香港中文大學(深圳)
The Chinese University of Hong Kong, Shenzhen

EIE4512
Digital Image Processing

Zhen Li

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School of Science and Engineering,

The Chinese University of Hong Kong, Shen Zhen

Basic Information

- Time & Venue
  - Tuesday: 10:30 am – 12:00 pm, TA207
  - Thursday: 10:30 am – 12:00 pm, TA 207

- Staff
  - Instructor: Zhen Li (lizhen@cuhk.edu.cn)
  - Tutors: Qin Wang (wangqin4377@qq.com)
    Bin Zeng (zeng_bin8888@163.com)

- One tutorial per week:
  Thursday: 8:00pm – 9:00pm, TA 207

Slides

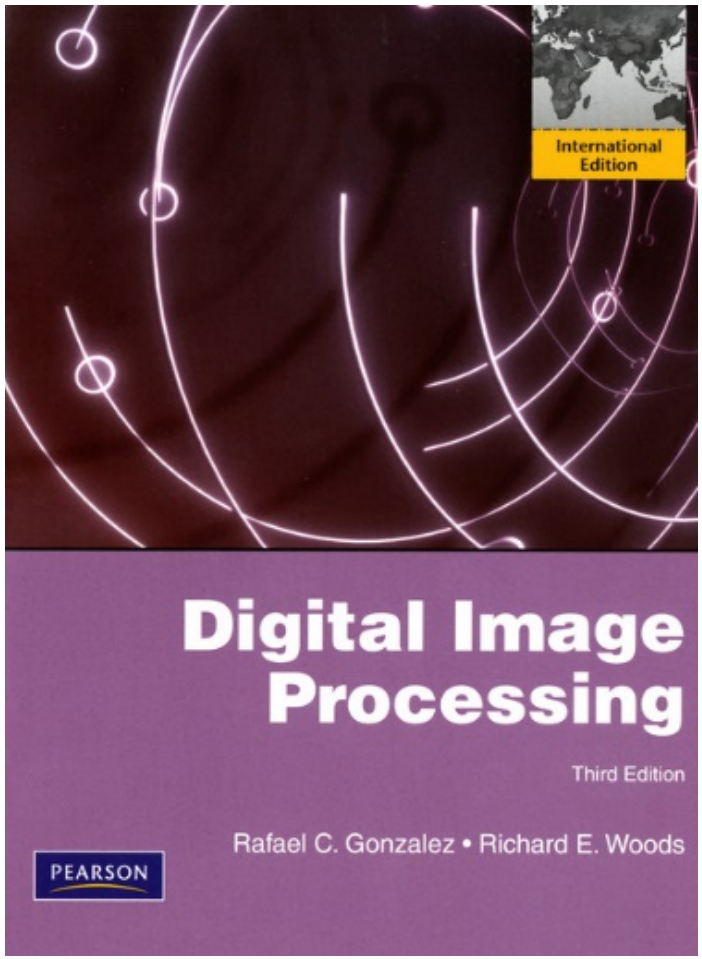
- Online address:
  - *https://github.com/icemansina/CUHKSZ_DIP*

- We use this repository for:
  - Make announcements
  - Release lecture slides
  - Release homework assignments
  - Discussions: wechat group

DIP course

该二维码7天内(1月14日前)有效，重新进入将更新

Reference Textbook



Digital Image Processing

By *Rafael C. Gonzalez & Richard E. Woods*

Grading

- Three assignments: 10% x 3
- Mid-term exam: 30%
- Final project: 40%
  - Topics
    - Applications of digital image processing
    - Implementation of digital image processing
    - Study digital image processing algorithms
  - You (at most two students as a group) should submit
    - One page proposal which briefly introduces the topic, idea, method, experiments.
    - A term paper of 4 pages (excluding figures) in maximum, double column, font size is equal or no larger than 10.
    - Code and sample data
    - Project presentation (5mins – 10mins)

What is this course about?

Face Beautification

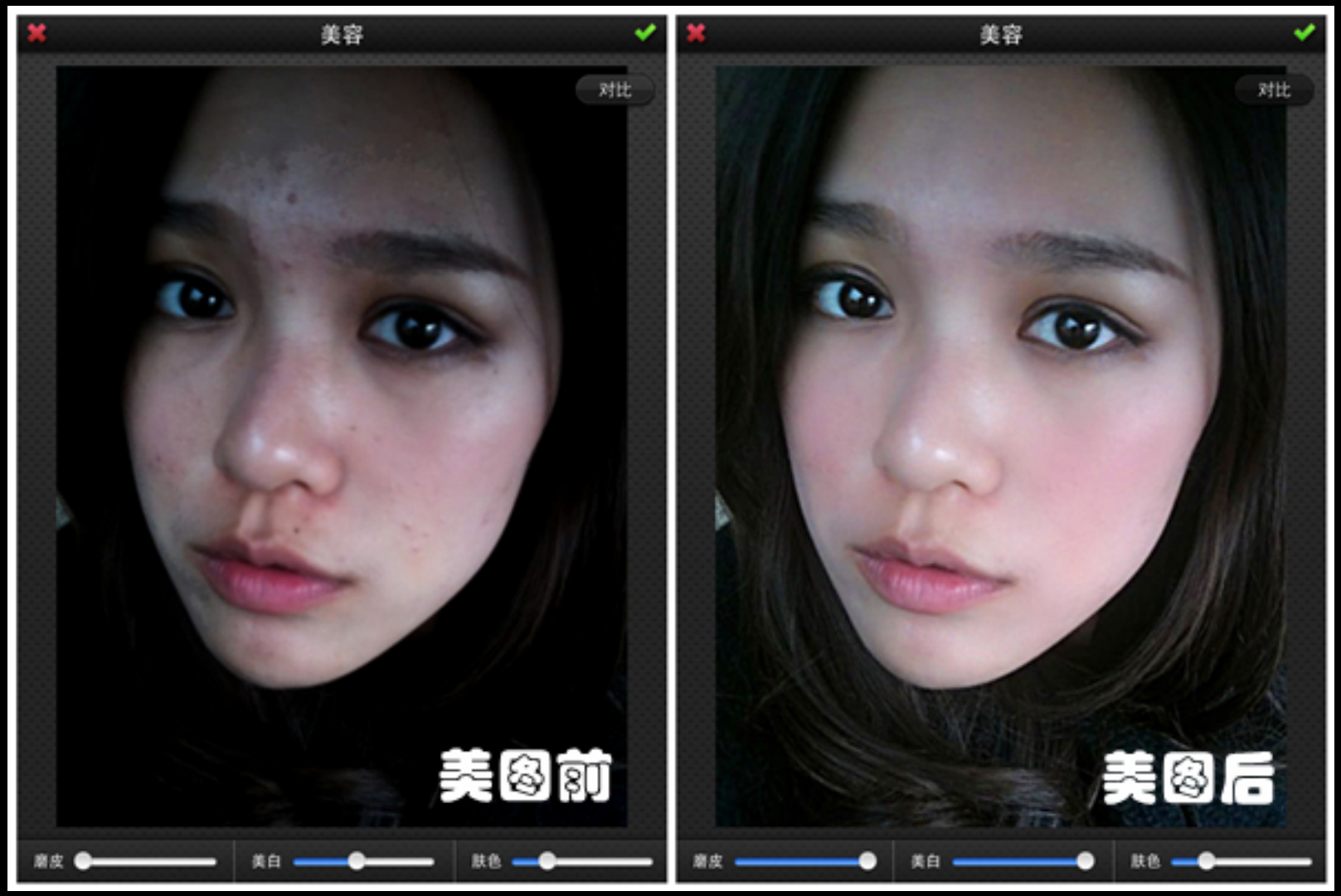


Image Filtering

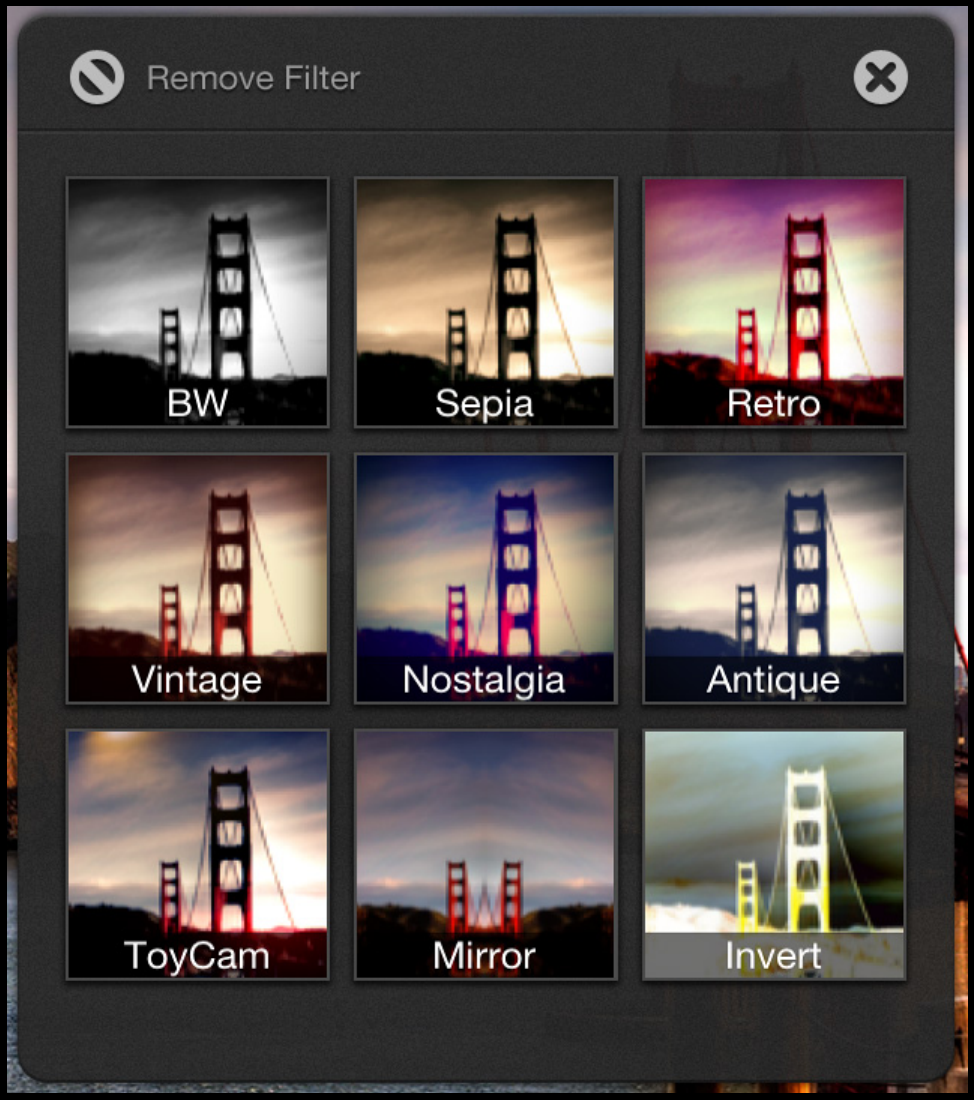
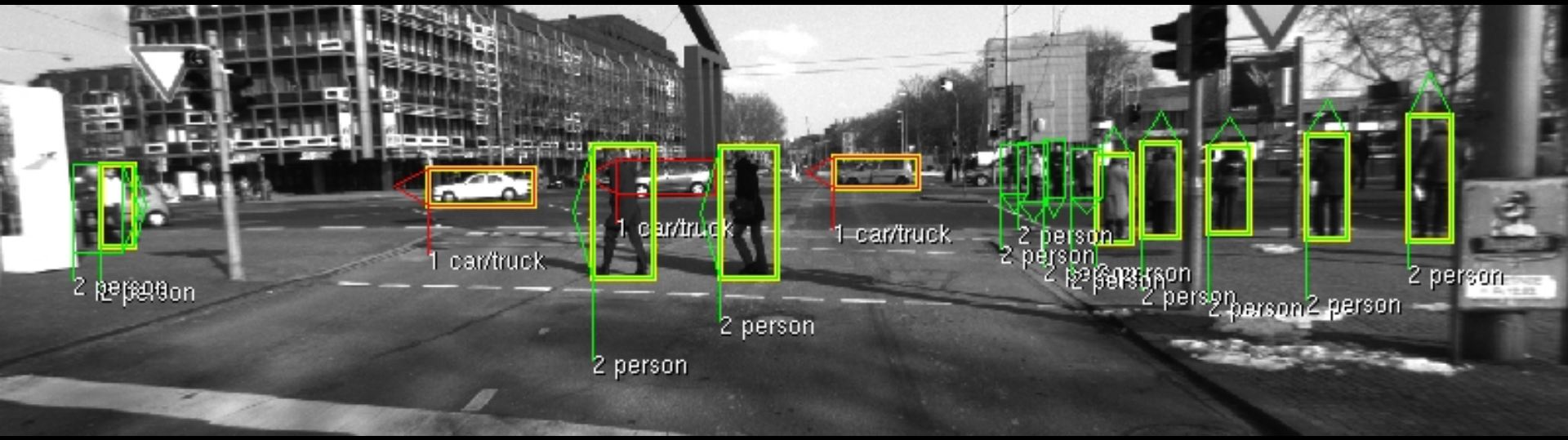


Image Superresolution

Face Recognition

Object Recognition

Pedestrian Detection



Scene Parsing

Topics

Image Representations

- Image Sensing and Acquisition
- Sampling and Quantization
- Basic Relationships between Pixels

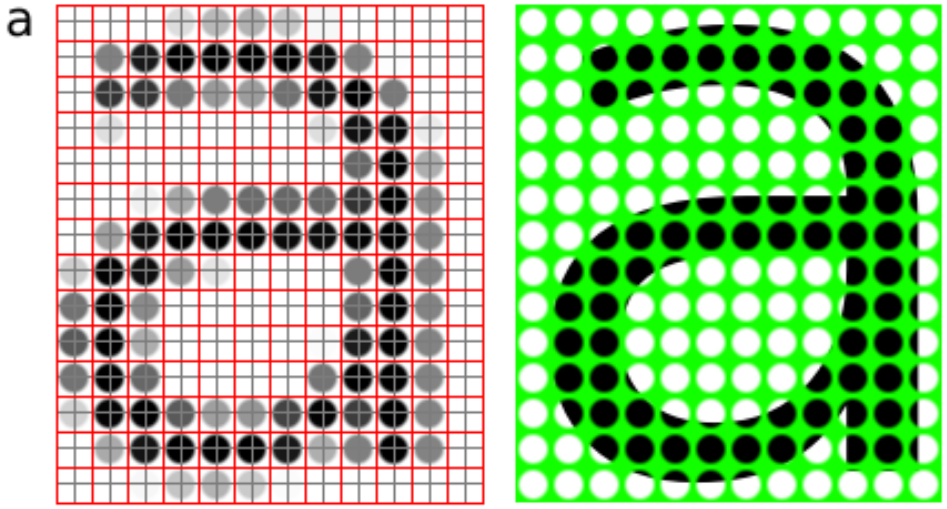
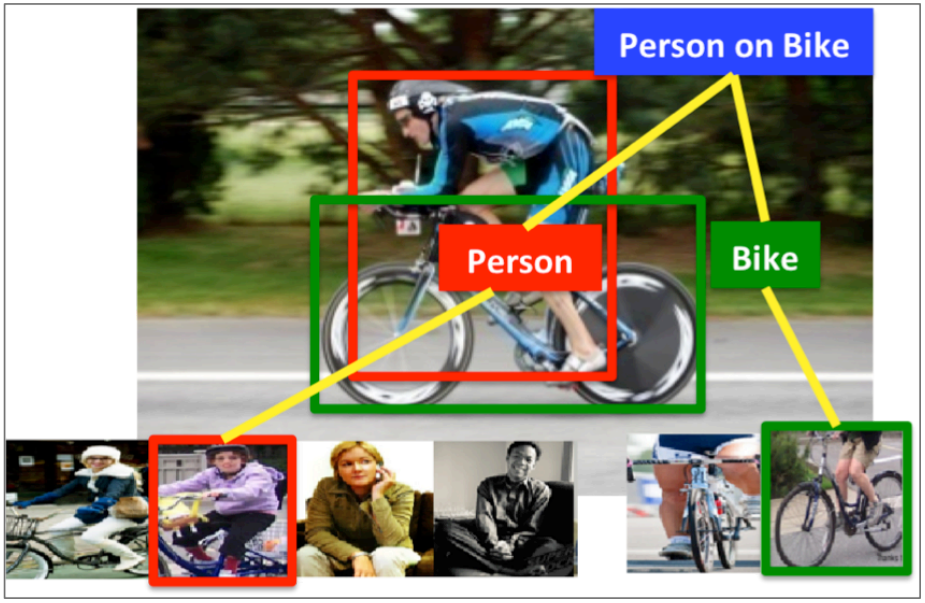


Image Processing

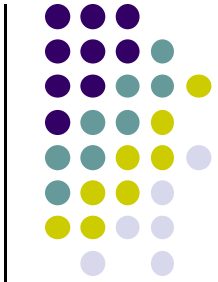
- Gray-level processing
- Image filtering
- Image restoration
- Morphological processing

Visual Understanding

- Features
- Image recognition
- Object detection
- Image segmentation



What is an Image?

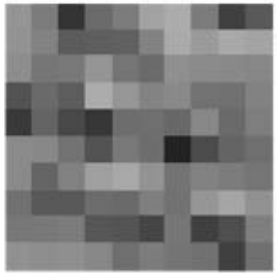


- 2-dimensional matrix of Intensity (gray or color) values

Set of Intensity values

Image coordinates are integers

$$I(u,v) \in \mathbb{P} \quad \text{and} \quad u,v \in \mathbb{N}.$$



$F(x,y)$

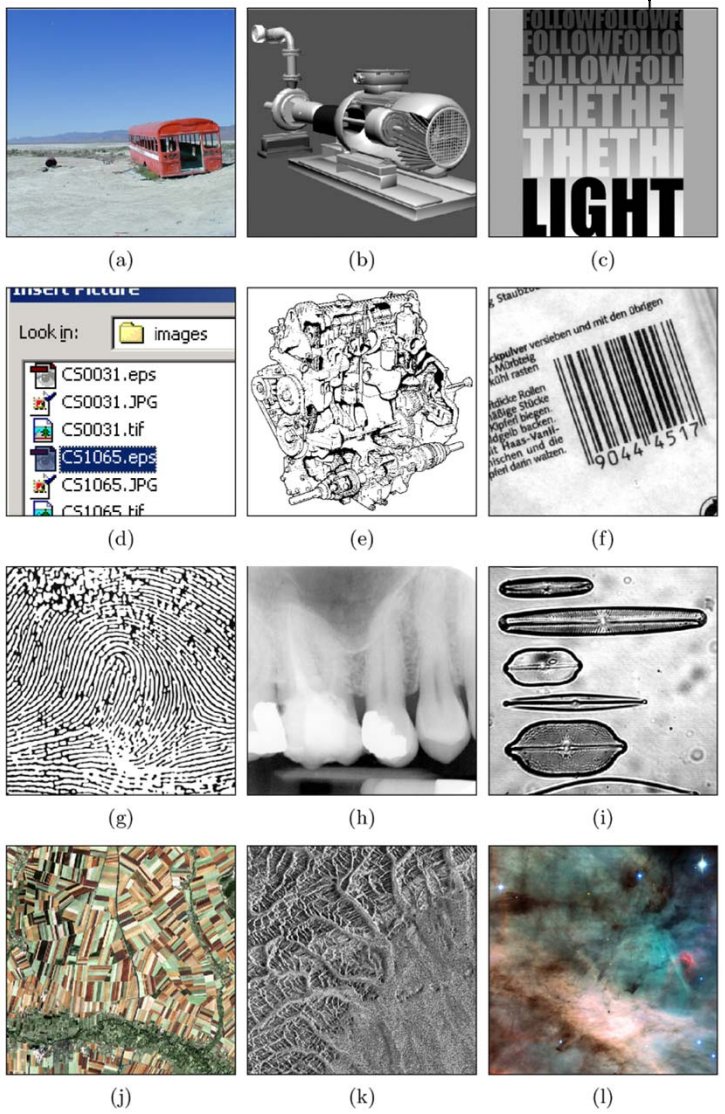
$\rightarrow$

148	123	52	107	123	162	172	123	64	89 ···
147	130	92	95	98	130	171	155	169	163 ···
141	118	121	148	117	107	144	137	136	134 ···
82	106	93	172	149	131	138	114	113	129 ···
57	101	72	54	109	111	104	135	106	125 ···
138	135	114	82	121	110	34	76	101	111 ···
138	102	128	159	168	147	116	129	124	117 ···
113	89	89	109	106	126	114	150	164	145 ···
120	121	123	87	85	70	119	64	79	127 ···
145	141	143	134	111	124	117	113	64	112 ···
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮

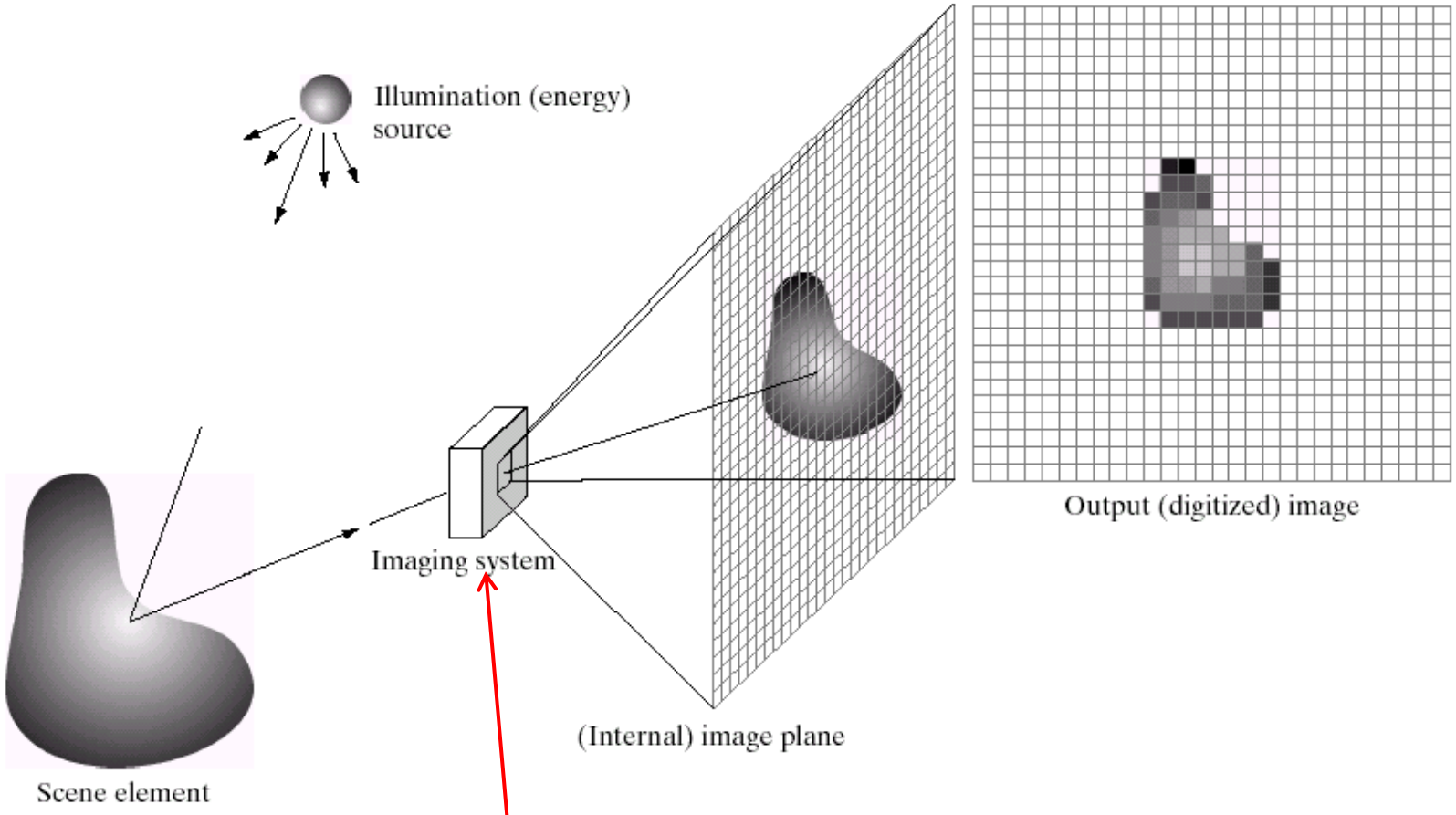
$I(u,v)$

Example of Digital Images

a) Natural landscape
b) Synthetically generated scene
c) Poster graphic
d) Computer screenshot
e) Black and white illustration
f) Barcode
g) Fingerprint
h) X-ray
i) Microscope slide
j) Satellite Image
k) Radar image
l) Astronomical object



Imaging System

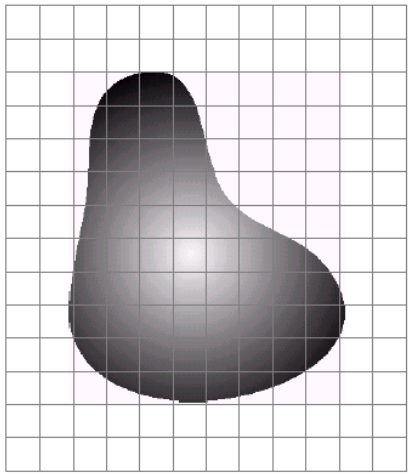


Example: a camera
Converts light to image

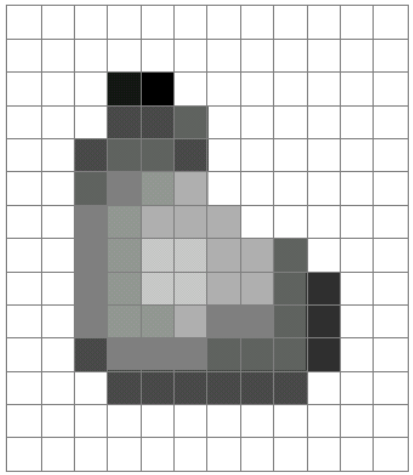
Credits: Gonzales and Woods

Digital Image?

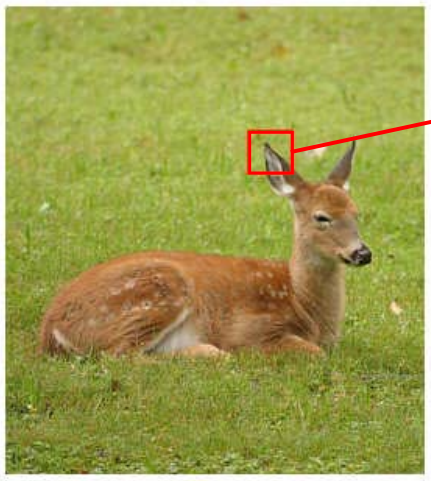
- **Remember:** *digitization* causes a digital image to become an *approximation* of a real scene



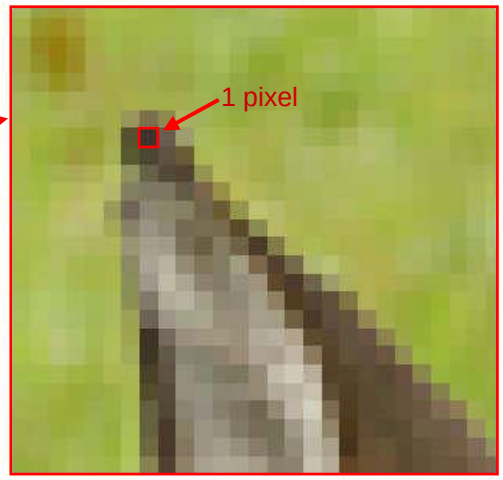
Real image



Digital Image
(an approximation)

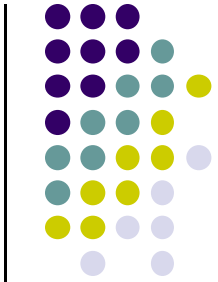


Real image



Digital Image
(an approximation)

Digital Image



- Common image formats include:
  - 1 values per point/pixel (B&W or Grayscale)
  - 3 values per point/pixel (Red, Green, and Blue)
  - 4 values per point/pixel (Red, Green, Blue, + “Alpha” or Opacity)

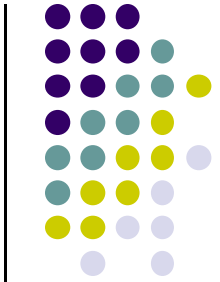
Grayscale

RGB

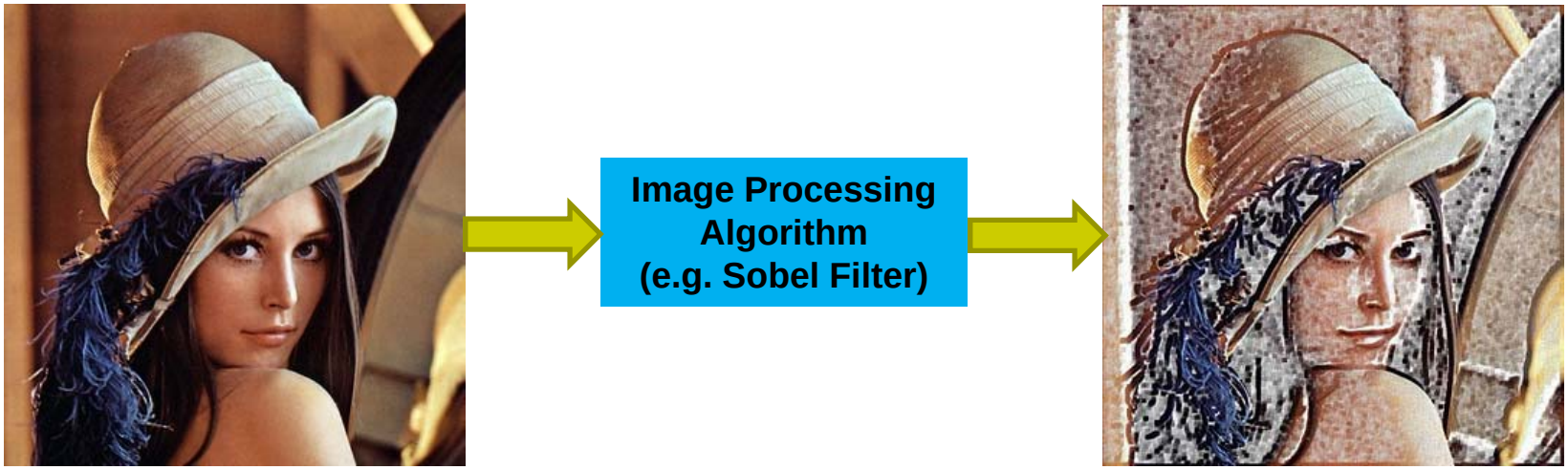
RGBA

- We will start with gray-scale images, extend to color later

What is image Processing?



- **Algorithms that alter an input image to create new image**
- **Input is image, output is image**



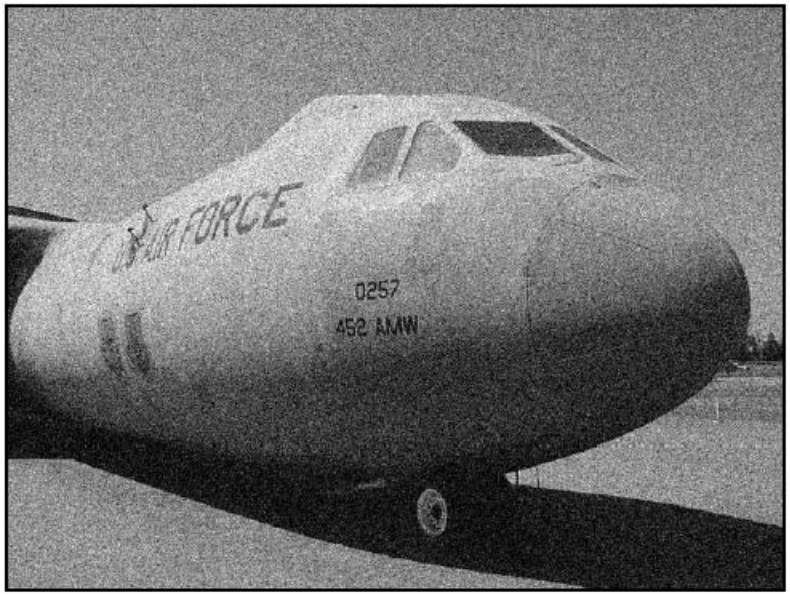
Original Image *Processed Image*

- **Improves an image for human interpretation in ways including:**
  - Image display and printing
  - Image editting
  - Image enhancement
  - Image compression

Example Operation: Noise Removal

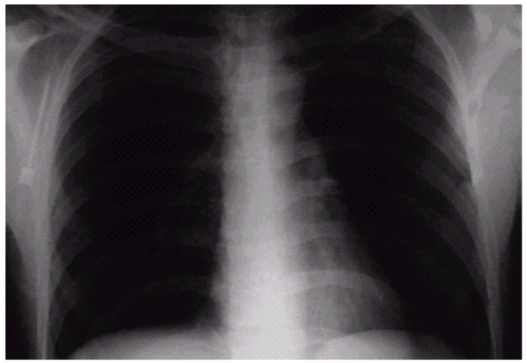
Noisy Image

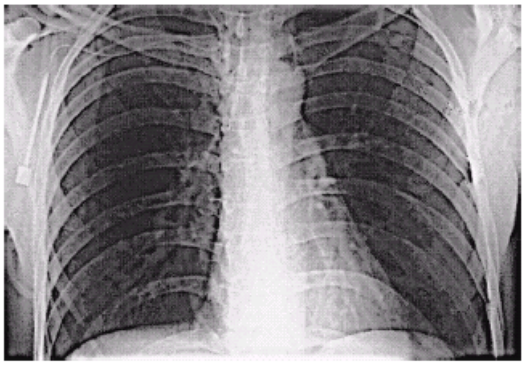
Denoised Image

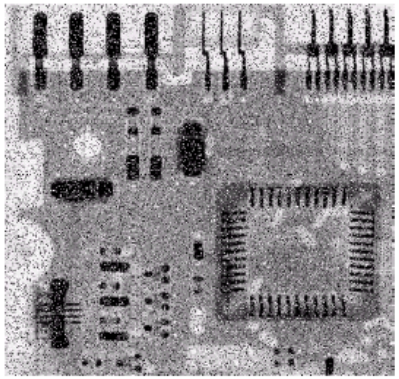


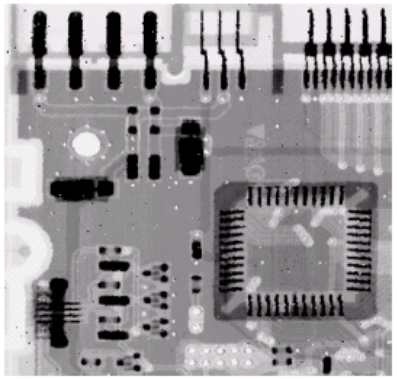
Think of noise as white specks on a picture (random or non-random)

Examples: Noise Removal









Images taken from Gonzalez & Woods, Digital Image Processing (2002)

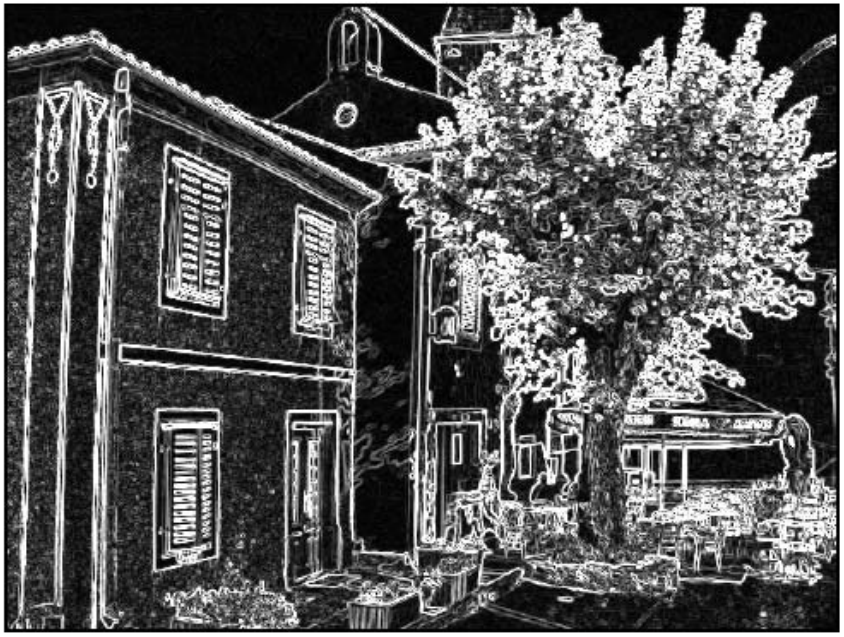
Example: Contrast Adjustment

Low Contrast

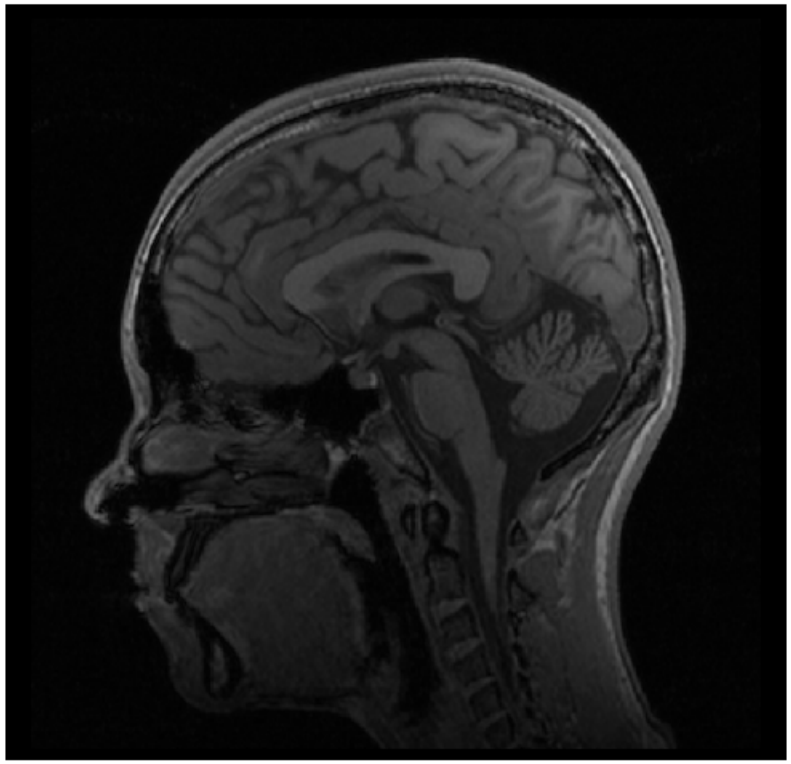
Original Contrast

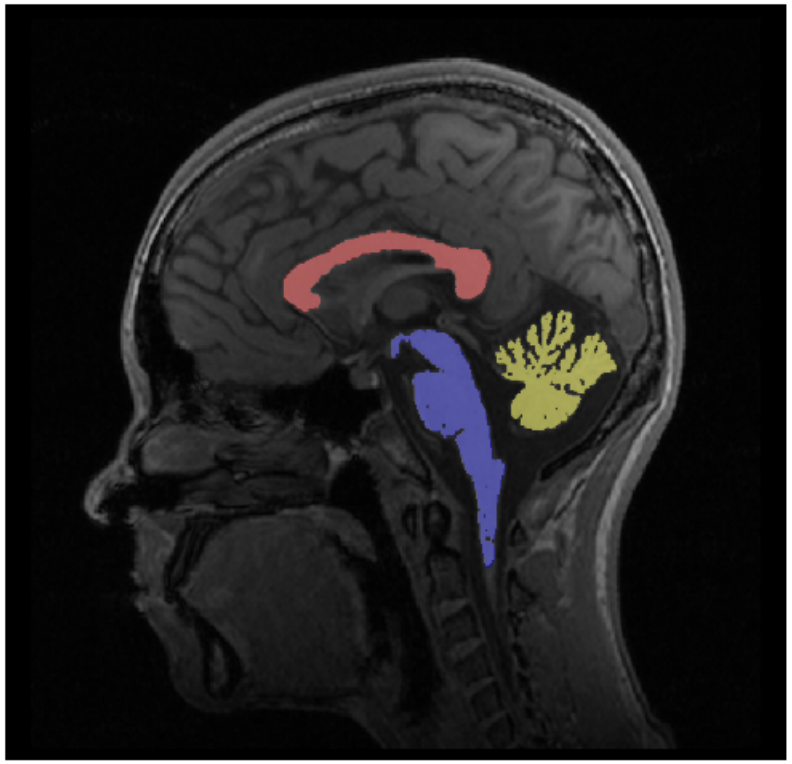
High Contrast

Example: Edge Detection



Example: Region Detection, Segmentation



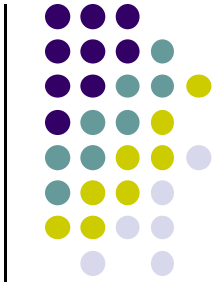


Example: Image Compression

Original, 2.1MB

JPEG Compression, 308KB (15%)

Example: Image Inpainting



Damaged Image

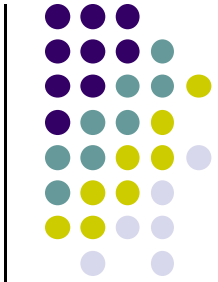
Restored Image

Credit: M. Bertalmio, G. Sapiro, V. Caselles, C. Ballester: Image Inpainting, SIGGRAPH 2000

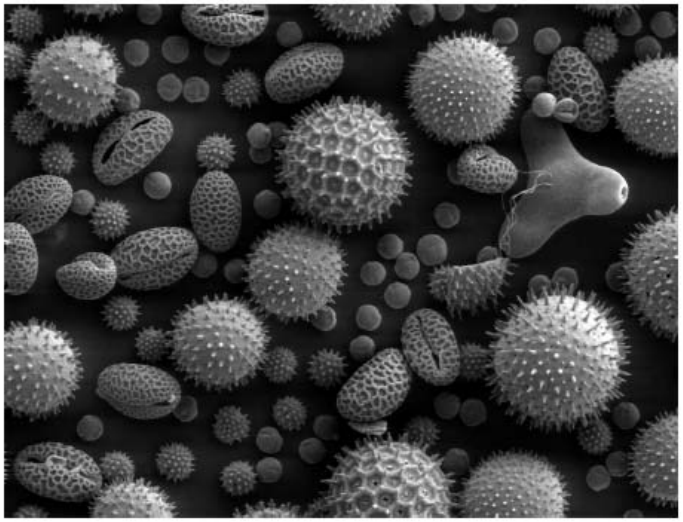
Inpainting? Reconstruct corrupted/destroyed parts of an image

Examples: Artistic (Movie Special)Effects

Applications of Image Processing

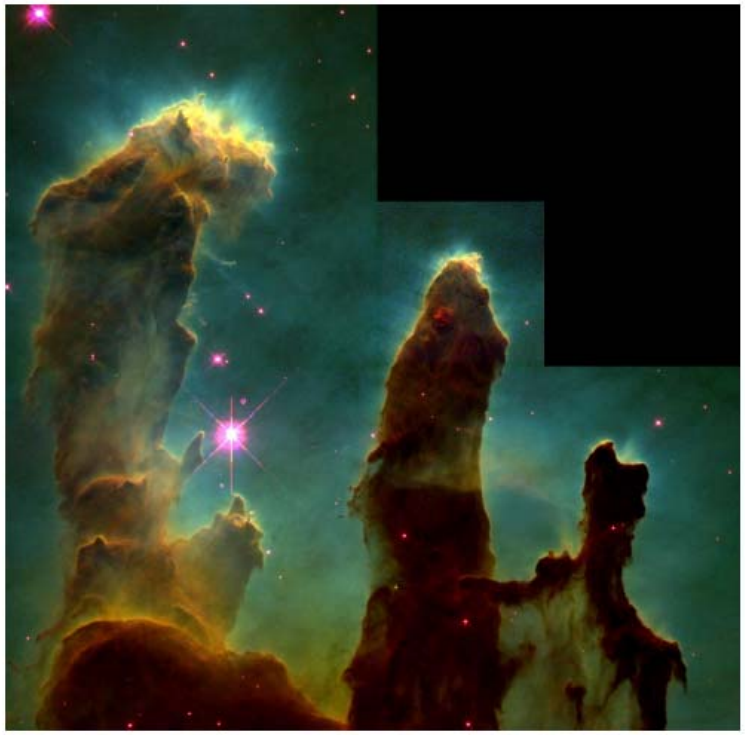


Biology



Credit: Dartmouth Electron Microscopy Facility

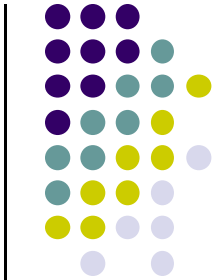
Astronomy



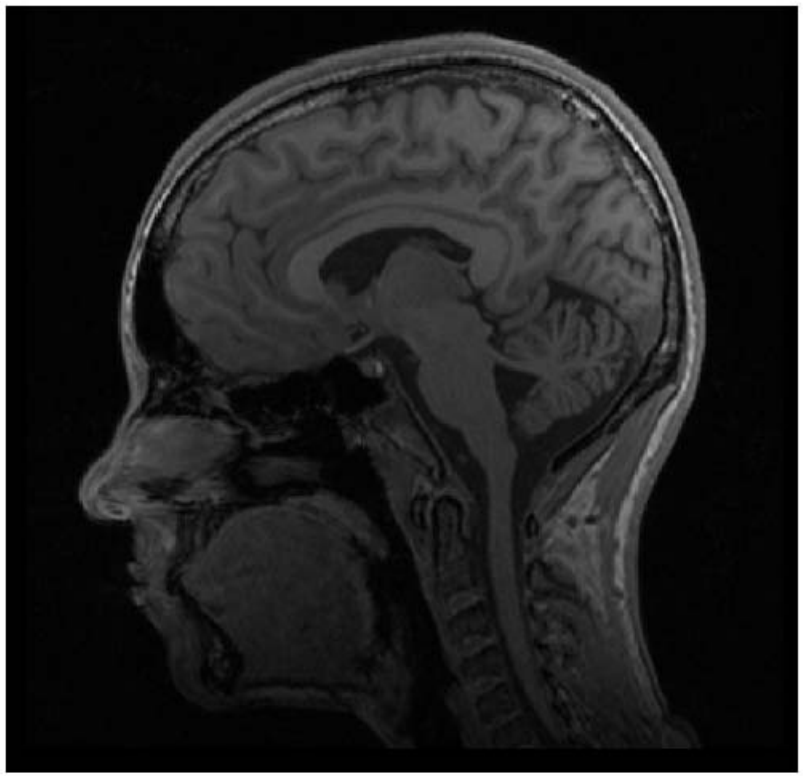
Credit: NASA, Jeff Hester, and Paul Scowen (Arizona State)

More info here

Applications of Image Processing



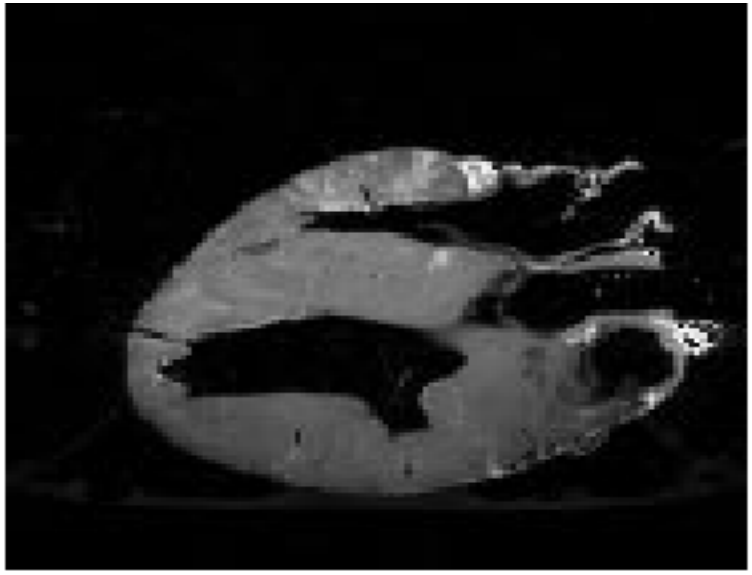
Medicine



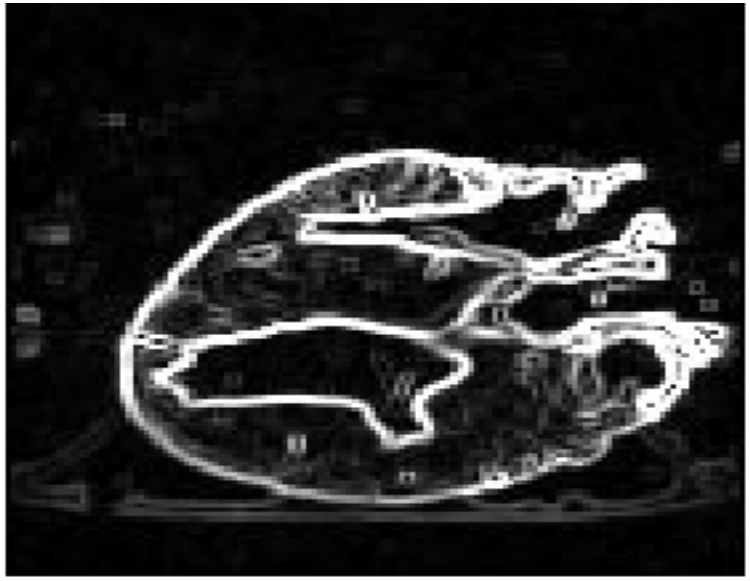
Credit: Dr. Janet Lainhart, UofU Psychiatry

Security, Biometrics

Applications of Image Processing: Medicine



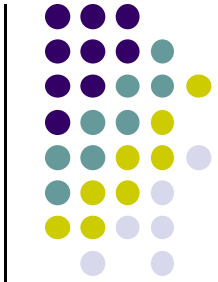
Original MRI Image of a Dog Heart



Edge Detection Image

Images taken from Gonzalez & Woods, Digital Image Processing (2002)

Applications of Image Processing



Satellite Imagery

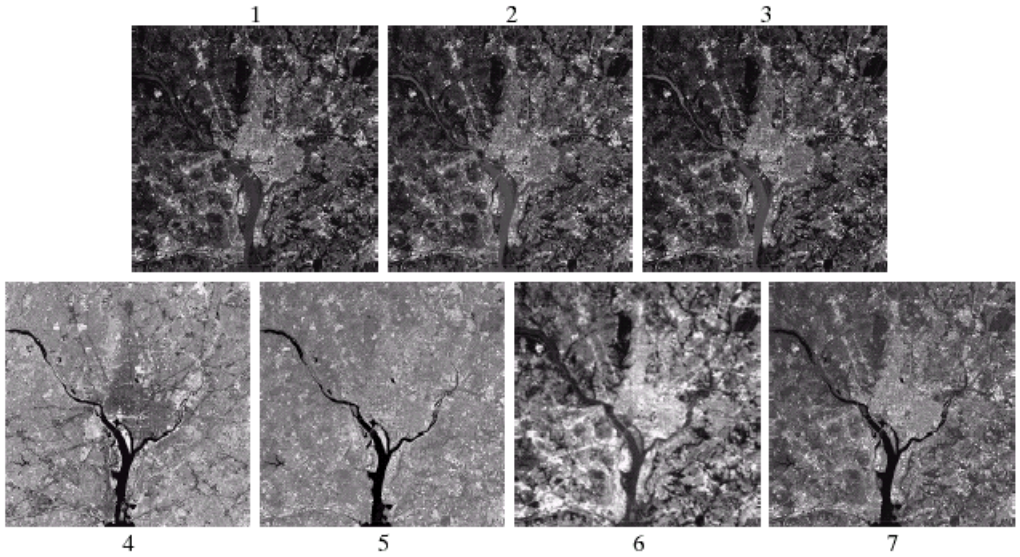
Credit: NASA

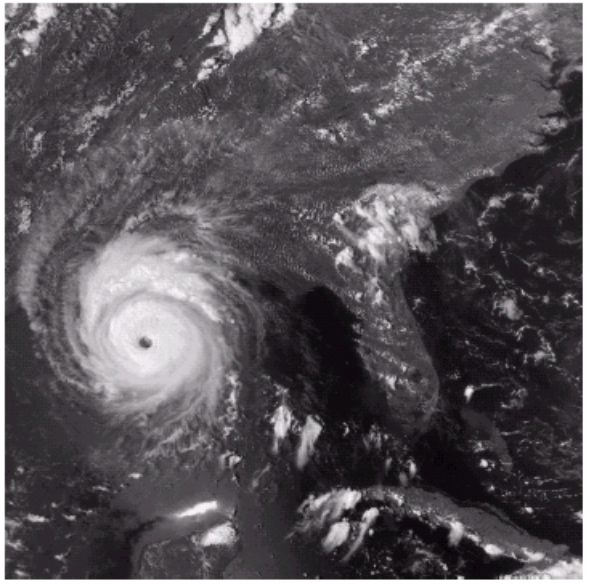
Personal Photos

Credit: Tom Fletcher

Applications of Image Processing: Geographic Information Systems (GIS)

- Terrain classification
- Meteorology (weather)

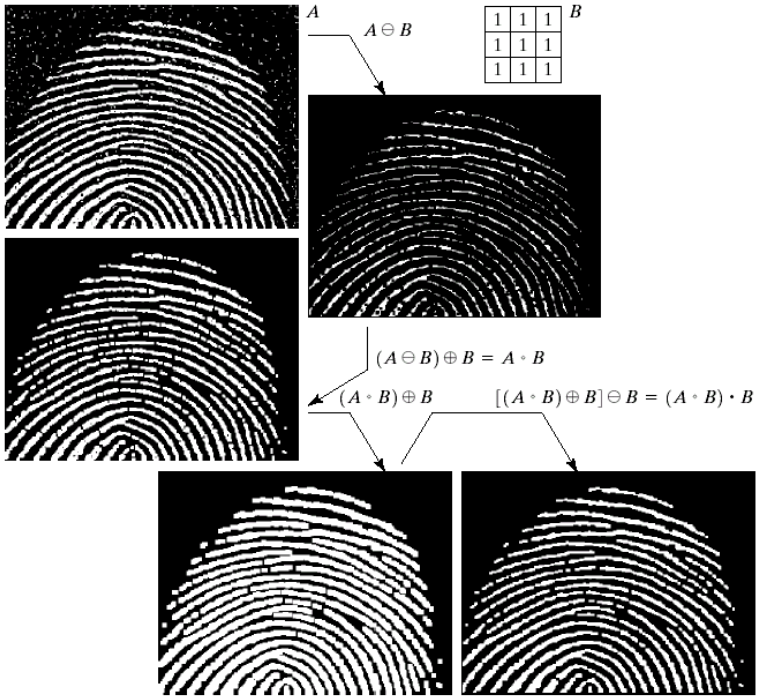




Images taken from Gonzalez & Woods, Digital Image Processing (2002)

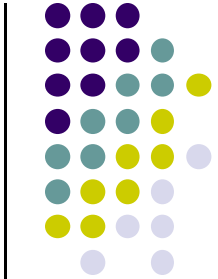
Applications of Image Processing: Law Enforcement

- Number plate recognition for speed cameras or automated toll systems
- Fingerprint recognition

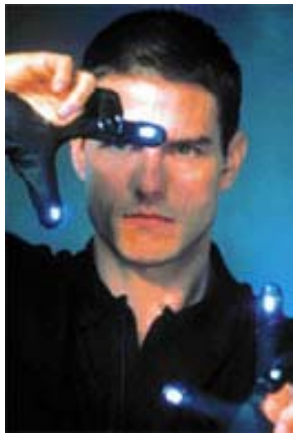


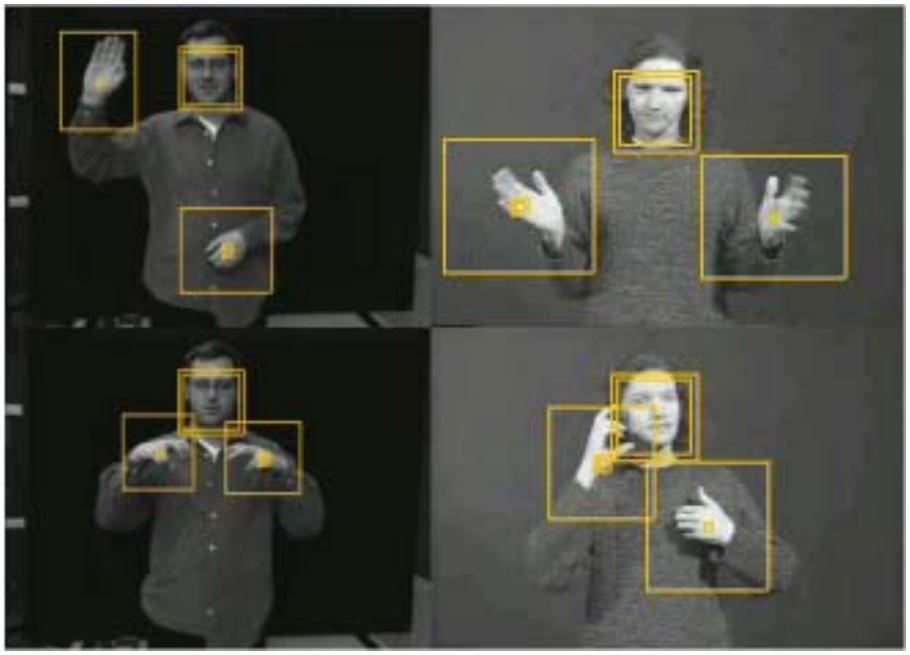
Images taken from Gonzalez & Woods, Digital Image Processing (2002)

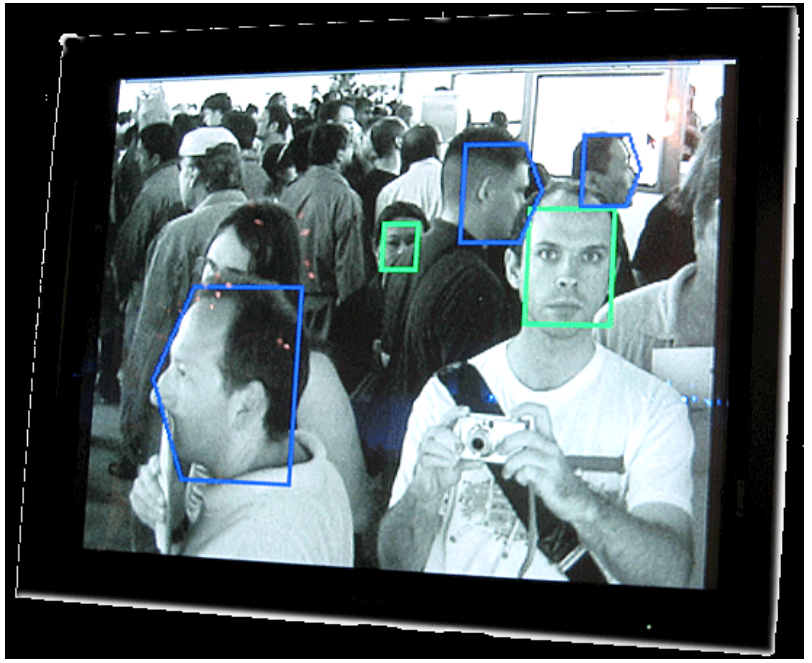
Applications of Image Processing: HCI



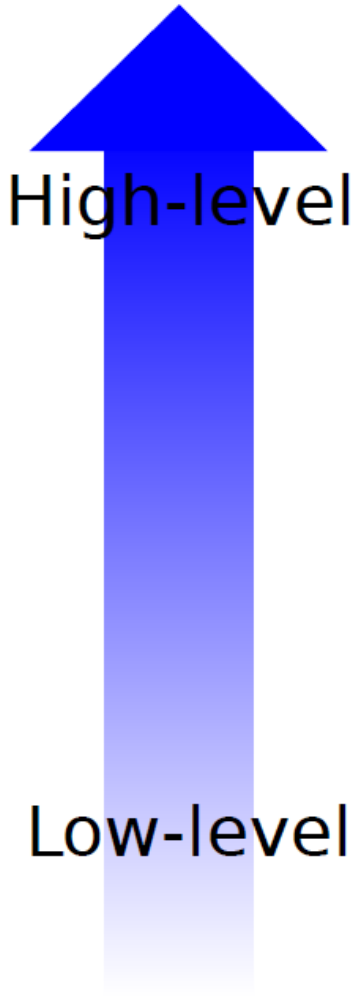
- Face recognition
- Gesture recognition







Relationship with other Fields



Computer Vision

Object detection, recognition, shape analysis, tracking
Use of Artificial Intelligence and Machine Learning

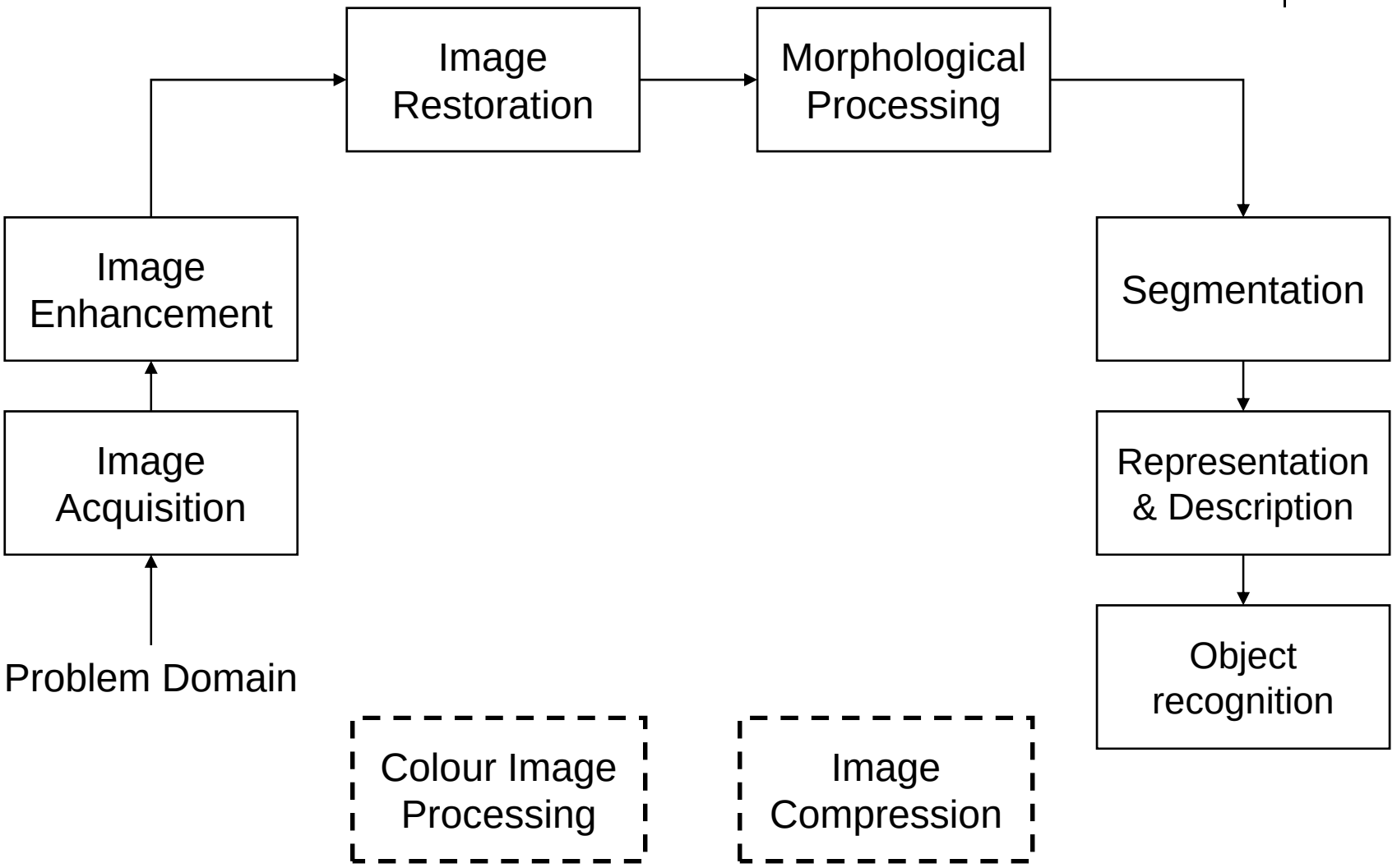
Image Analysis

Segmentation, image registration, matching

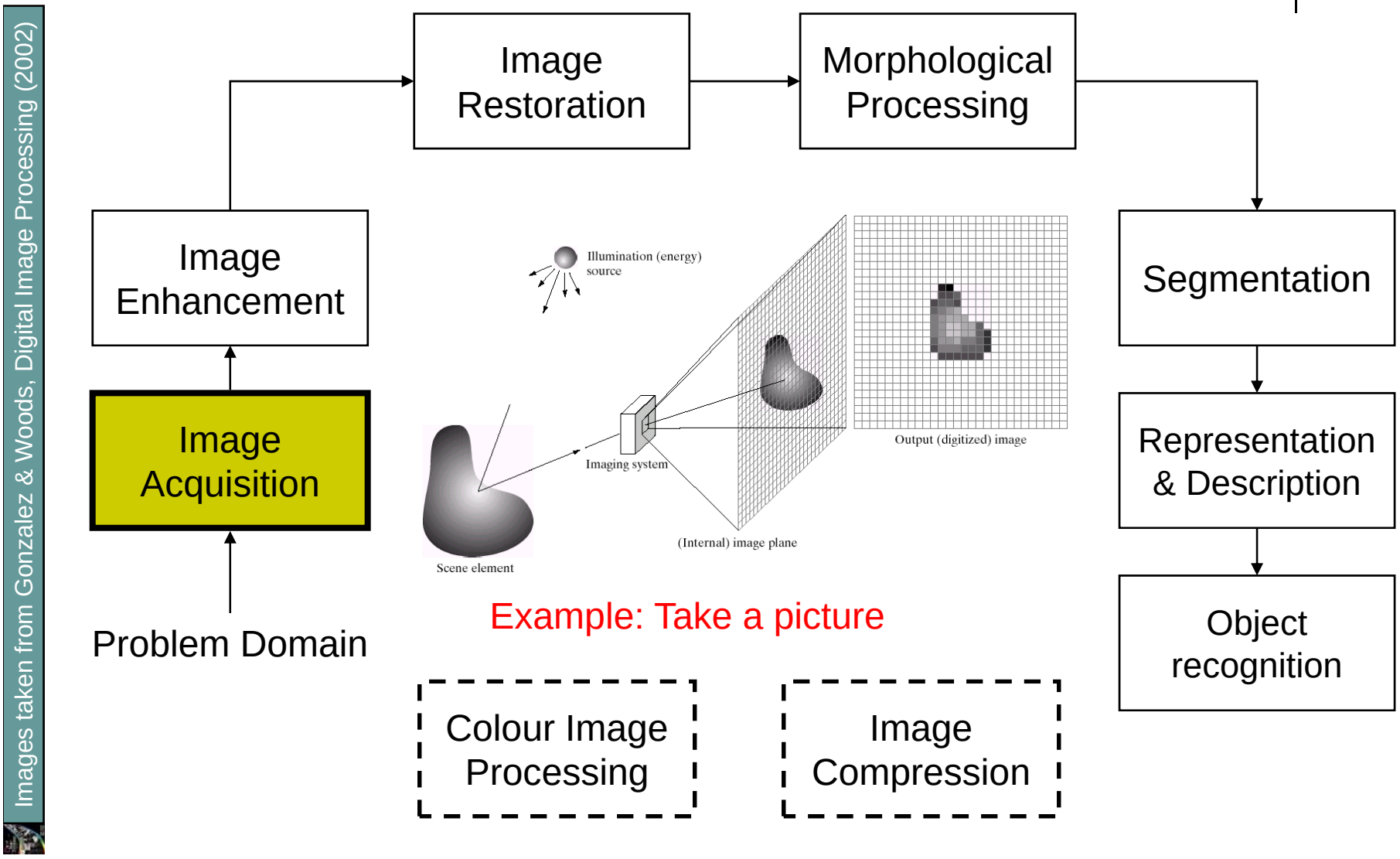
Image Processing

Image enhancement, noise removal, restoration,
feature detection, compression

Key Stages in Digital Image Processing

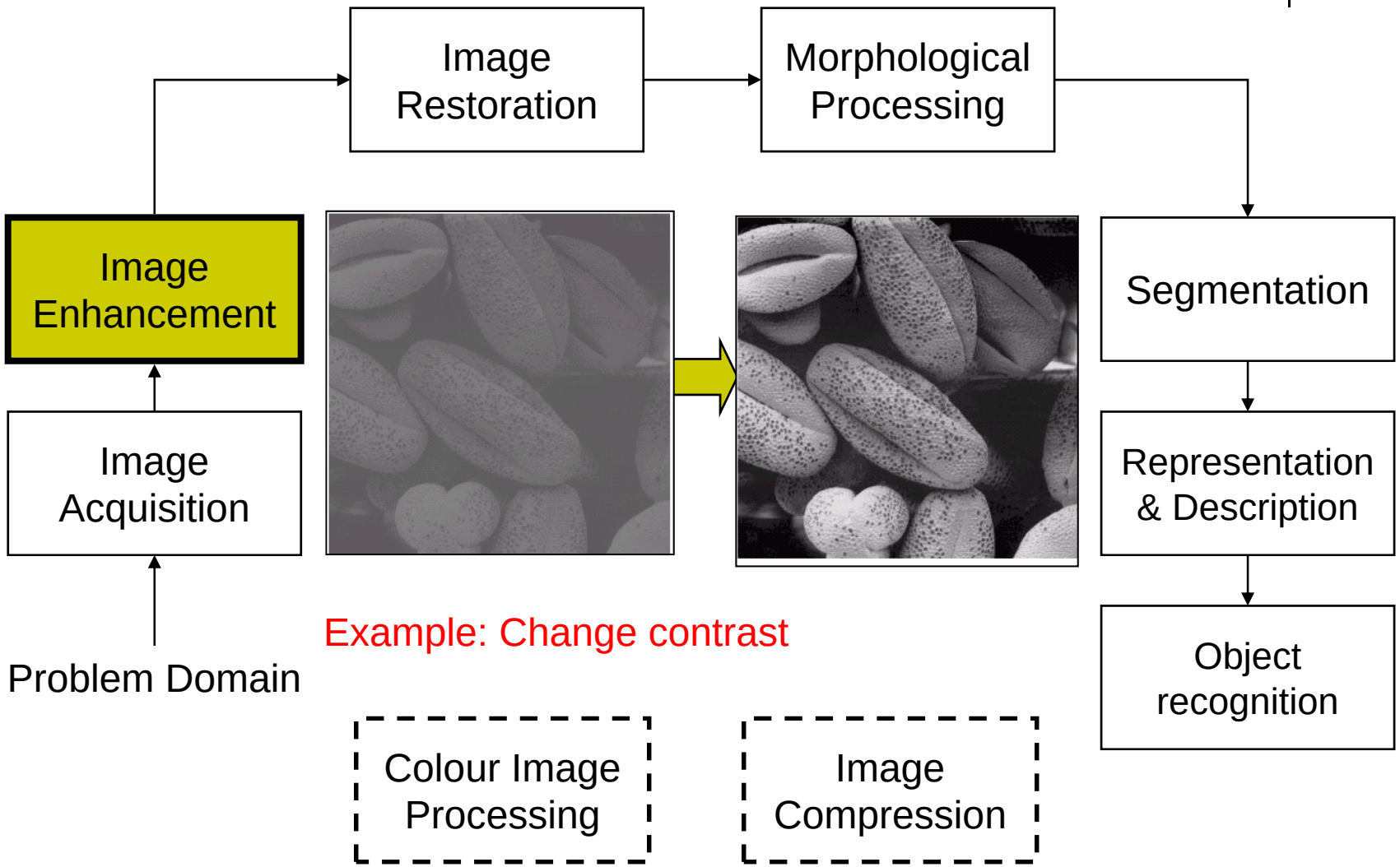


Key Stages in Digital Image Processing: Image Aquisition

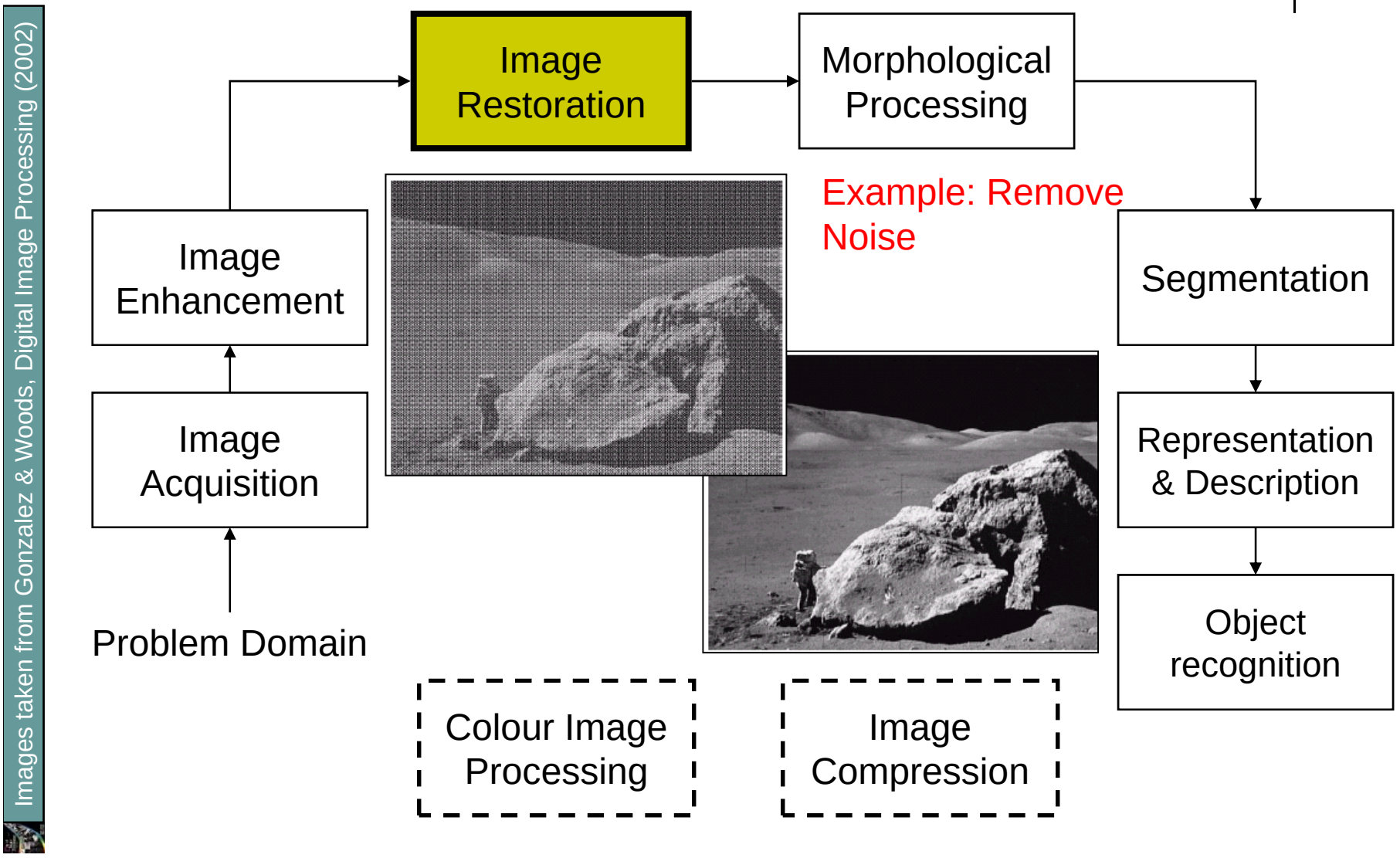


Images taken from Gonzalez & Woods, Digital Image Processing (2002)

Key Stages in Digital Image Processing: Image Enhancement

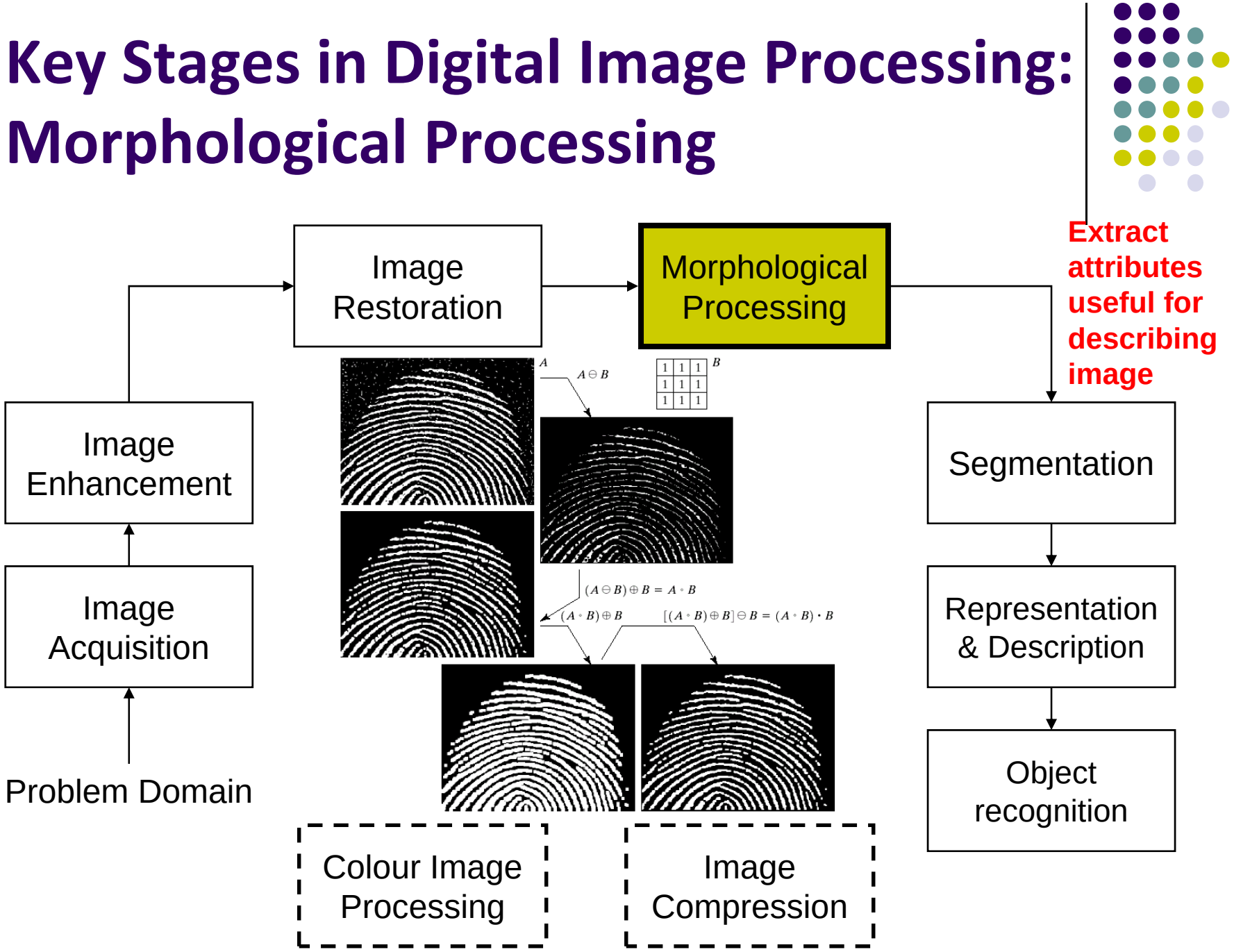


Key Stages in Digital Image Processing: Image Restoration



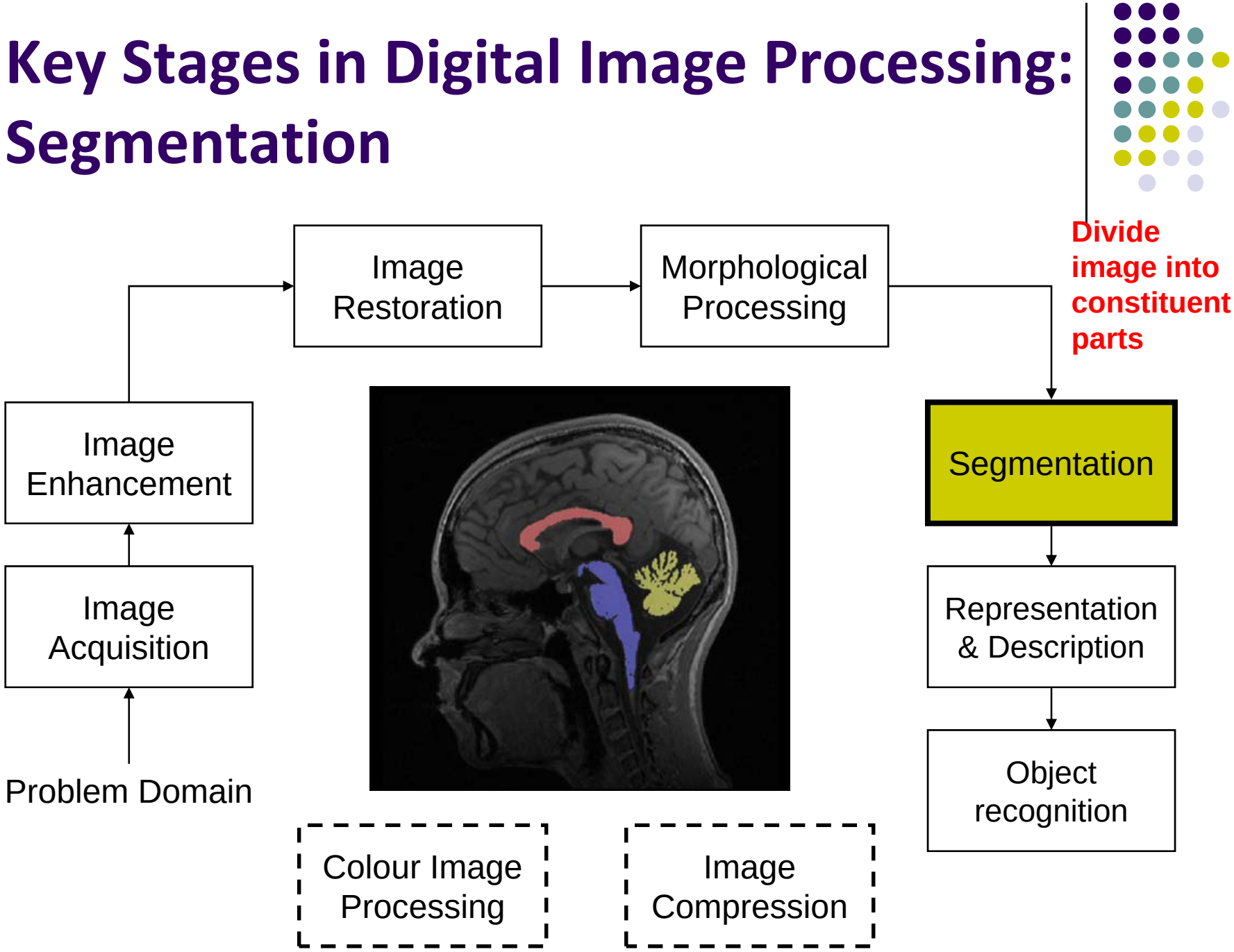
Images taken from Gonzalez & Woods, Digital Image Processing (2002)

Key Stages in Digital Image Processing: Morphological Processing



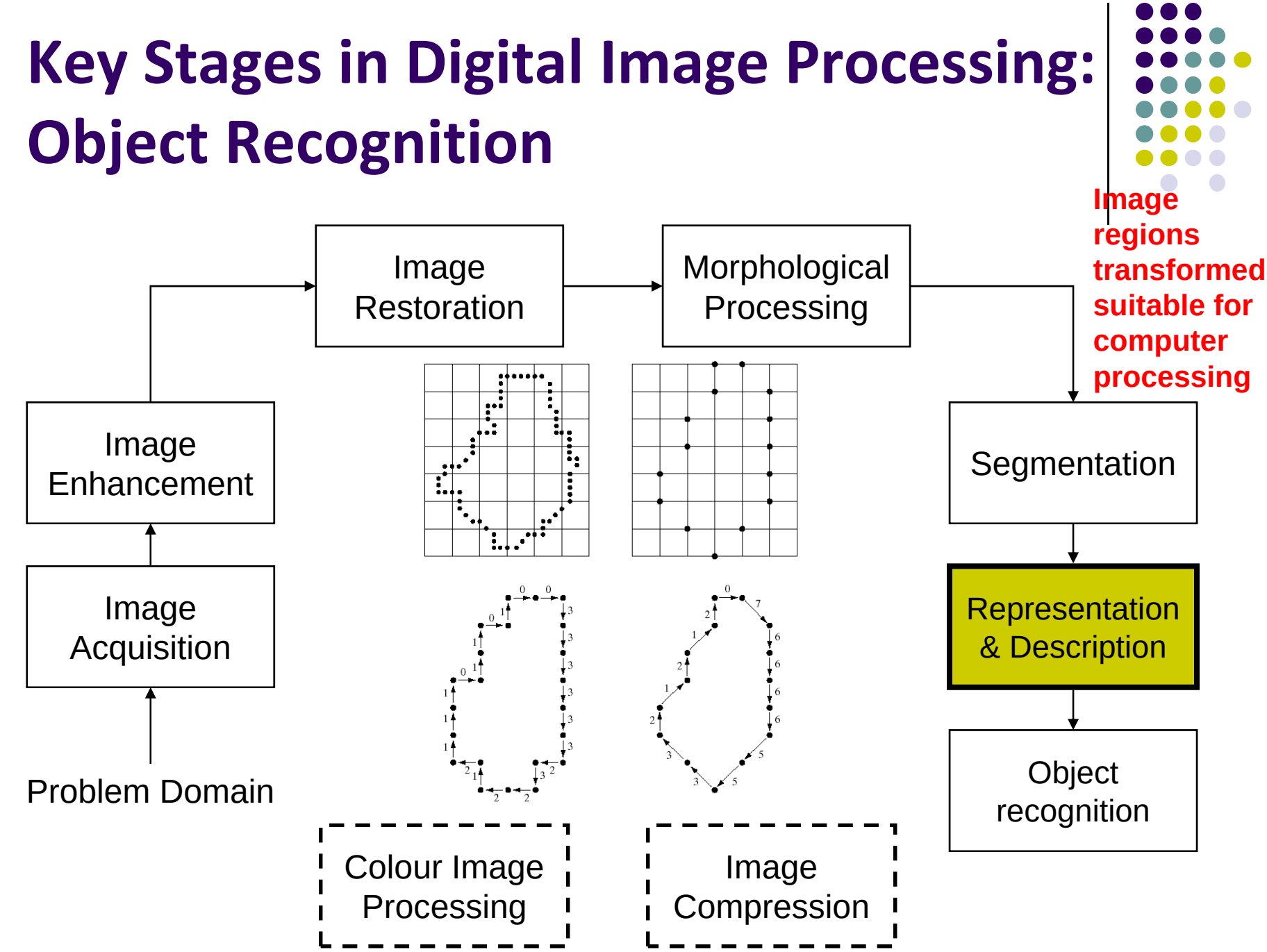
Images taken from Gonzalez & Woods, Digital Image Processing (2002)

Key Stages in Digital Image Processing: Segmentation



Images taken from Gonzalez & Woods, Digital Image Processing (2002)

Key Stages in Digital Image Processing: Object Recognition



Images taken from Gonzalez & Woods, Digital Image Processing (2002)

Key Stages in Digital Image Processing: Representation & Description

Finds & Labels objects in scene (e.g. motorbike)

Image Restoration

Morphological Processing

Image Enhancement

Segmentation

Image Acquisition

Representation & Description

Problem Domain

Object recognition

Colour Image Processing

Image Compression

Images taken from Gonzalez & Woods, Digital Image Processing (2002)

Key Stages in Digital Image Processing: Image Compression

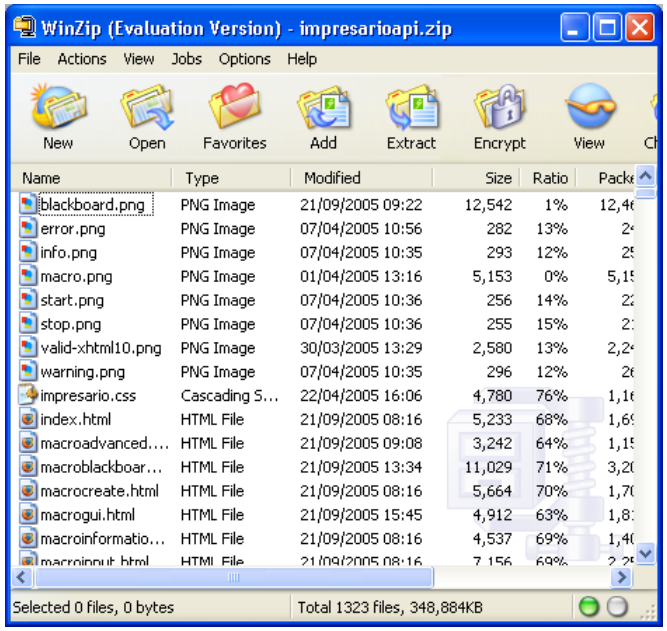
Reduce image size (e.g. JPEG)

Image Restoration

Morphological Processing

Image Enhancement

Segmentation



Representation & Description

Image Acquisition

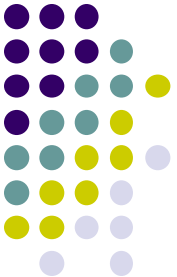
Object recognition

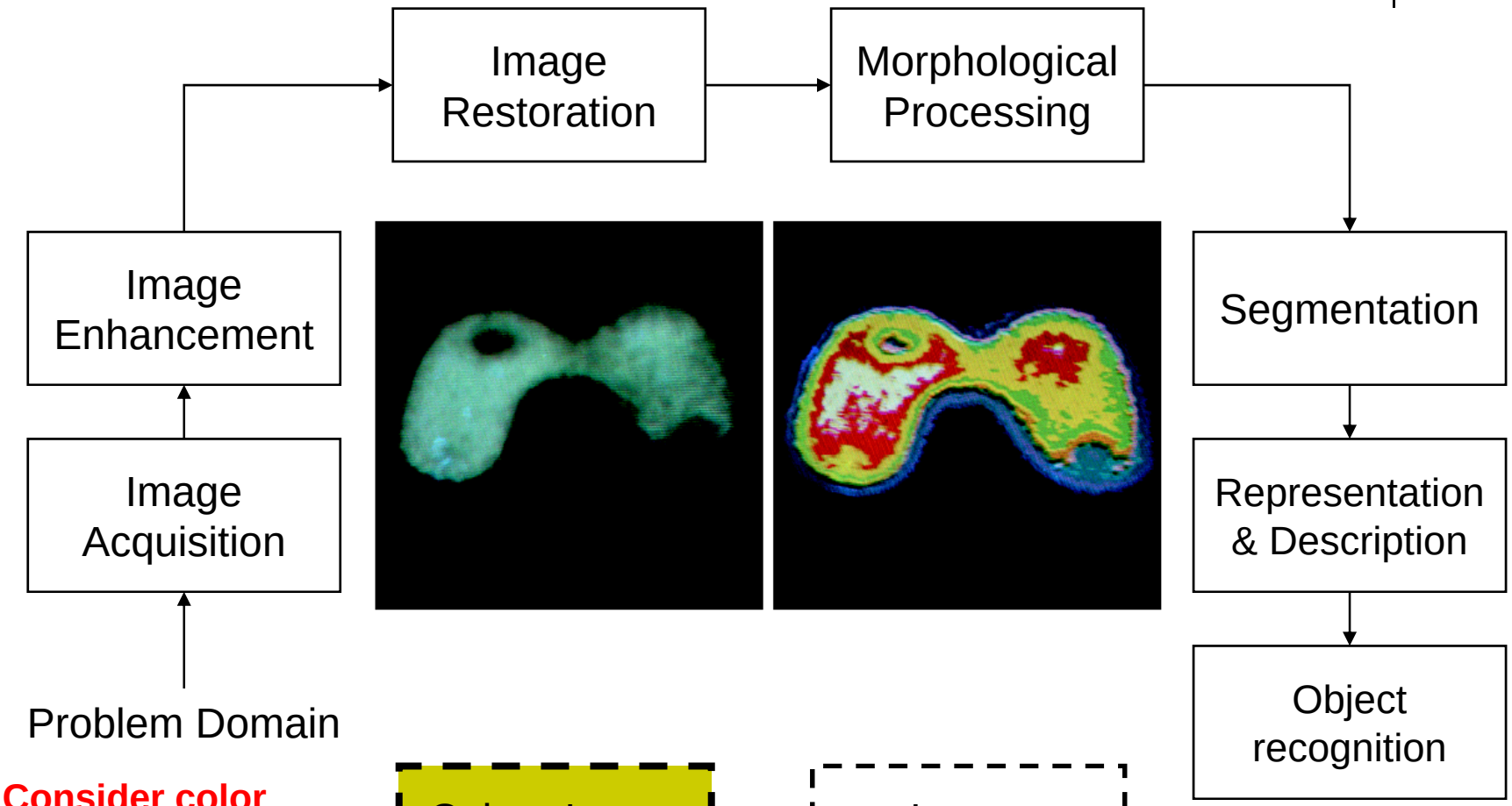
Problem Domain

Colour Image Processing

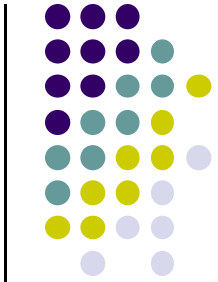
Image Compression

Key Stages in Digital Image Processing: Colour Image Processing





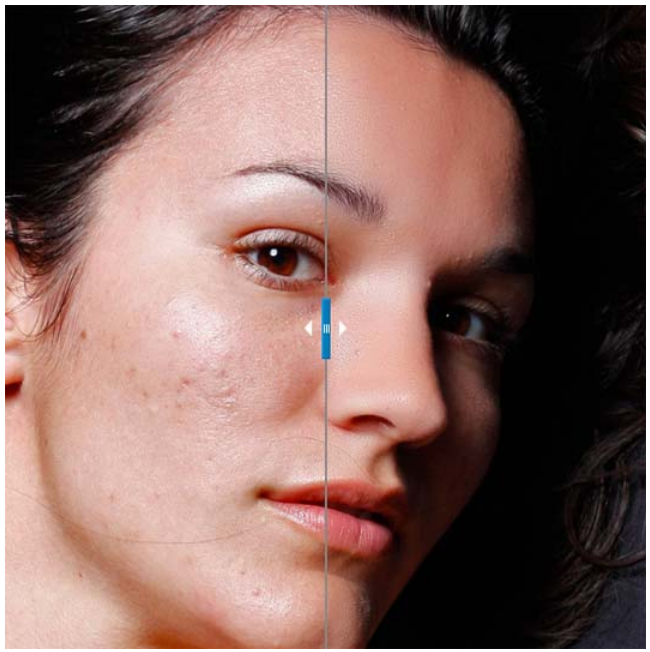
Mathematics for Image Processing



- Calculus
- Linear algebra
- Probability and statistics
- Differential Equations (PDEs and ODEs)
- Differential Geometry
- Harmonic Analysis (Fourier, wavelet, etc)

About This Course

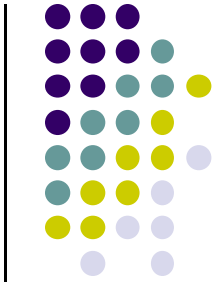
- Image Processing has many aspects
  - **Computer Scientists/Engineers** develop tools (e.g. photoshop)
    - **Requires** knowledge of maths, algorithms, programming
  - **Artists** use image processing tools to modify pictures
    - **DOES NOT** require knowledge of maths, algorithms, programming



Example: Portraiture photoshop plugin

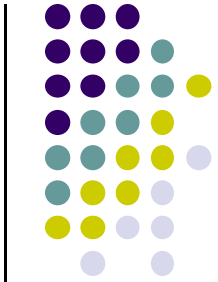
Example: Knoll Light Factory photoshop plugin

Example: ToonIt photoshop plugin



About This Course

- Most hobbyists follow artist path. Not much math!
- This Course: Image Processing for computer scientists and Engineers!!!
- Teaches concepts, uses Matlab/Python as concrete example
- Matlab Image Processing Toolbox
  - Includes lots of already working algorithms,
  - Can be extended by programming new image processing techniques
- Course is **NOT**
  - just about programming Matlab image processing toolbox
  - a comprehensive course in matlab image processing toolbox and python image processing library (PIL, scipy, opencv-python and so on)
  - about using packages like Photoshop



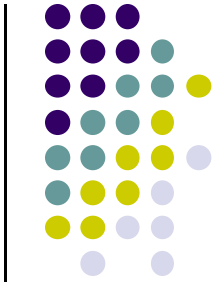
About This Course

- Class is concerned with:
  - How to implement image processing algorithms
  - Underlying mathematics
  - Underlying algorithms

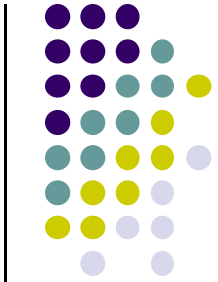
- This course is a lot of work. **Especially heavy coding!!!**
  Requires:

  - Lots of programming (maybe in MATLAB/Python)
  - Lots of math, linear systems, fourier analysis

Administrivia: Syllabus Summary



- 3 Assignments (30%), one Mid-Exam (30%), 1 final Projects (40%)
- Projects:
  - Develop image processing algorithm on any platform using MATLAB/Python
  - May discuss projects but turn in individual projects
- Class website: http://web.cs.wpi.edu/~emmanuel/courses/cs545/S14/
- Text:
  - *Digital Image Processing: An Algorithmic Introduction using Java* by Wilhelm Burger and Mark J. Burge, Springer Verlag, 2008
- Cheating: Immediate 'F' in the course
- My advice:
  - Come to class
  - Read the text
  - Understand concepts before coding



References

- Wilhelm Burger and Mark J. Burge, Digital Image Processing, Springer, 2008
- University of Utah, CS 4640: Image Processing Basics, Spring 2012
- Gonzales and Woods, Digital Image Processing (3rd edition), Prentice Hall
- Digital Image Processing slides by Brian Mac Namee

Thank You