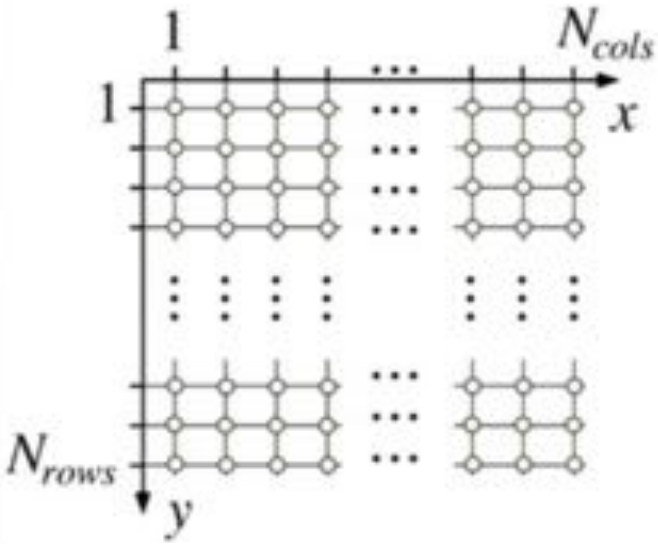




What computer sees!

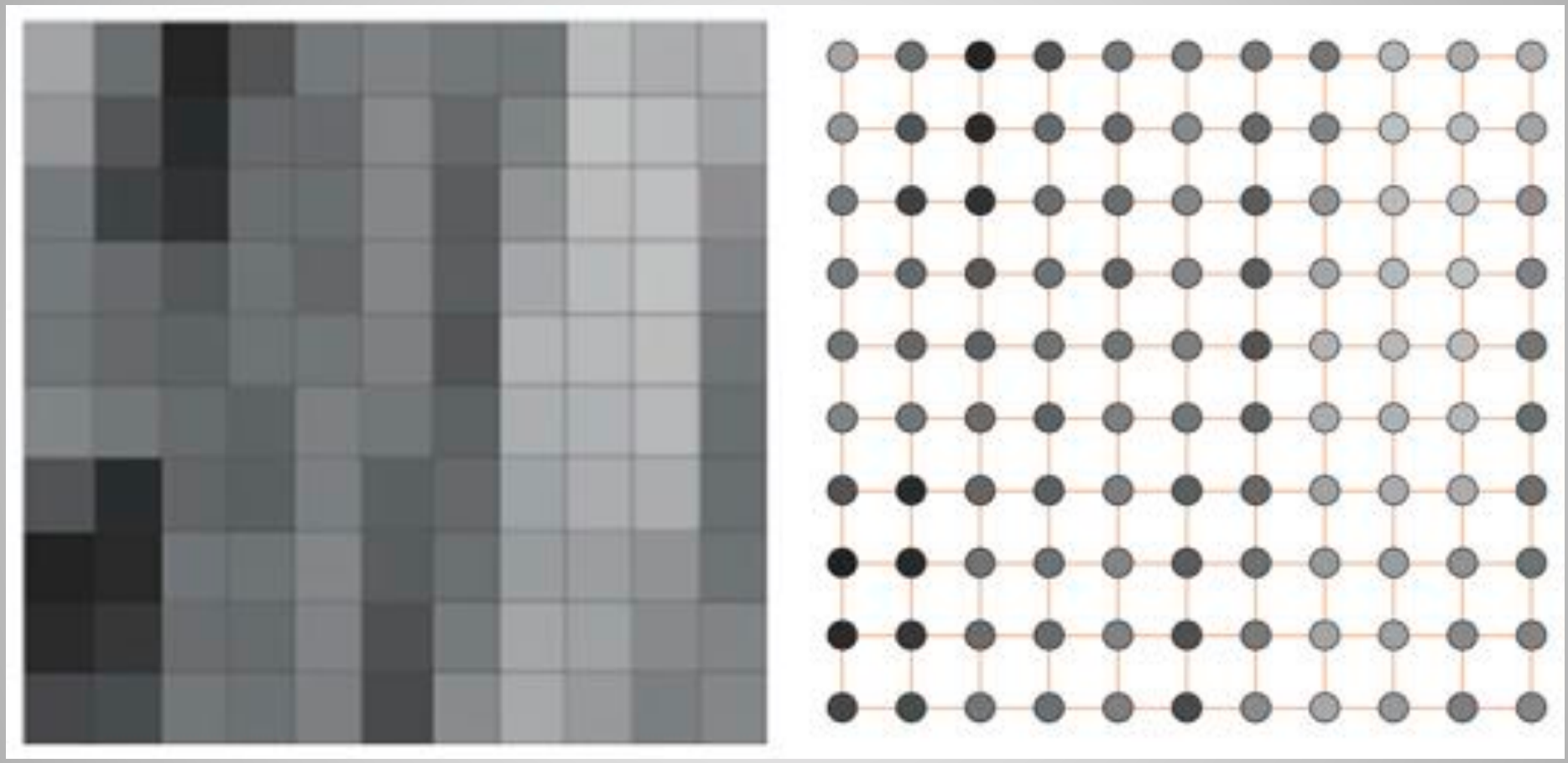
What is a (digital) Image?

- Definition: A digital image is defined by *integrating* and *sampling* continuous (analog) data in a spatial domain [Klette, 2014].



Left hand coordinate system

Picture Elements - PIXEL



PIXELS are ATOMIC ELEMENTS of an image.
In late 1960s, terminology 'pixel' was introduced by a group of scientist at JPL in California!

Image Types: 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

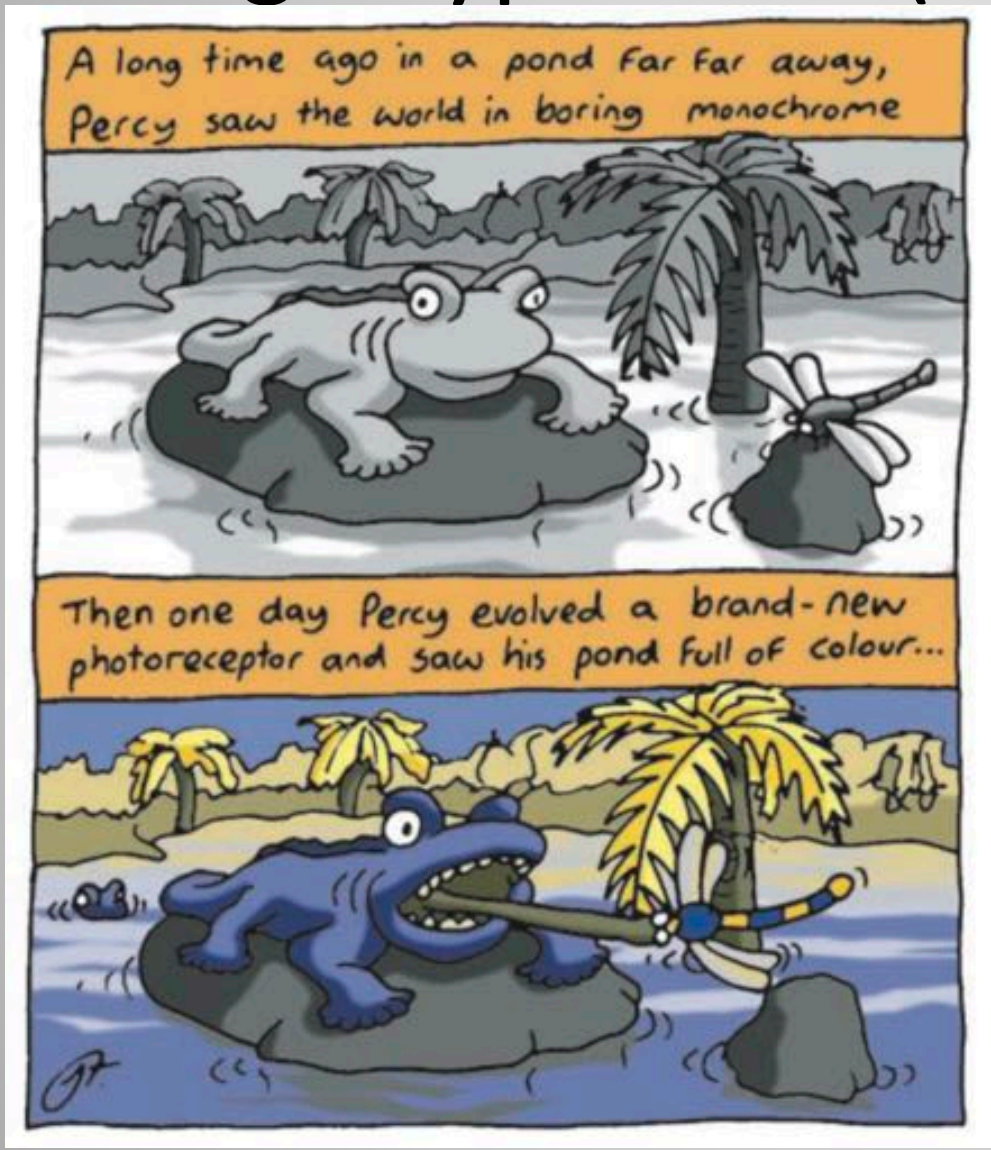
255 white

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.

Image Type: RGB (red, green, blue)



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

Image Format

- Some formats: TIF, PGM, PBM, GIF, JPEG, PNG, RAW,…
- Medical Images: DICOM, Analyze, NIFTI,…

HEADER: contains image information, image size, pixel size, …

DATA: integer, double, float, unsigned integer, char,…

Practice: Image Format/Read/Show

```
from scipy import misc
l = misc.lena()
misc.imsave('lena.png', l) # uses the Image module (PIL)

import matplotlib.pyplot as plt
plt.imshow(l)
plt.show()
```

PIL: Python Imaging Library

from PIL import Image
Img = Image.open('empire.jpg')

Matplotlib is a good graphics library with much
More powerful features than the
Plotting available in PIL

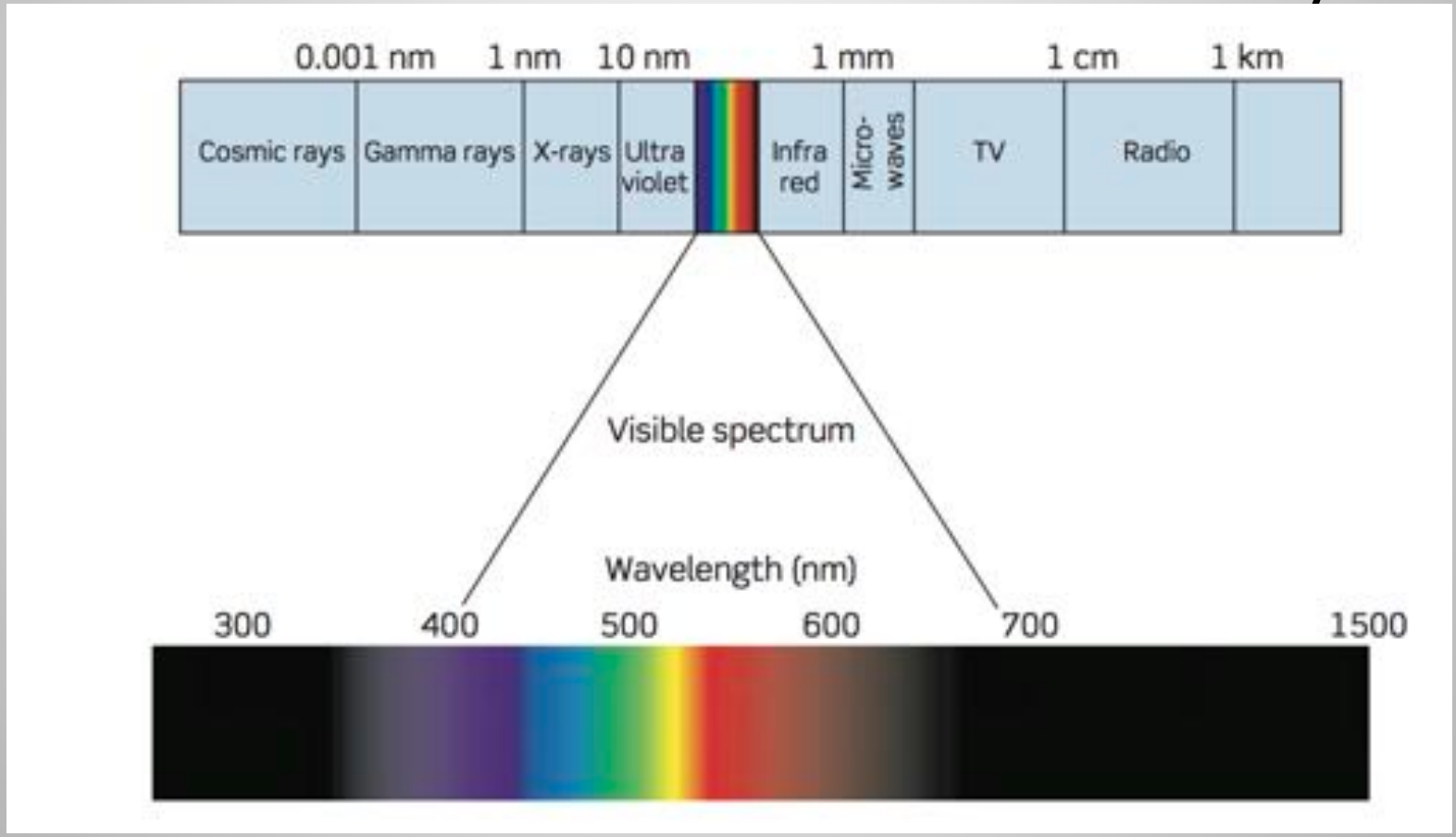
Color

- If there is no light, there is no color!
- Human vision can only discriminate a few dozens of grey levels on a screen, but hundreds of thousands of different colors.

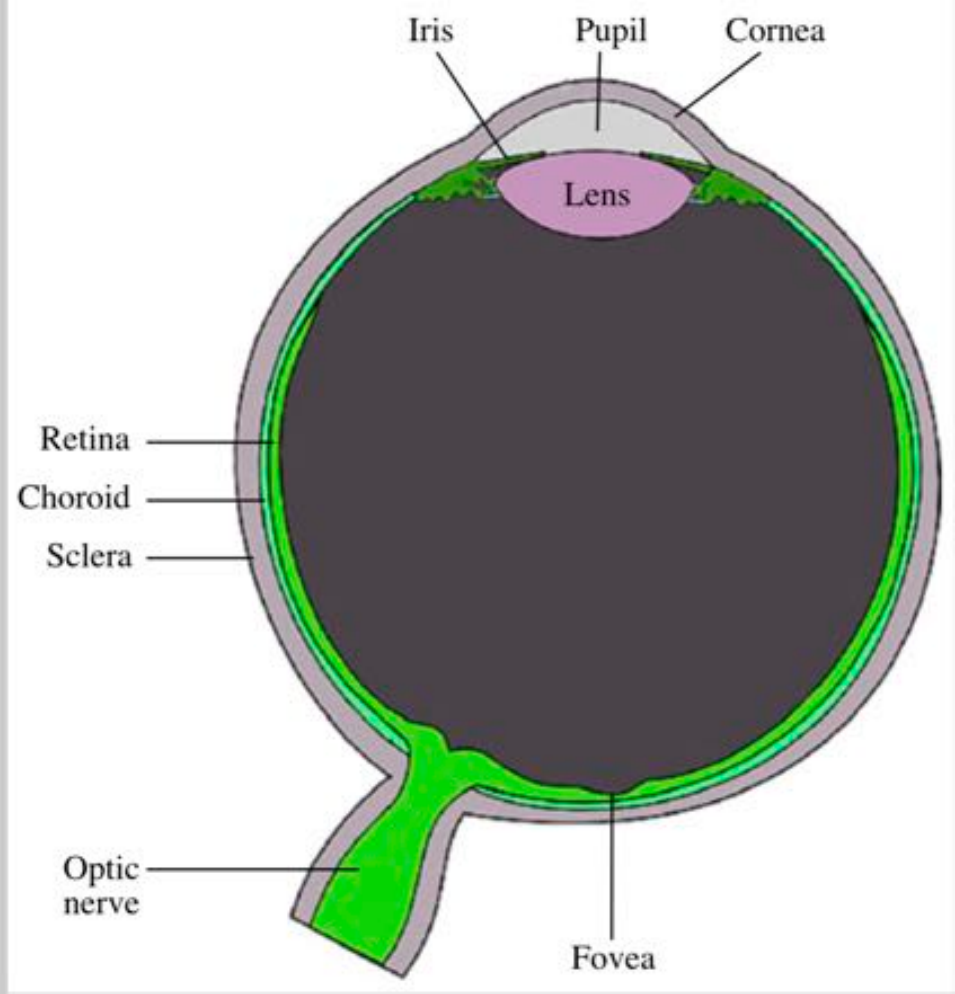
  - RED -> ~625 to 780 nm [long wavelength]
  - ORANGE -> ~ 590 to 625 nm [long wavelength]
  - YELLOW -> ~565 to 590 nm [middle range wavelength]
  - GREEN -> ~ 500 to 565 nm [middle range wavelength]
  - CYAN -> ~485 to 500 nm [middle range wavelength]
  - BLUE -> ~440 to 485 nm [short wavelength]
  - VIOLET -> ~330 to 440 nm [very short wavelength]

COLOR

- Color vision has evolved over millions of years.



Retina of Human Eye



There are three different types of color-sensitive cones corresponding to (roughly) RED (64% of the cones), GREEN (about 32%), and BLUE (about 2%).

6-7 million cones
120 million rods

Credit: Klette, 2012.

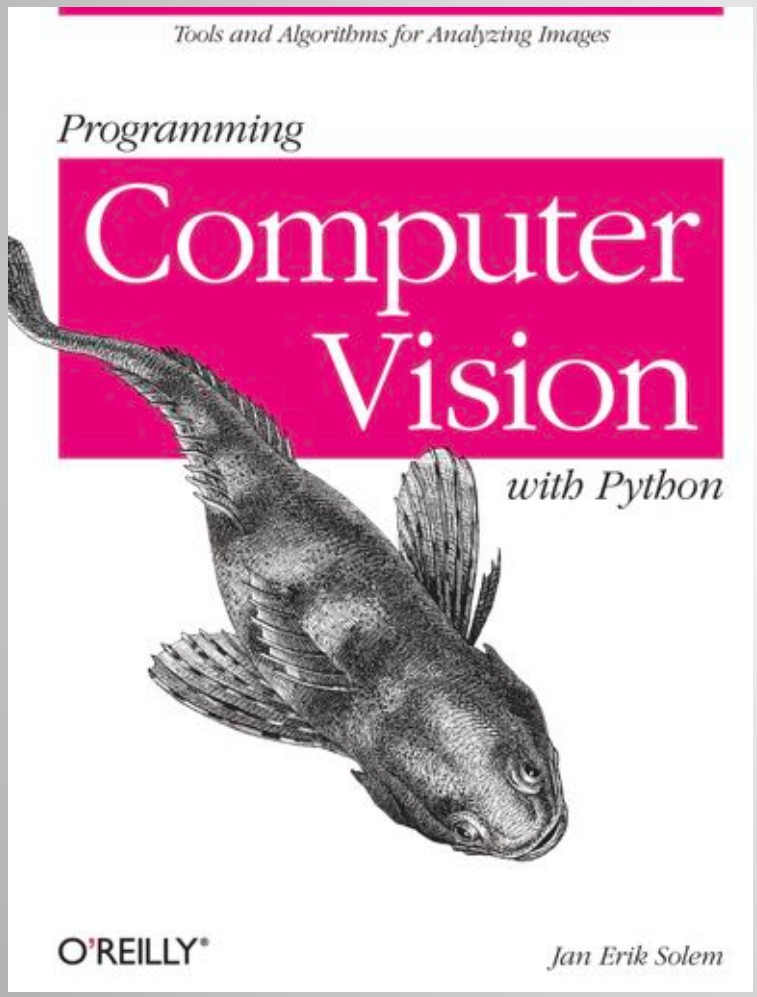
LIGHT/COLOR-Isaac Newton's House

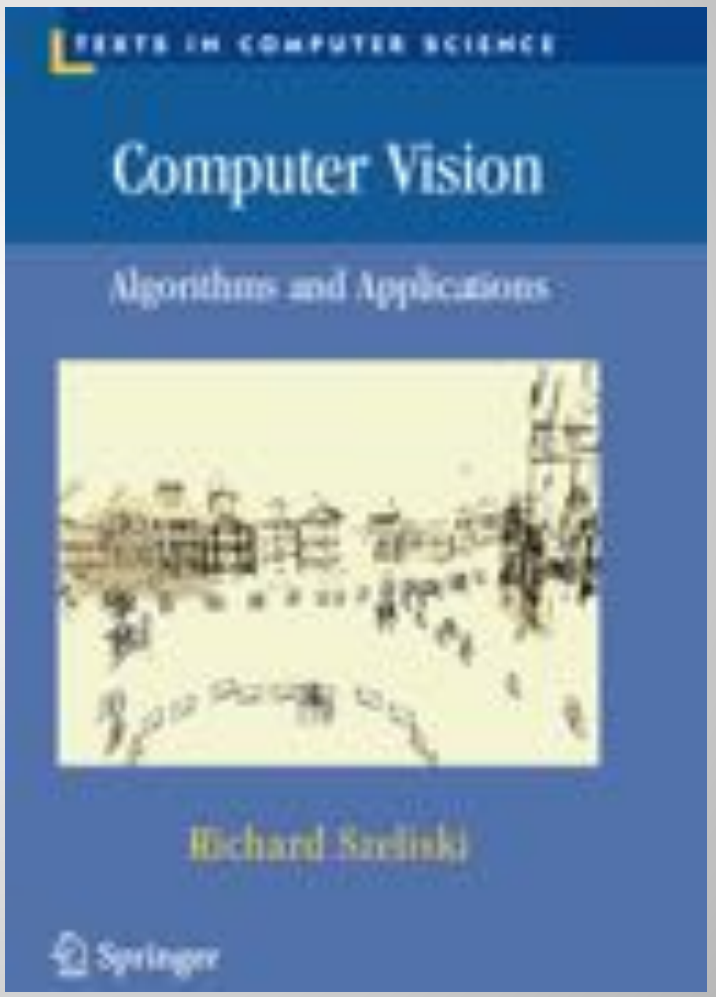
Video Clip

- Sequences of frames
- 30 frames per second

Sequences of Images

Available online!





Programming Assignments

Thu Sep 3, 2015	Programming Assignment #0 (BONUS)
Thu Sep 10, 2015	Programming Assignment #1
Thu Sep 24, 2015	Programming Assignment #2
Thu Oct 8, 2015	Programming Assignment #3
Thu Oct 22, 2015	Programming Assignment #4
Thu Nov 5, 2015	Programming Assignment #5
Mon Nov 23, 2015	Mini-project #1
Thu Dec 10, 2015	Mini-project #2

Submissions: ONLINE (web-course).
Descriptive explanations should be included in the code (i.e., comments).
Individual efforts are sought (collaborations are allowed at discussion level only).
Mini-projects will be selected from a list of projects.