# CSCE 590 INTRODUCTION TO IMAGE PROCESSING

## Introduction

Ioannis Rekleitis

# Why Image Processing?

- Who here has a camera?
- How many cameras do you have
- Point where computers fast/cheap
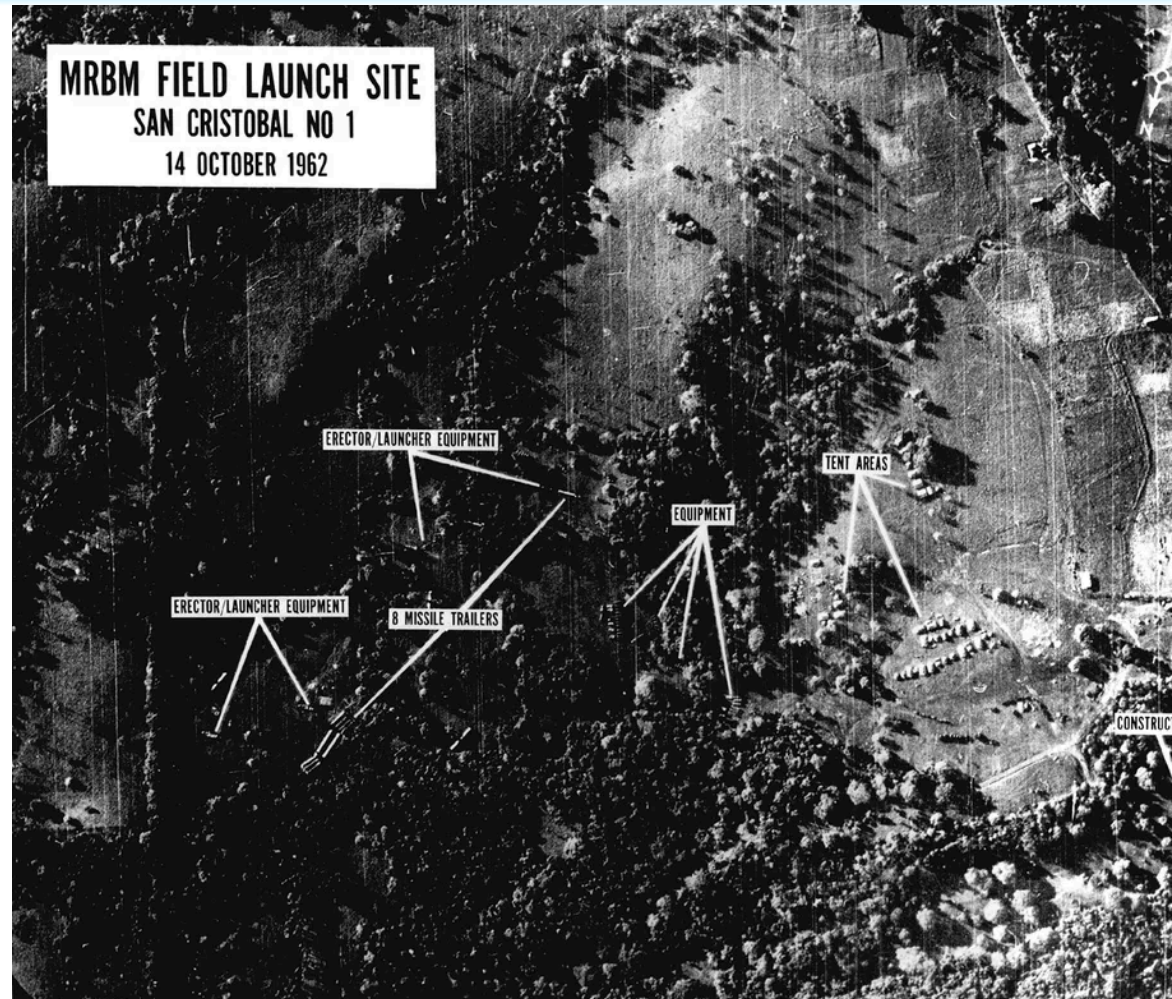- Cameras become omnipresent
- Deep Learning…

# Long time ago



https://en.wikipedia.org/wiki/Cave_painting#/media/File:Rhinos_Chauvet_Cave.jpg

# From early analysis



MRBM FIELD LAUNCH SITE
SAN CRISTOBAL NO 1
14 OCTOBER 1962

ERECTOR/LAUNCHER EQUIPMENT

ERECTOR/LAUNCHER EQUIPMENT

8 MISSILE TRAILERS

EQUIPMENT

TENT AREAS

CONSTRUCTIO

From: https://www.vox.com/videos/2019/5/31/18647684/cuban-missile-crisis-photo-prevented-nuclear-war

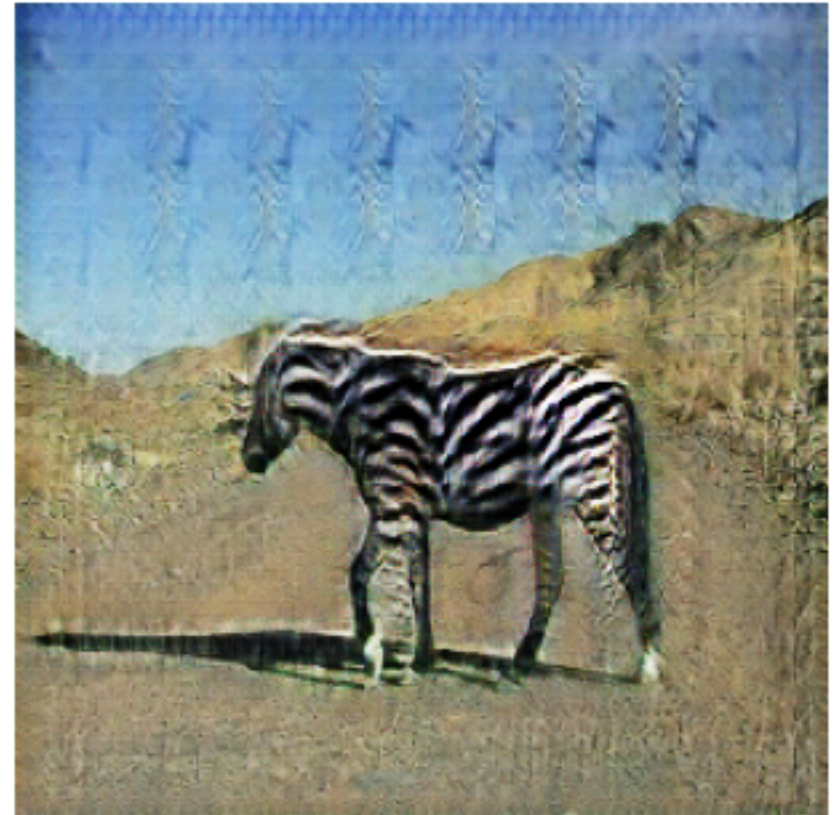# Exciting

https://www.youtube.com/watch?v=pW6nZXeWlGM

# Generative Adversarial Networks

Input Image

Predicted Image



From: https://towardsdatascience.com/horse-to-zebra-cycle-gan-in-tensorflow-2-0-d5ad979d0314

# Zebras to Horses



From: https://towardsdatascience.com/cyclegan-learning-to-translate-images-without-paired-training-data-5b4e93862c8d

# Major Topics Covered in Class

- image acquisition
- digital image representation
- Image enhancement
- Image restoration
- Color image processing
- Image compression
- Image segmentation
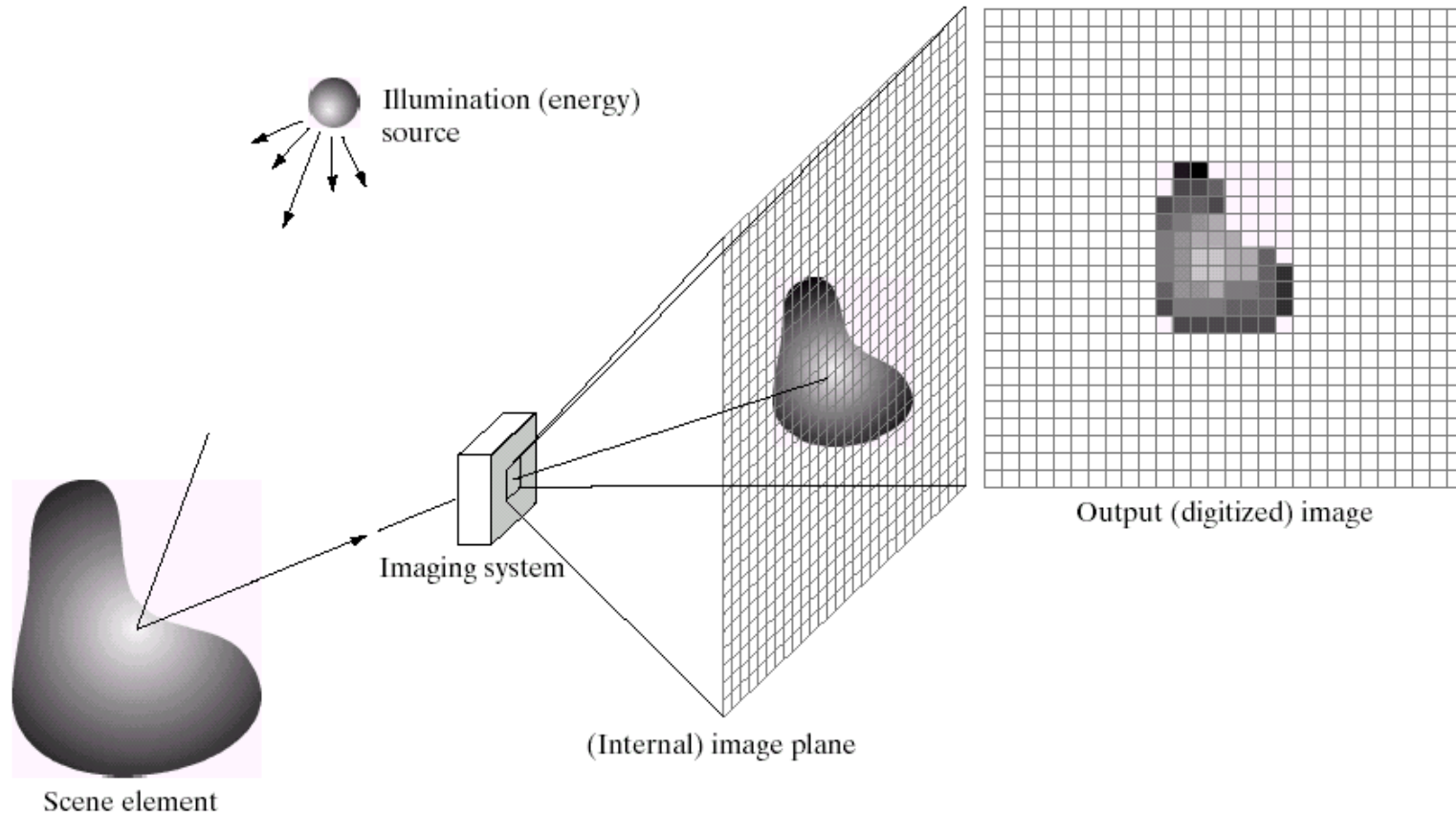- Morphological image processing

# Human Perception VS Machine Vision

- ## Limited vs entire EM spectrum

THE ELECTRO MAGNETIC SPECTRUM



http://www.kollewin.com/blog/electromagnetic-spectrum/
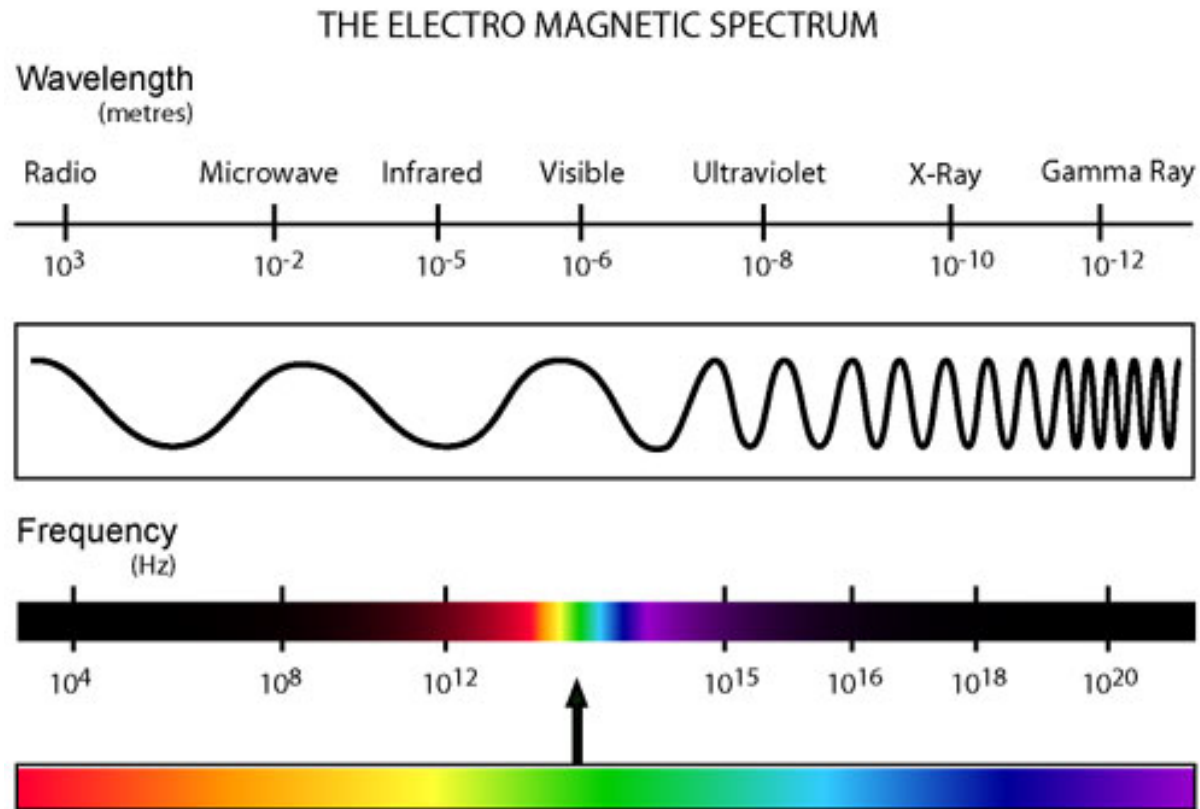
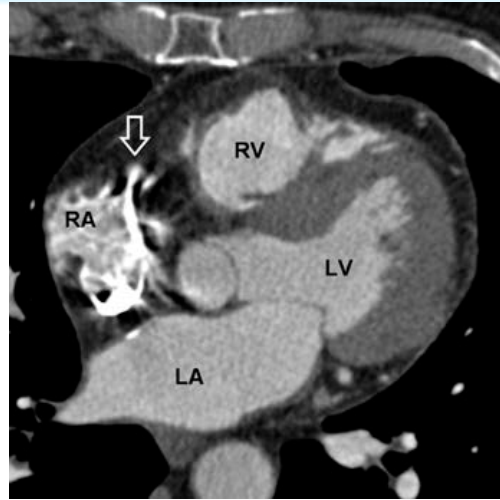# Image Acquisition and Representation



a
b  c  d  e

**FIGURE 2.15** An example of the digital image acquisition process. (a) Energy ("illumination") source. (b) An element of a scene. (c) Imaging system. (d) Projection of the scene onto the image plane. (e) Digitized image.
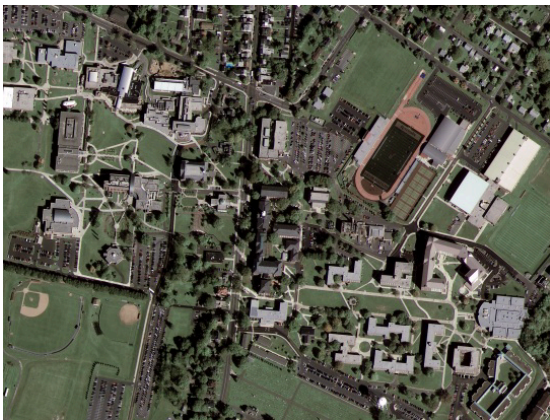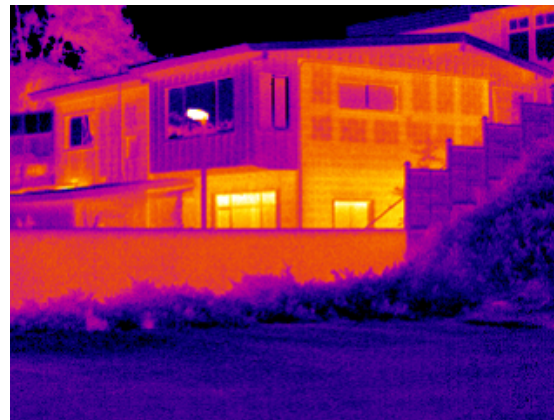
# Examples
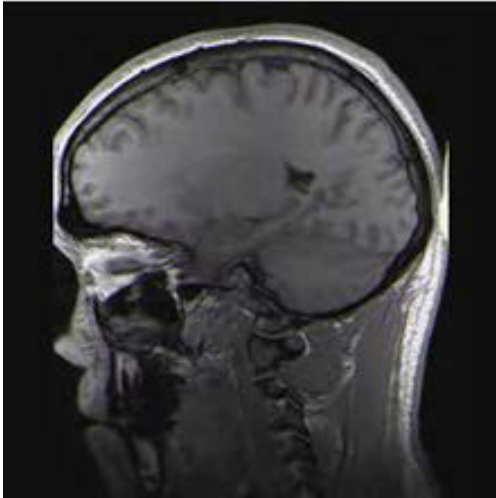


**1. Brain MRI**



**2. Cardiac CT**
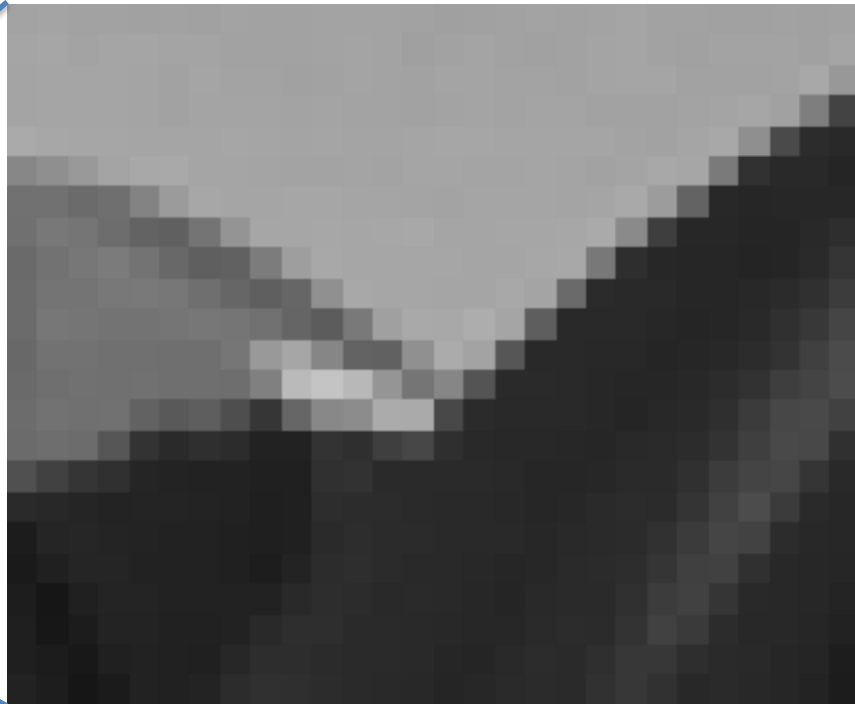


**3. Fetus Ultrasound**



**4. Satellite image**



**5. IR image**

**1 and 3. http://en.wikipedia.org**
**2. http://radiology.rsna.org**
**4. http://emap-int.com**
**5. http://www.imaging1.com**

Slides courtesy of Prof. Yan Tong
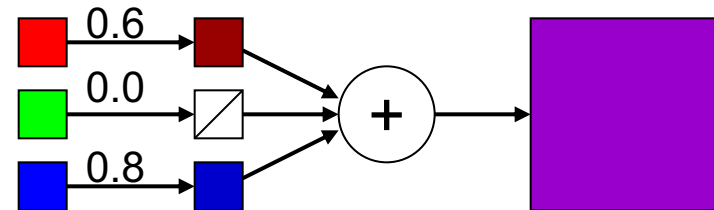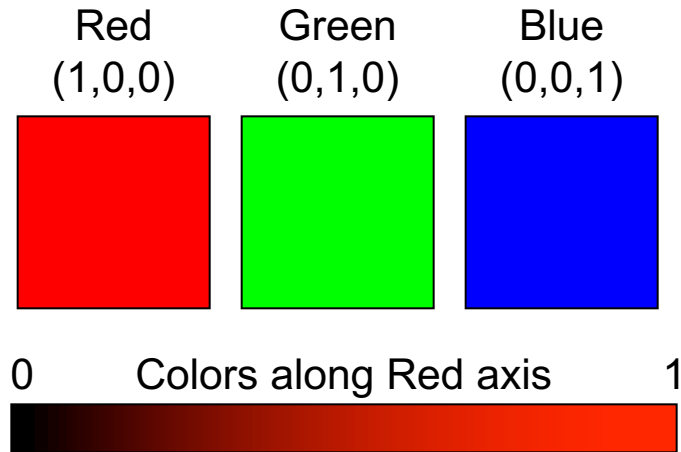
# Image Representation

- **Discrete representation of images**
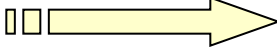  - we'll carve up image into a rectangular grid of pixels $P[x,y]$
  - •each pixel $p$ will store an intensity value in [0 1]
  - •0 →black; 1 →white; in-between →gray
  - •Image size $m$ by n →($mn$) pixels
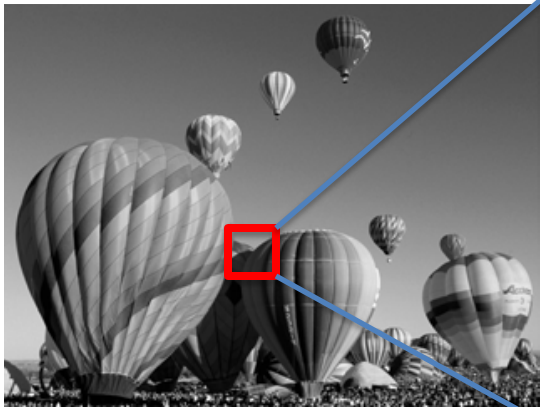
Slides courtesy of Prof. Yan Tong

# Color Image

Red
(1,0,0)

Green
(0,1,0)

Blue
(0,0,1)

0    Colors along Red axis    1

0.6

0.0

0.8

+

RGB
channels

Slides courtesy of Prof. Yan Tong

# Video: Frame by Frame

- 30 frames/second

Slides courtesy of Prof. Yan Tong

# Applications of Digital Image Processing

- **Digital cameras, portable devices**
- **Photoshop**
- **Human computer interaction**
- **Medical imaging for diagnosis and treatment**
- **Surveillance**
- **Aerial Drones**
- **Autonomous Cars**
- **Convolutional Neural Networks**
- **Virtual/Augmented Reality**
- **...**
- **Fast-growing market!**

# Image Enhancement

# Image Restoration

Slides courtesy of Prof. Yan Tong

# Image Compression



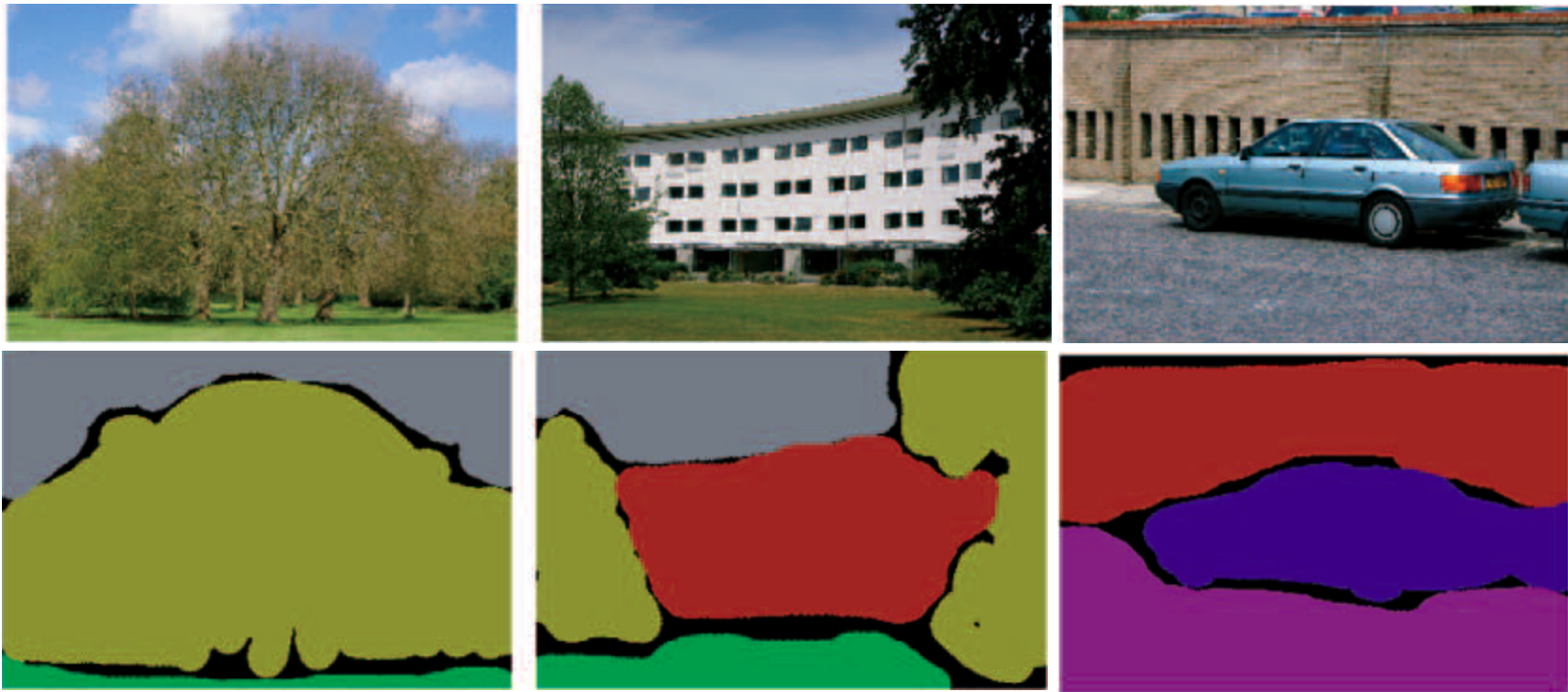100% fidelity — Image is 725kB | 90% — 250kB | 10% — 37kB | 1% — 20kB

- → Video compression

# Image Segmentation



**Microsoft multiclass segmentation data set**

# Image Completion

•Interactively select objects. Remove them and automatically fill with similar background (from the same image)
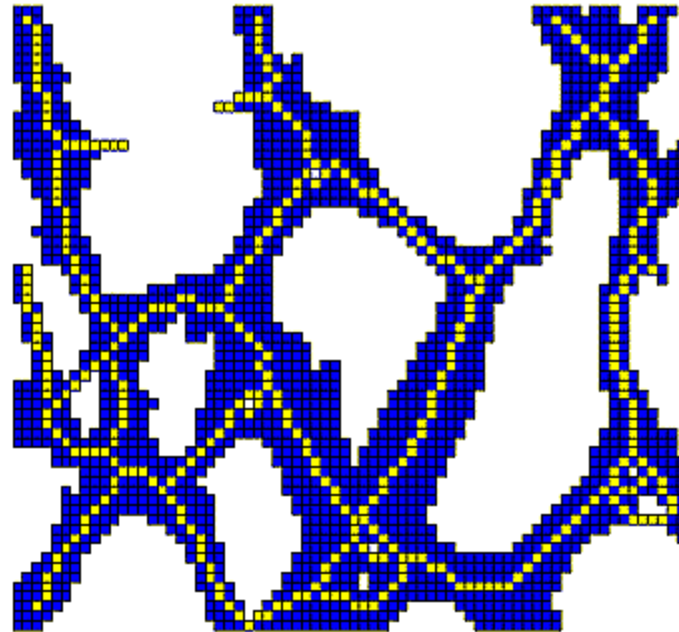


I. Drori, D. Cohen-Or, H. Yeshurun, SIGGRPAH'03

Slides courtesy of Prof. Yan Tong

# Morphological Image Processing

# Object Detection / Recognition
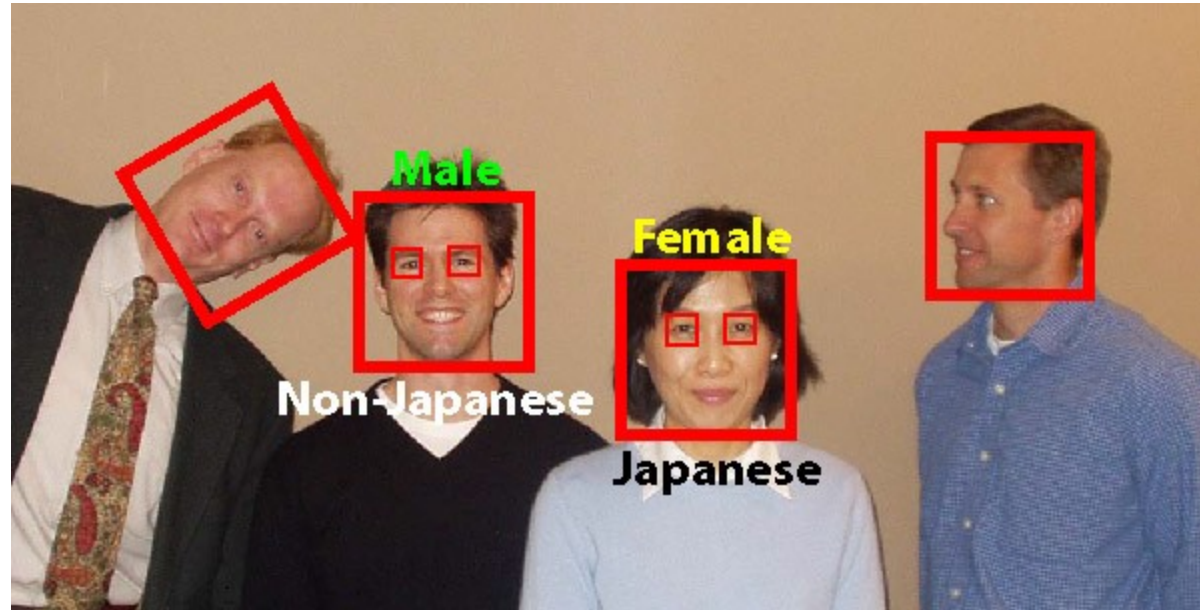
# Image Colorization

# Biometrics



crossover

core

bifurcation

ridge ending

island

delta

pore

Slides courtesy of Prof. Yan Tong

# Super-Resolution

Slides courtesy of Prof. Yan Tong
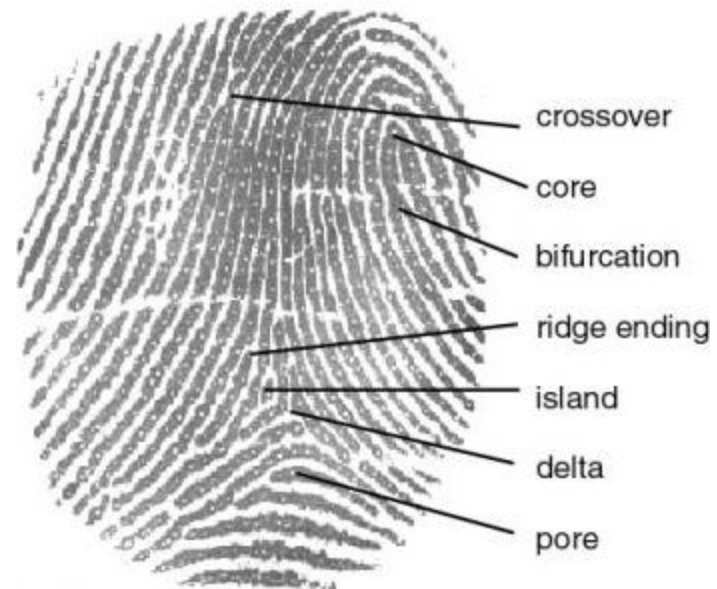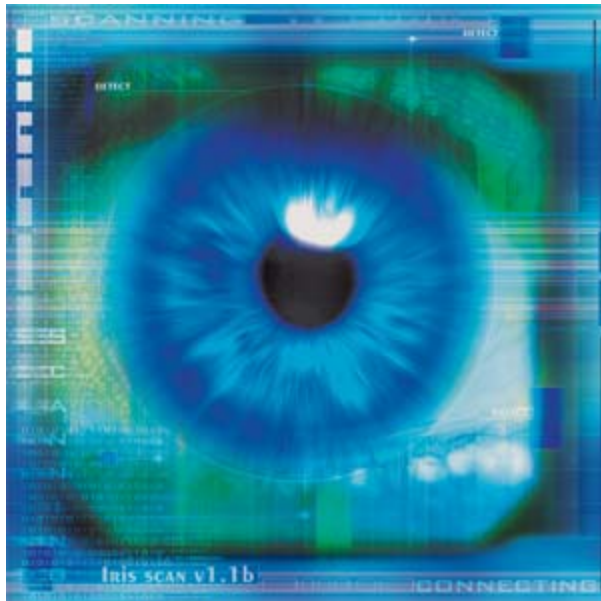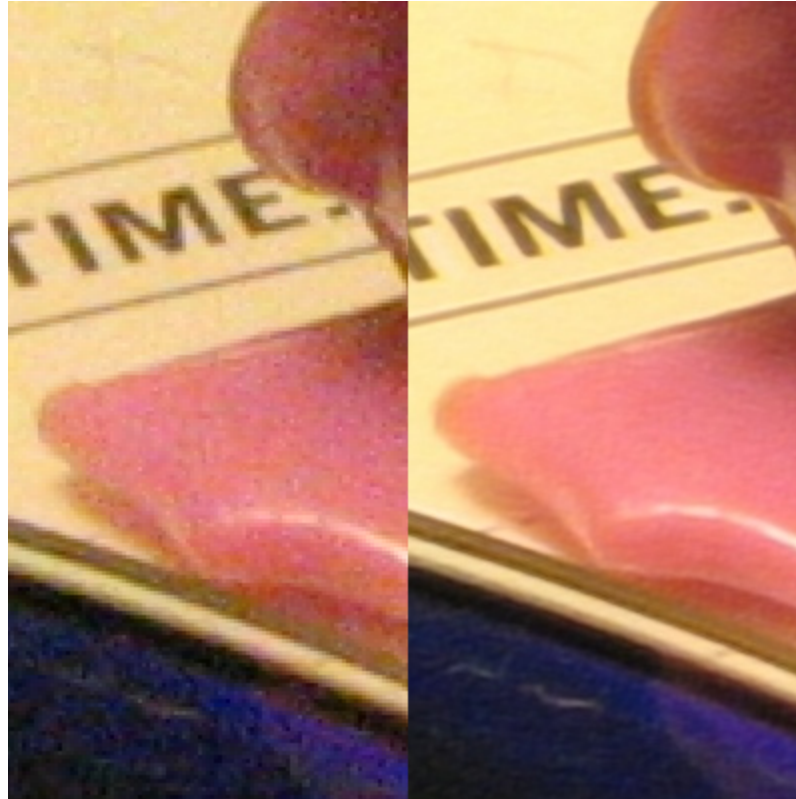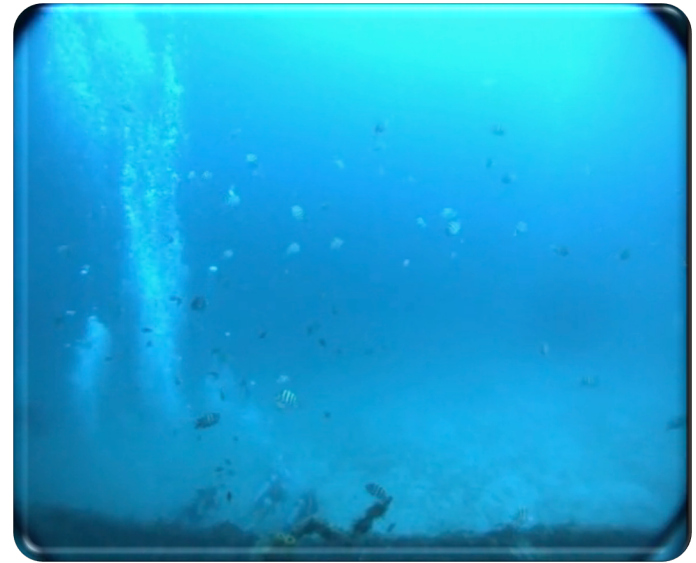
# Computer vision algorithms

- Image processing
- Geometric computer vision
- Semantic computer vision

- It is fundamental first to understand image formation

# Difficult scenarios

- In certain settings, such as the underwater, robotic vision is particularly challenging
  - Different lighting conditions
  - Color loss
  - Hazing and blur
  - Texture loss

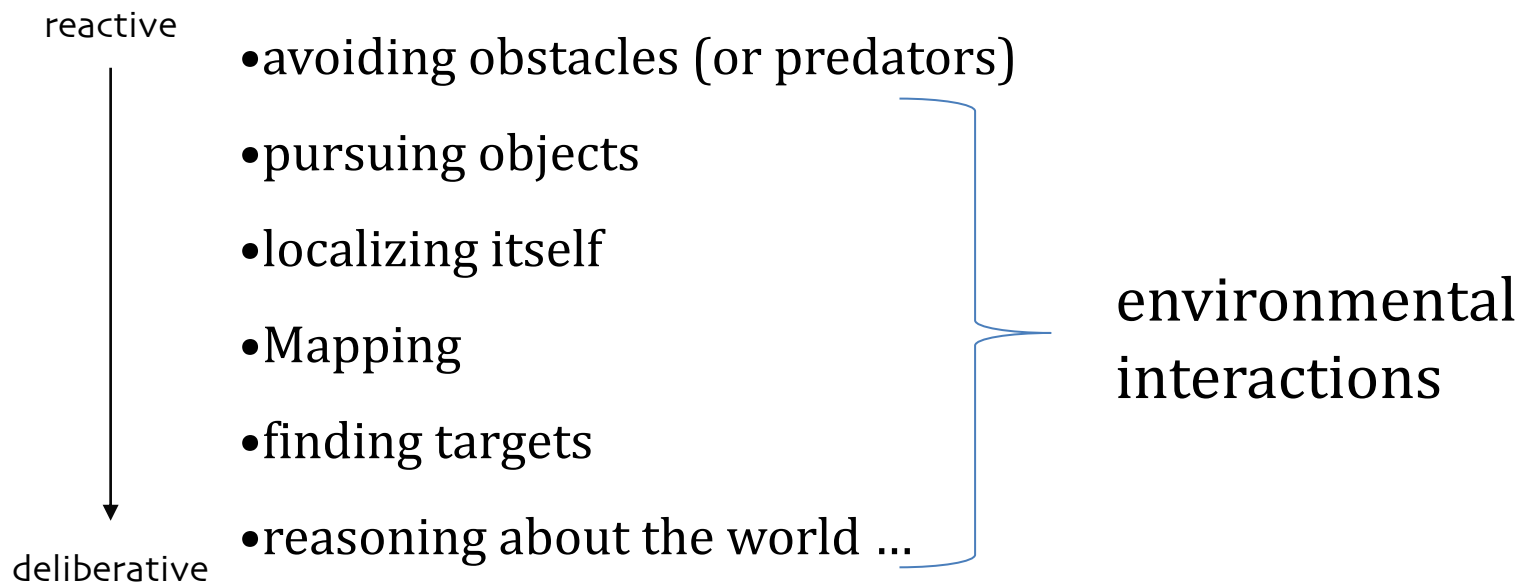# What does a robot need ?

*doesn't*  need a full interpretation of available images

"This is Prof. X in his office offering me a cup of iced tea."

*does*  need information about what to do...

"Run Away!!"

reactive

- avoiding obstacles (or predators)

- pursuing objects

- localizing itself

- Mapping

- finding targets

- reasoning about the world ...

deliberative

environmental interactions
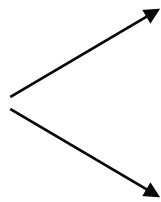
# Key problems

- Recognition:
  - What is that thing in the picture?
  - What are all the things in the image?
- Scene interpretation
  - Describe the image?
- Scene "reconstruction":
  - What is the 3-dimensional layout of the scene?
  - What are the physical parameters that gave rise to the image?
  - What is a description of the scene?

Notion of an "inverse problem."

# Robot vision sampler

A brief overview of robotic vision processing...

(1) Image streams

→ simplified via generality

→ simplified via specificity

(2) Stereo vision ⟶ (or beyond...)

(3) Incorporating vision within robot control
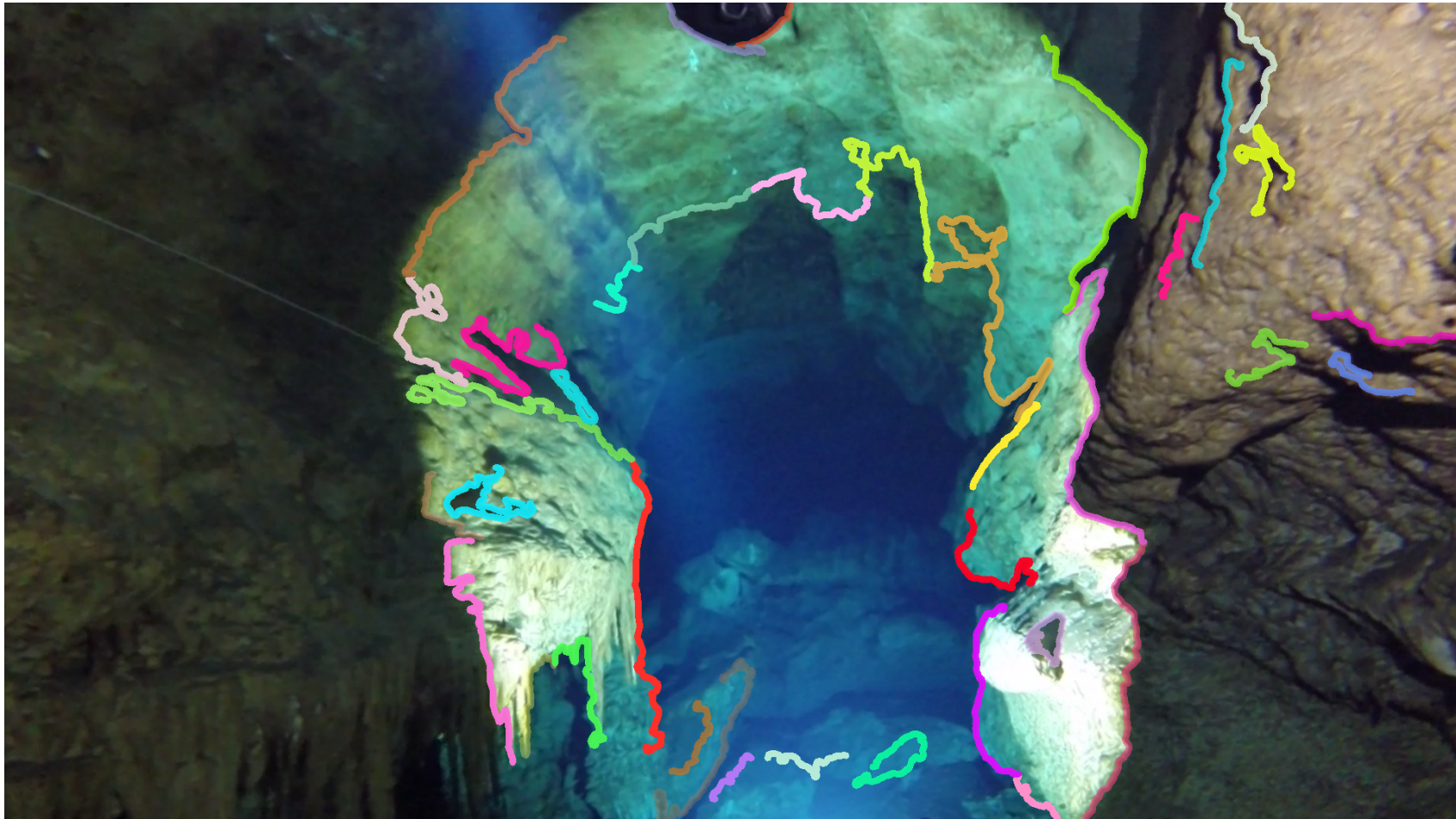
↓ 3d reconstruction

↓ Visual "servoing"

# Thresholded image

# Edge detection

# (VERY) Tentative Schedule

| | Tuesday | Thursday | | Tuesday | Thursday |
|---|---|---|---|---|---|
| Week 01 | Introduction | Image Generation Perspective Transformation | Week 09 | Advanced Topics: Motion | Advanced Topics: Shape from X |
| Week 02 | Color Spaces | Image Formats, Compression | Week 10 | Features (Detection) | Features (Matching) |
| Week 03 | Statistics, Histogram, Thresholding | Single Image Operations | Week 11 | | |
| Week 04 | Logical, Arithmetic Operations | Correlation | Week 12 | | |
| Week 05 | Segmentation | Neurons and Convolutions | Week 13 | | |
| Week 06 | CNNs | CNNs | Week 14 | | |
| Week 07 | CNNs | **WELLNESS HOLIDAY** | Week 15 | | |
| Week 08 | Advanced Topics: Stereo | Advanced Topics: Flow | Week 16 | | |

# Textbook

Digital Image Processing

By R. C. Gonzalez and R. E. Woods

3rd edition
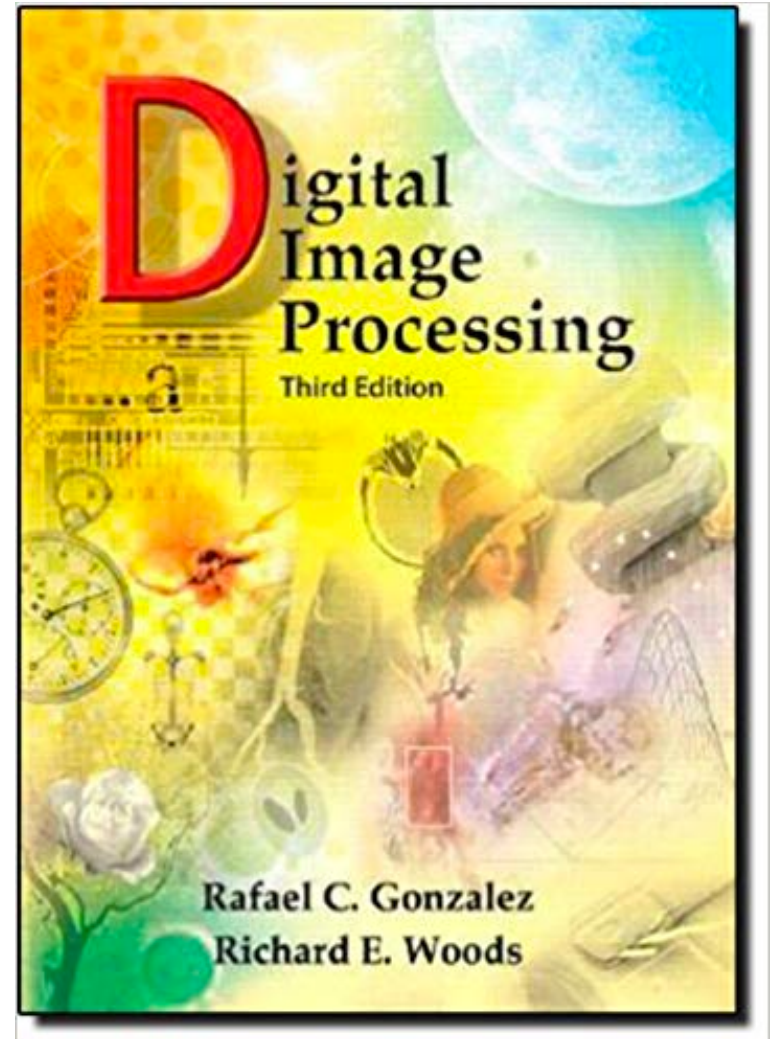
# Evaluation

**Schedule, deliverables, and evaluation**:

| Component | Undergraduate | Graduate |
|---|---|---|
| Assignments (4) | 12.5% | 12.5% |
| Graduate Assignments (4) | --- | 2.5% |
| Midterm Exam (Take home) | 20% | 15% |
| Final Exam (Take home) | 30% | 25% |
| **Total** | **100%** | **100%** |

Midterm and final exam will be programming assignments as take-home exams

# Homeworks

- Using OpenCV
  - C++
  - Python
- Using MATLAB

# Contact

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- **Office hours**: by appointment