

Digital Image Processing

Lecture I

Chapter 1: Introduction

Fall 2012

Digital Image Processing

Chapter 1: Introduction

What is Image Processing?

- **Processing of images which are digital in nature by computer.**
- **Image processing is a subclass of signal processing concerned specifically with pictures.**
- **Improve image quality for human perception and/or computer interpretation.**
- **Processing of image data for storage, transmission and representation for autonomous machine perception.**

Computer graphics: the creation of images

Computer vision: analysis of image content

Digital Image Processing

Chapter 1: Introduction

Several fields deals with images

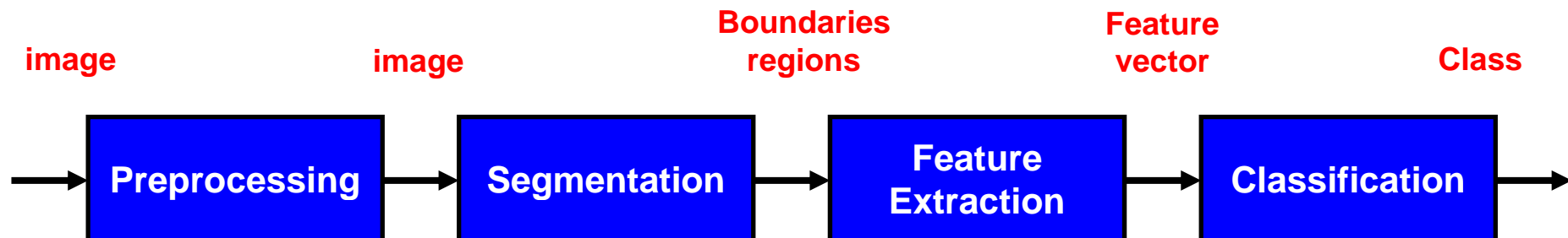
Input/Output	Image	Description
Image	Image Processing	Computer Vision
Description	Computer Graphics	AI

Digital Image Processing

Chapter 1: Introduction

Typical Computer Vision System

- Preprocessing: Filtering, Enhancement
- Segmentation: images in, boundaries and regions out
- Feature extraction: images in; patterns out
- Classification: Calssify into one of predetermined classes



Digital Image Processing

Chapter 1: Introduction

Digital Image Processing Concerned fields:

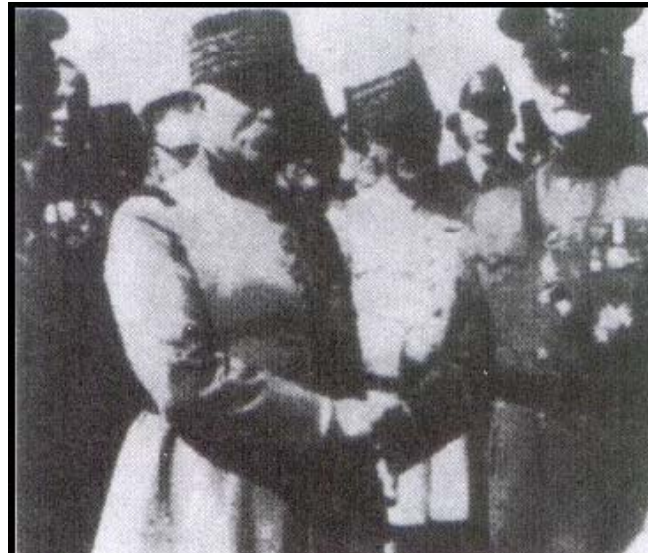
- ❑ Digital Signal Processing
- ❑ Digital Communication
- ❑ Data Compression
- ❑ Speech Processing and Recognition
- ❑ Computer Graphics
- ❑ Computer Vision

Digital Image Processing

Chapter 1: Introduction

History of Image Processing

1920's - Digitized newspaper picture transmitted through submarine cable (London New York)



Digital Image Processing

Chapter 1: Introduction

History of Image Processing

1960's - Images from space probe



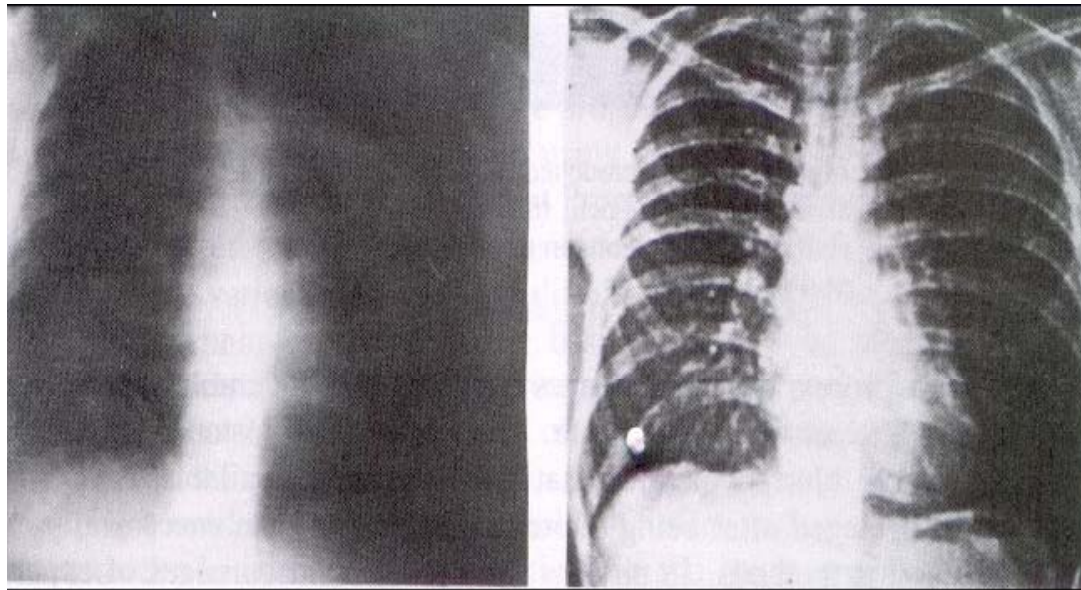
Digital Image Processing

Chapter 1: Introduction

History of Image Processing

- 1970's - Computerized Tomography (CT)
- 1980's and later

Computer image processing in industry, biomedical area, military recognition, satellite imagery for weather and environment.



Digital Image Processing

Chapter 1: Introduction

History of Image Processing

- 2000s: Augmented Reality, Virtual Reality
- Combination of real and synthetic images



Digital Image Processing

Chapter 1: Introduction

Areas of Application

- Image transmission and storage
- Biomedical applications
- Robotics
- Remote Sensing
- Radar/sonar
- Computer graphics
- Document Analysis
- Law enforcement
- Human computer interaction

Examples: Image Correction

- • Needed when image data is erroneous:
 - Bad transmission
 - Some bits are missing: *Salt & Pepper Noise*

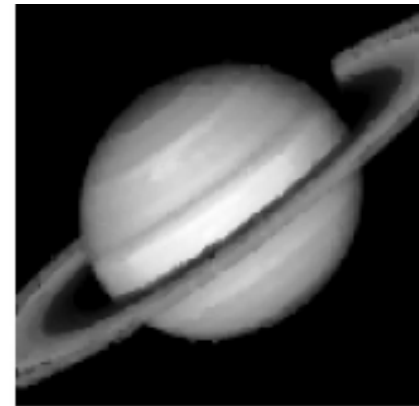
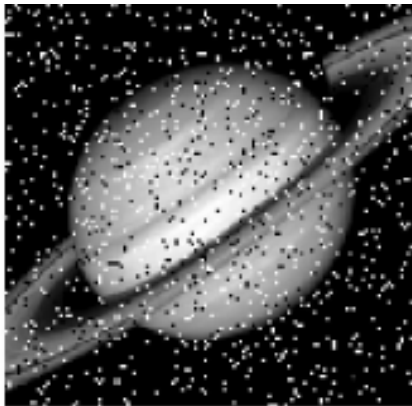


Image Deblurring: Motion Blur

- Can be used when camera moved during exposure!



Deblurring

- Can be used when the camera was not focused properly!!

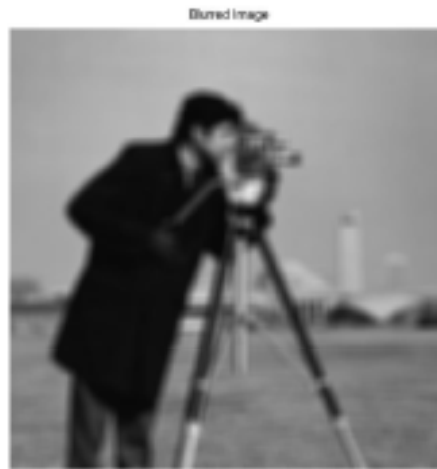


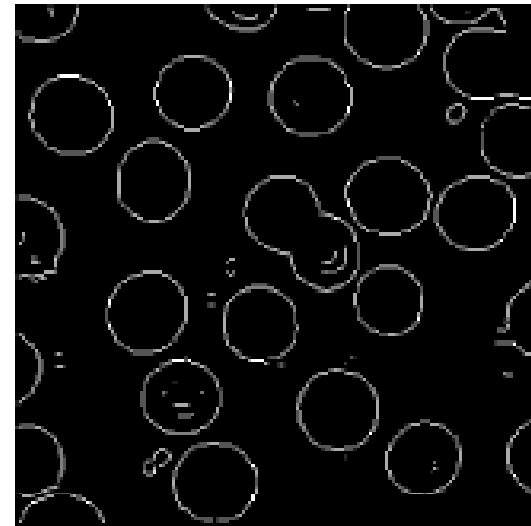
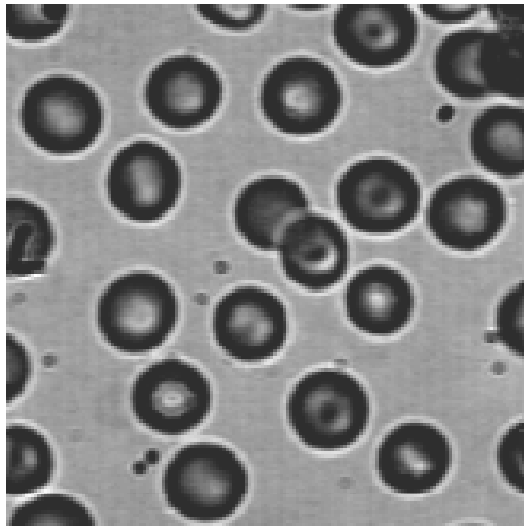
Image manipulation

- Image improvement, e.g. too dark image



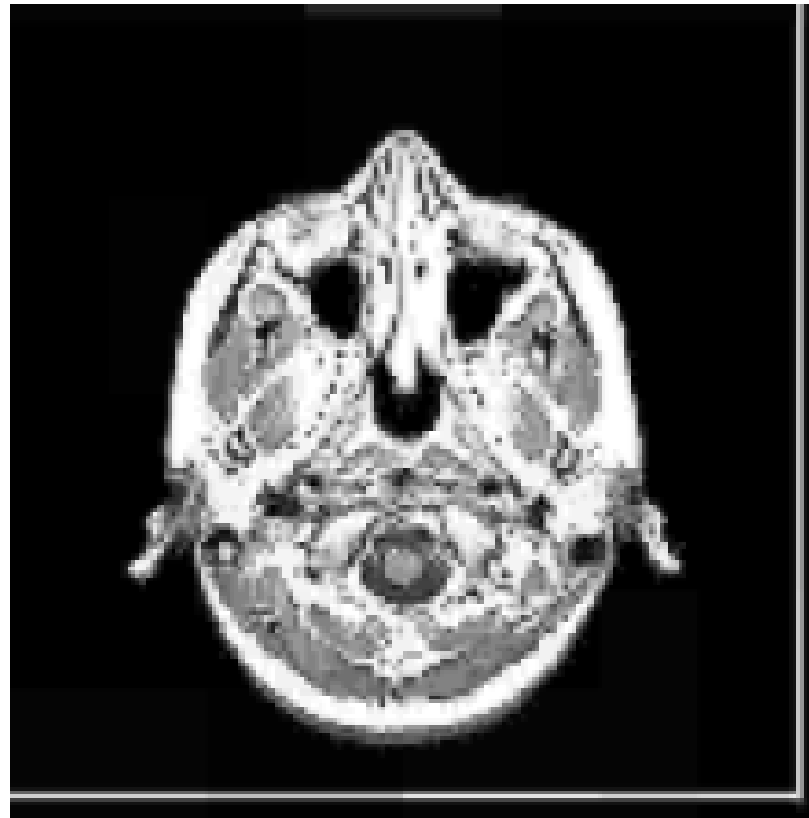
Medical Image Processing

- Image Processing becomes widely used
- E.g. Analysis of microscopic images



Medical Image Processing

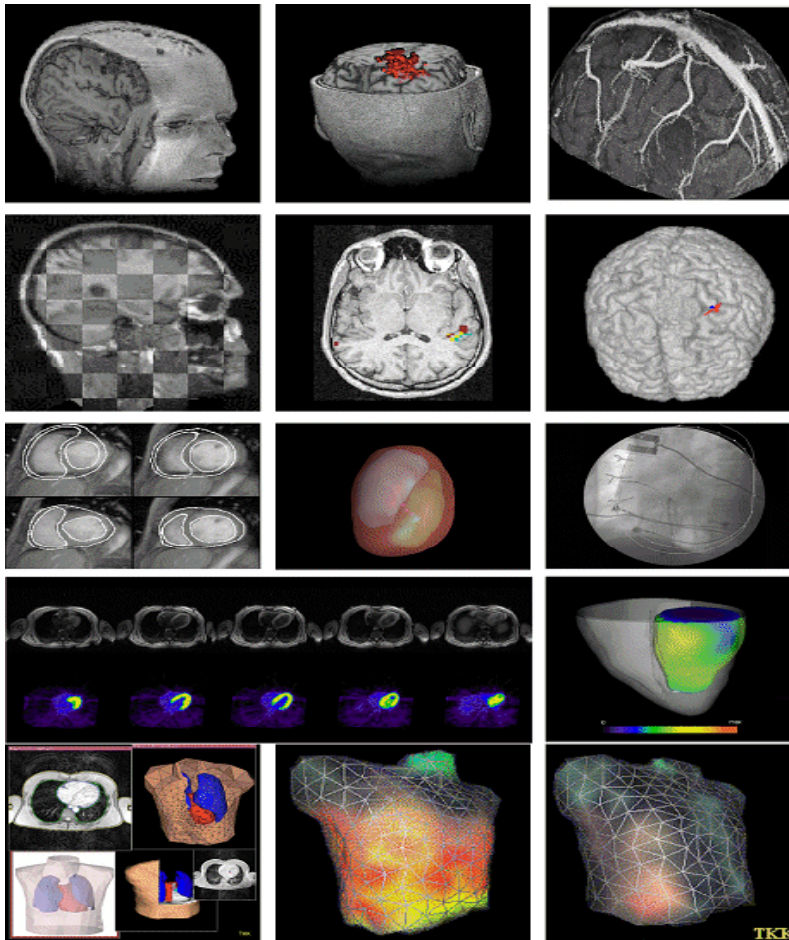
- MR/CT Imaging of a human body
- Use for Brain Surgery



Digital Image Processing

Chapter 1: Introduction

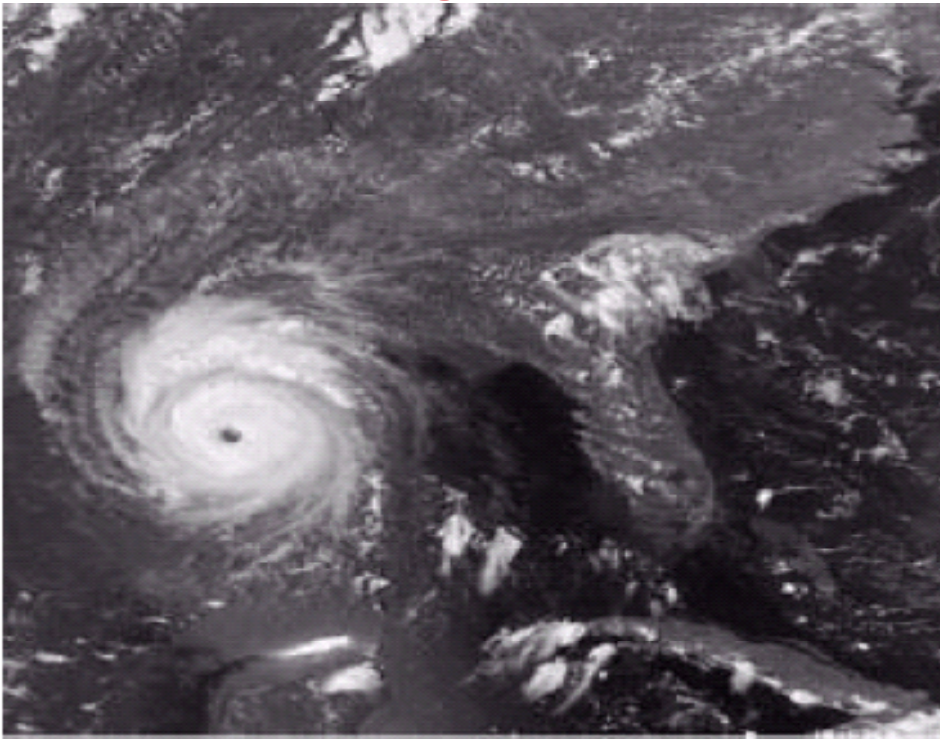
Biomedical imaging



Digital Image Processing

Chapter 1: Introduction

Remote Sensing: weather observation and prediction



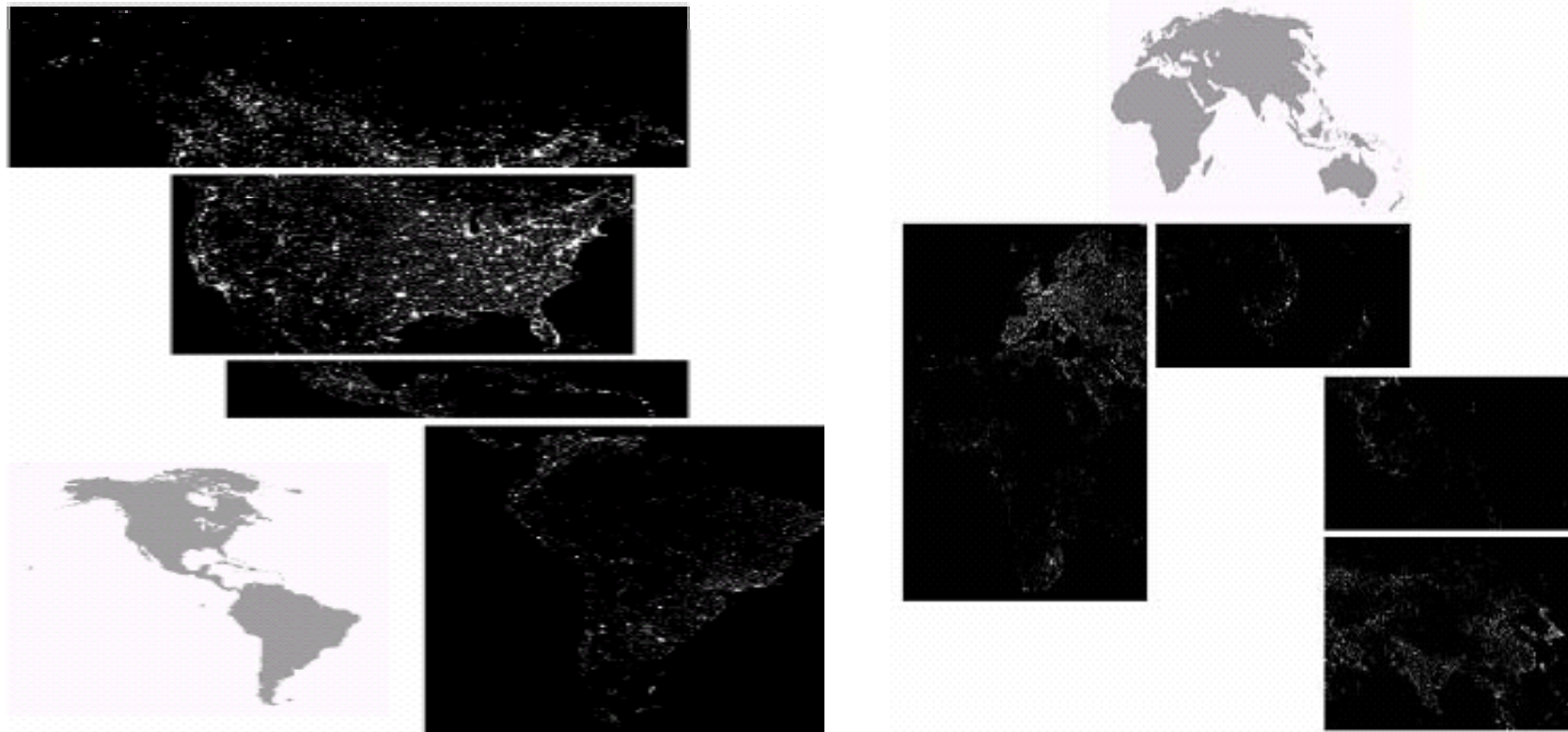
Multispectral image of Hurricane Andrew from satellite images in visible and infrared bands

Digital Image Processing

Chapter 1: Introduction

Remote Sensing: Nighttime lights of the world

(provides a global inventory of human settlements)

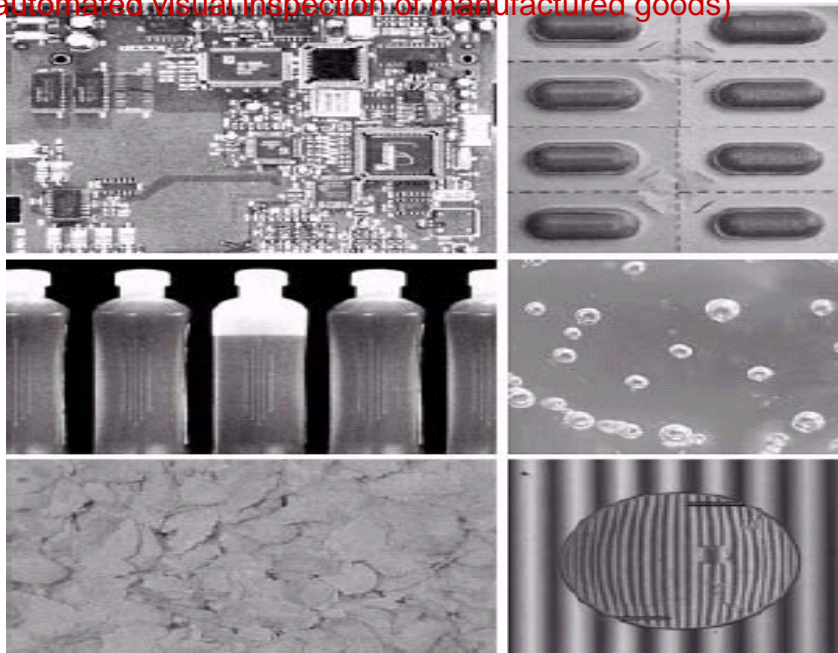


Digital Image Processing

Chapter 1: Introduction

Industry: Visual Spectrum

(automated visual inspection of manufactured goods)



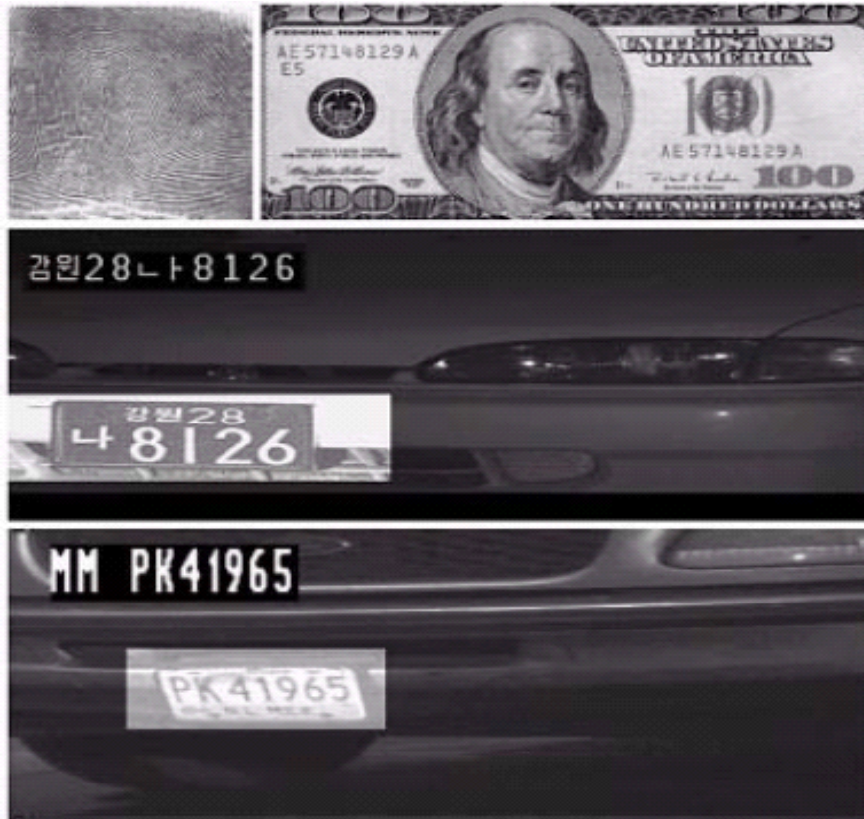
a	d
b	e
c	f

- (a). A circuit board: missing parts
- (b). Pill container: missing pills
- (c). Bottles : not filled up to an acceptable level
- (d). Bubbles in product : detect unacceptable air pockets
- (e). Cereal : inspection for color and anomalies like burned flake.
- (f). Lens for human eye : inspection of damaged implants

Digital Image Processing

Chapter 1: Introduction

Law Enforcement: Visual Spectrum



- (a). Thumb print: automated search for a potential matches
- (b). Paper currency : automated counting / reading of the serial number for tracking and identifying bills
- (c) and (d) Automated license plate reading

Digital Image Processing

Chapter 1: Introduction

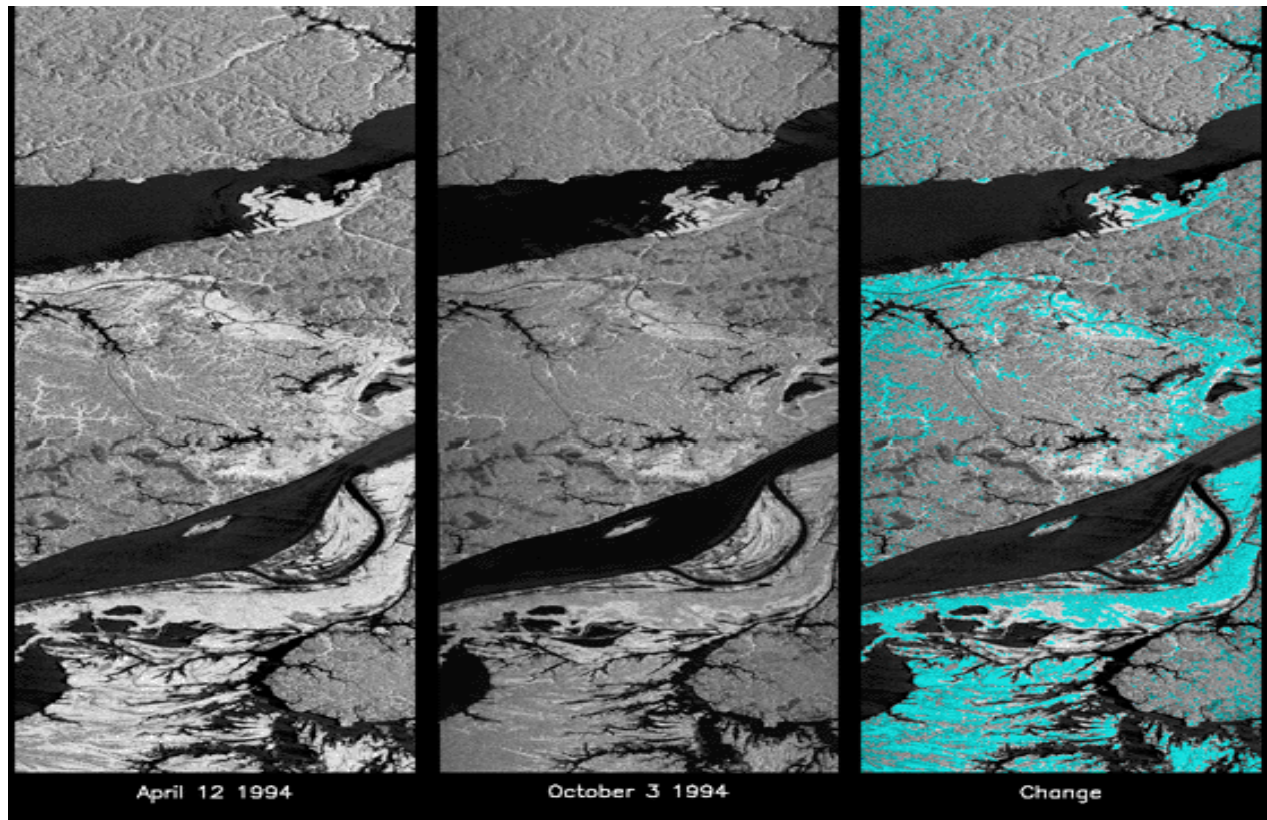
SAR imaging



Digital Image Processing

Chapter 1: Introduction

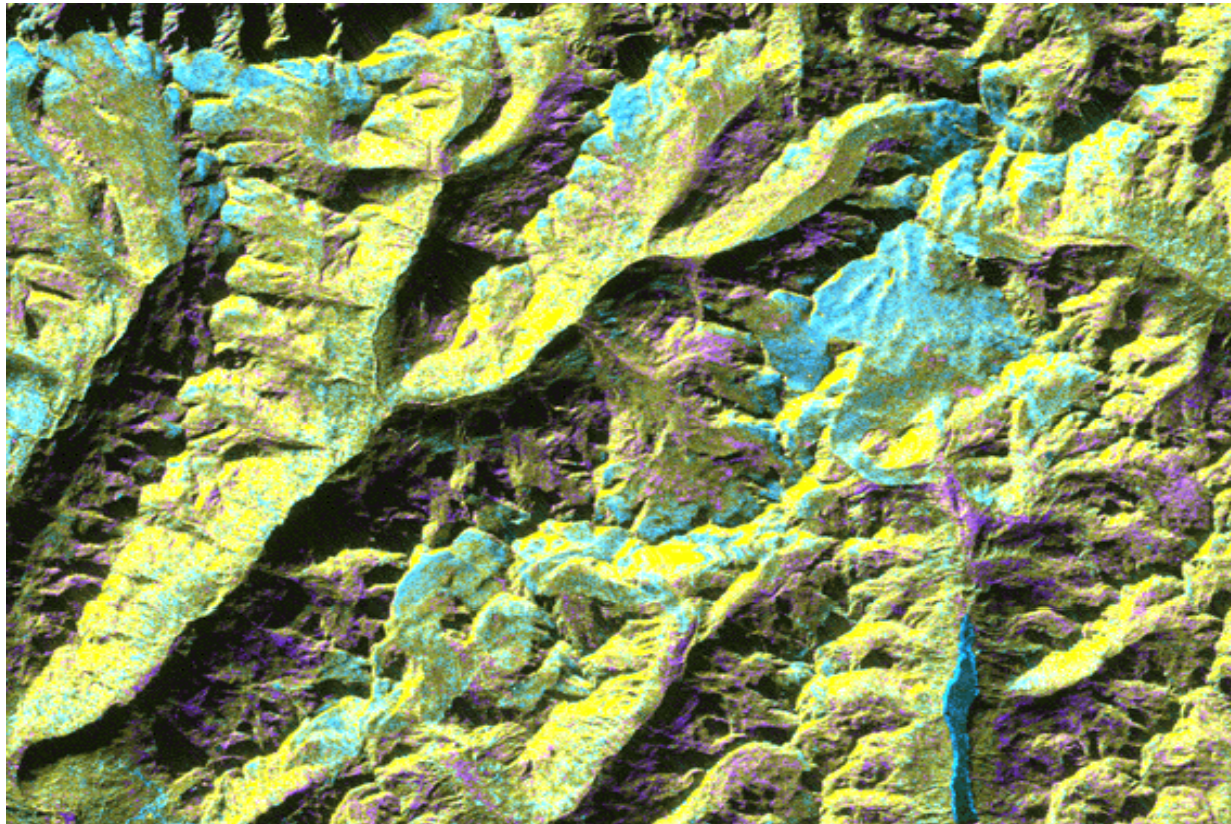
SAR imaging



Digital Image Processing

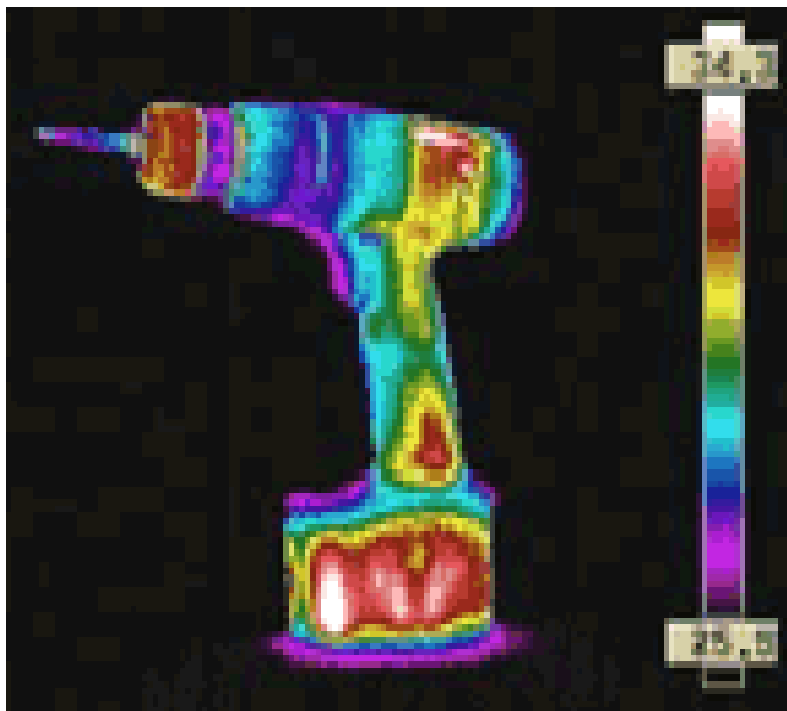
Chapter 1: Introduction

SAR imaging

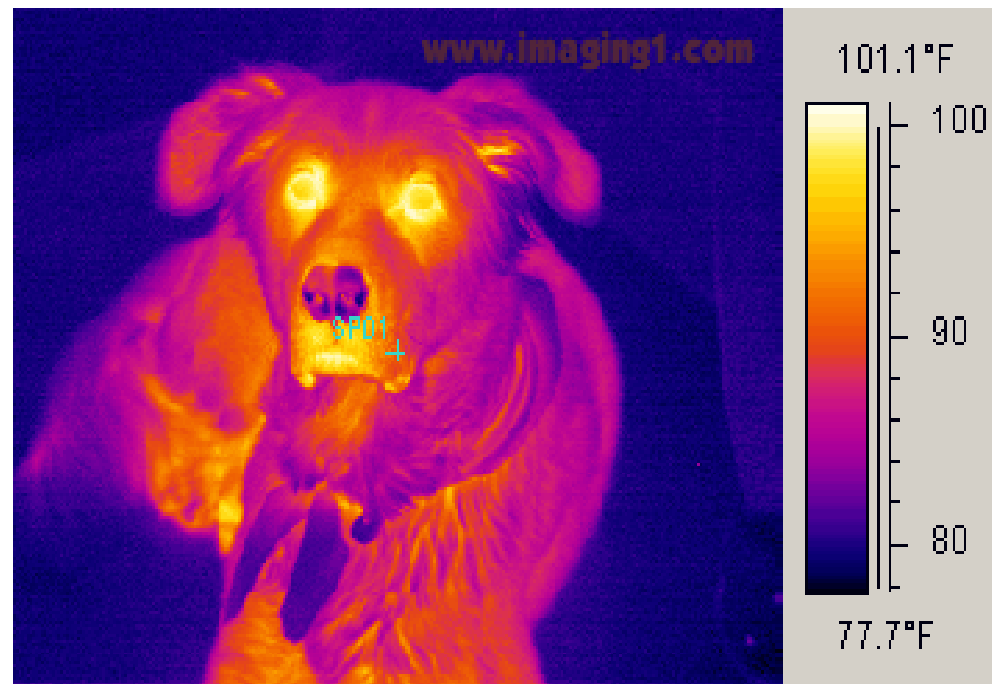


Digital Image Processing

Chapter 1: Introduction

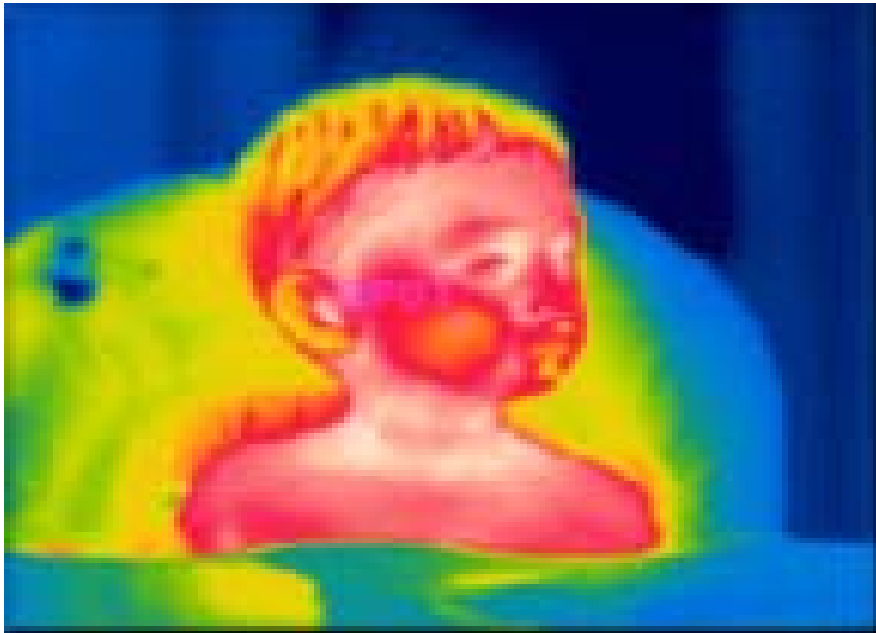


Thermal Imaging



Digital Image Processing

Chapter 1: Introduction

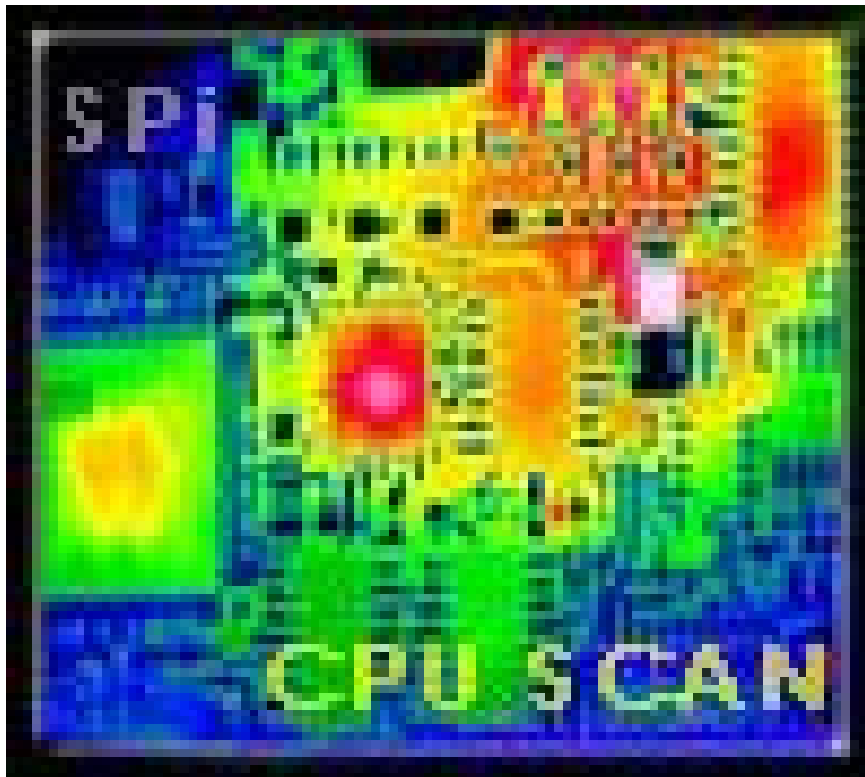


Thermal Imaging



Digital Image Processing

Chapter 1: Introduction



Thermal Imaging



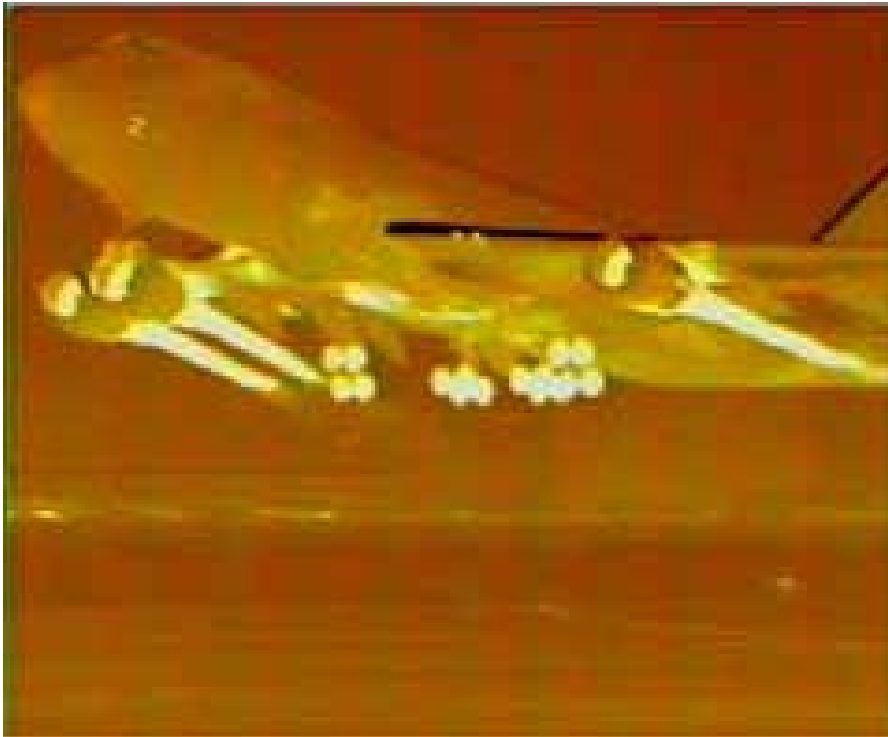
Digital Image Processing

Chapter 1: Introduction



Digital Image Processing

Chapter 1: Introduction



Thermal Imaging



Conveyer belt applications

- Checking and sorting
 - For example: checking bottles in the supermarket
- Quality control
 - Does the object have the correct dimensions, color, shape, etc.?
 - Is the object broken?
- Robot control
 - Find precise location of the object to be picked

Analysis of Sport Motions

- 3D Tracking of body parts
- Motion interpretation
- Action recognition, Identification (Surveillance)



Digital Image Processing

Chapter 1: Introduction

Basic Classes of Problems

- Image Representation and Modelling
- Image Enhancement
- Image Restoration
- Image Segmentation and Analysis
- Image Reconstruction
- Image Compression

Digital Image Processing

Chapter 1: Introduction

3 types of computerized process:

- **Low-level:**
 - input-output are images
 - Primitive operations such as image processing to reduce noise, contrast enhancement, and image sharpening
- **Mid-level:**
 - inputs may be images, outputs are attributes extracted from the images
 - Segmentation
 - Description of objects
 - Classification of objects
- **High-level:**
 - Image analysis (target recognition, motion characterization, 3-D feature analysis)

Digital Image Processing

Chapter 1: Introduction

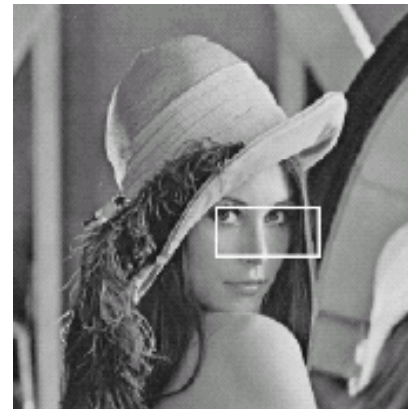


Transpose



Flip Vertical

Simple Processing:



Cropping

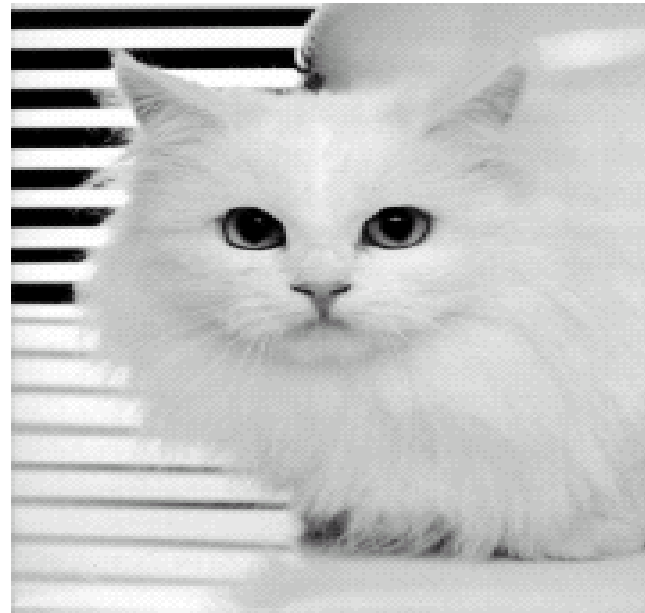
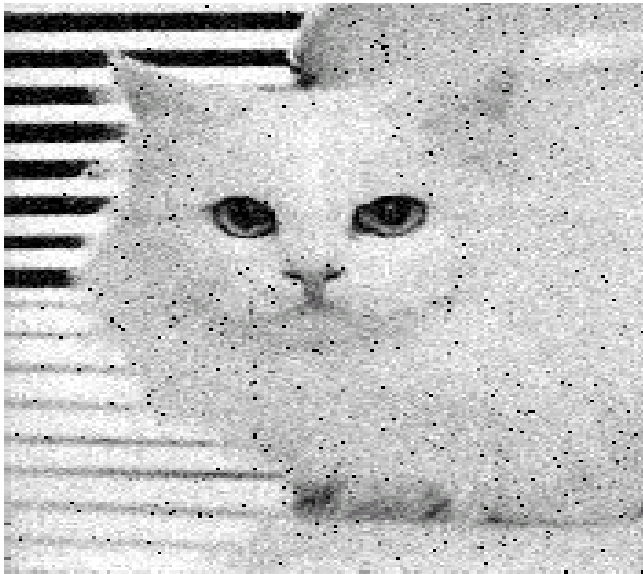


Digital Image Processing

Chapter 1: Introduction

Image Enhancement:

To bring out detail is obscured, or simply to highlight certain features of interest in an image.

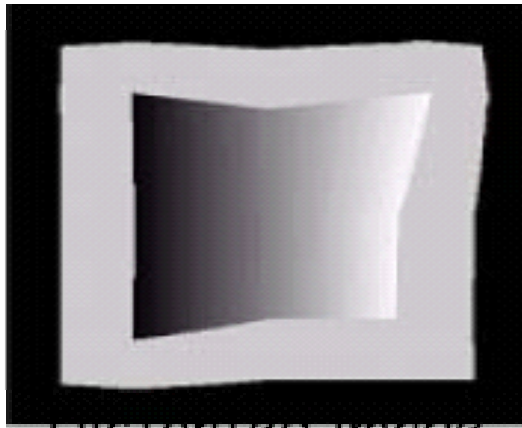


Digital Image Processing

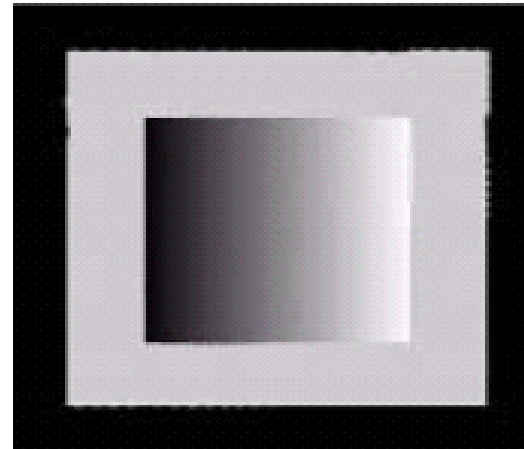
Chapter 1: Introduction

Image Restoration:

Improving the appearance of an image Tend to be based on mathematical or probabilistic models of image degradation



Distorted image

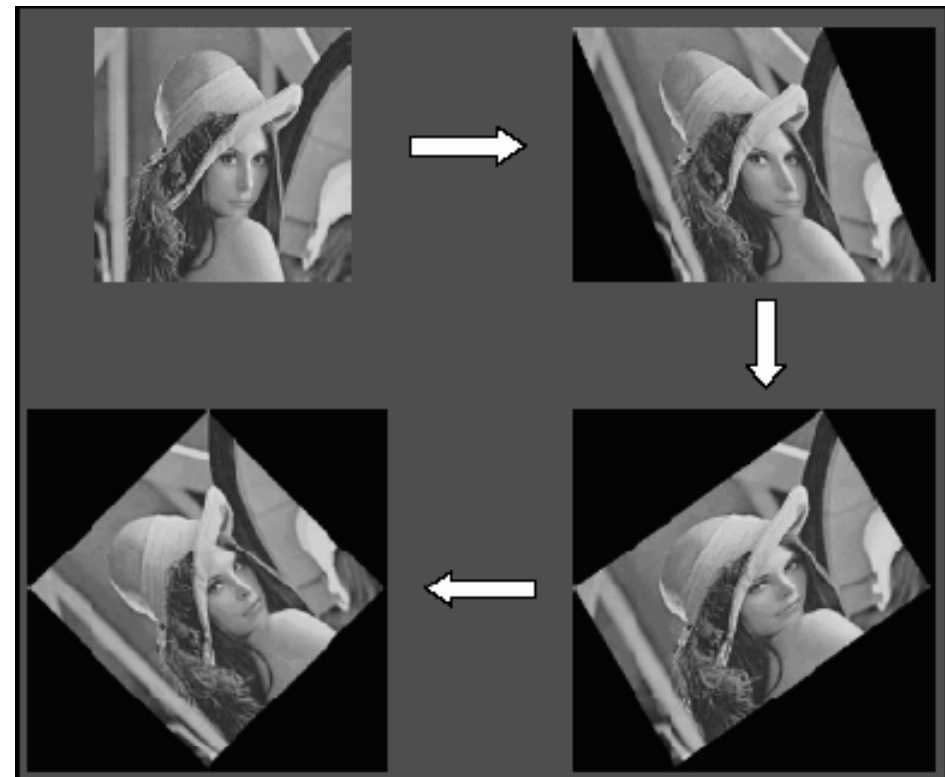
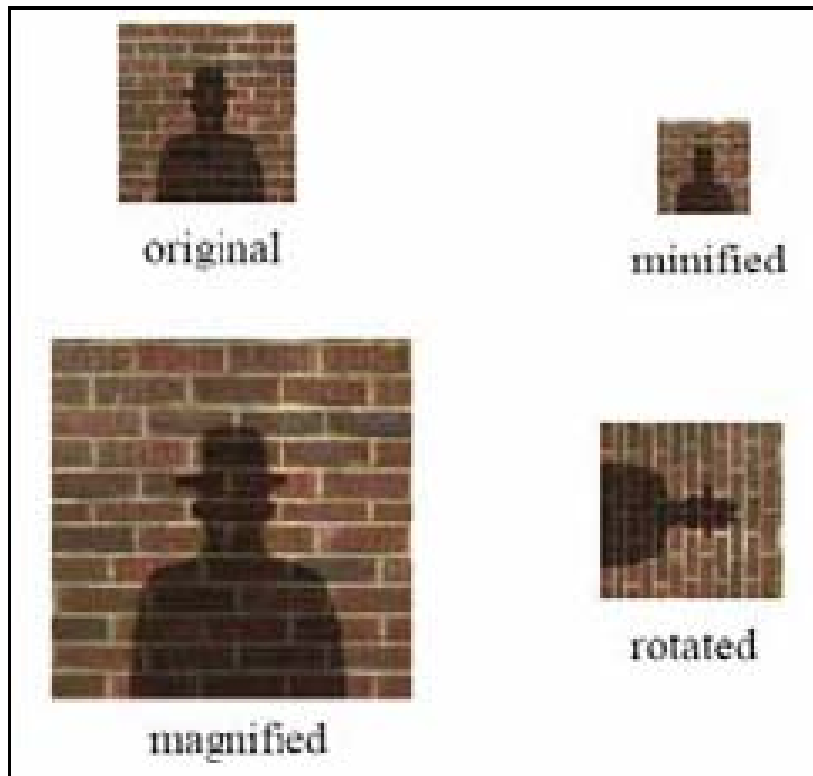


Restored image

Digital Image Processing

Chapter 1: Introduction

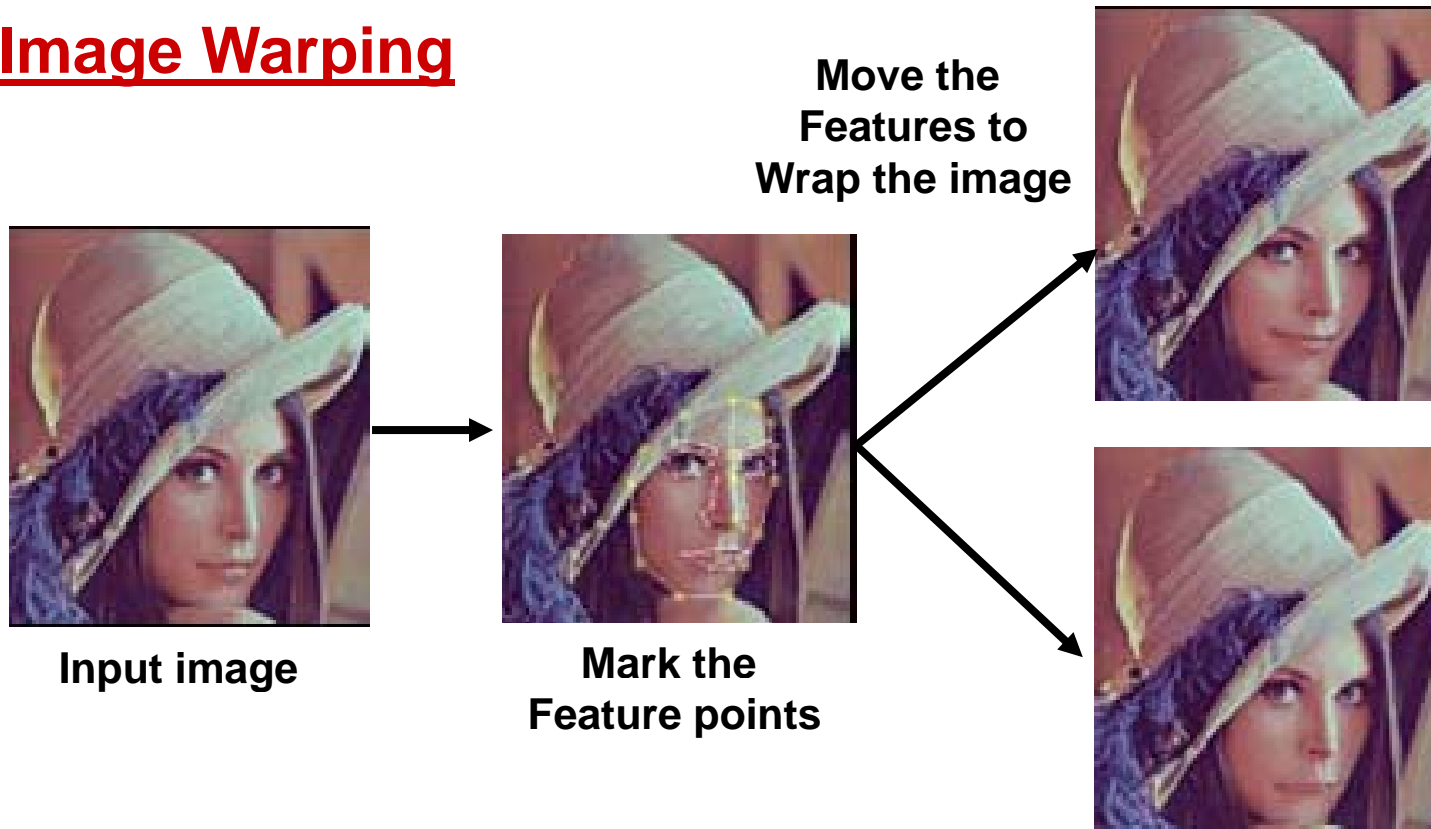
Image Warping



Digital Image Processing

Chapter 1: Introduction

Image Warping

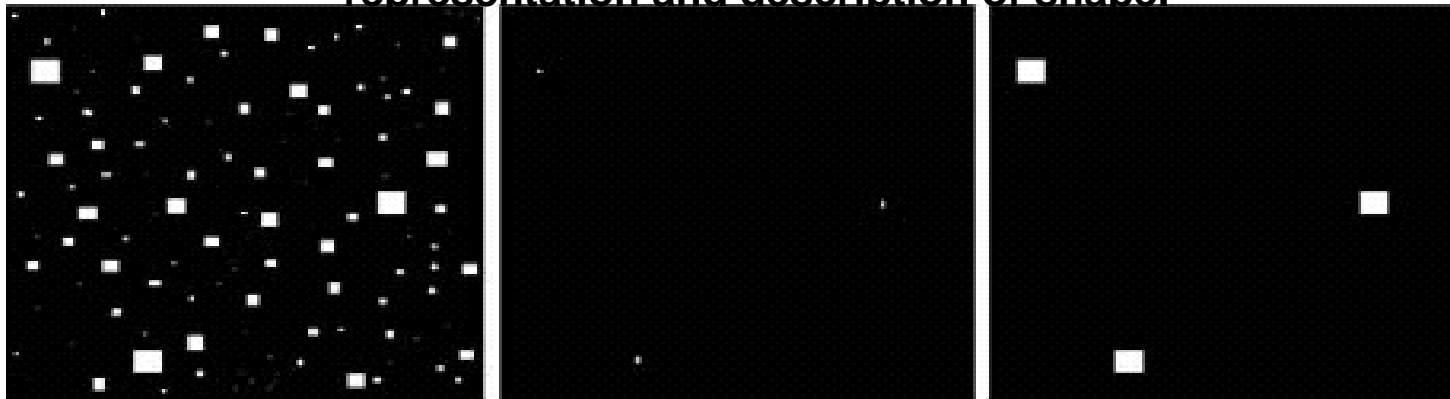


Digital Image Processing

Chapter 1: Introduction

Morphological Processing:

Tools for extracting image components that are useful in the representation and description of shape.



- (a) Image of squares of size 1,3,5,7,9 and 15 pixels on the sides
- (b) (b) Erosion of (a) with a square structuring element of 1's 13 pixels on the sides
- (c) Dilation of (b)

Digital Image Processing

Chapter 1: Introduction

Image Segmentation:

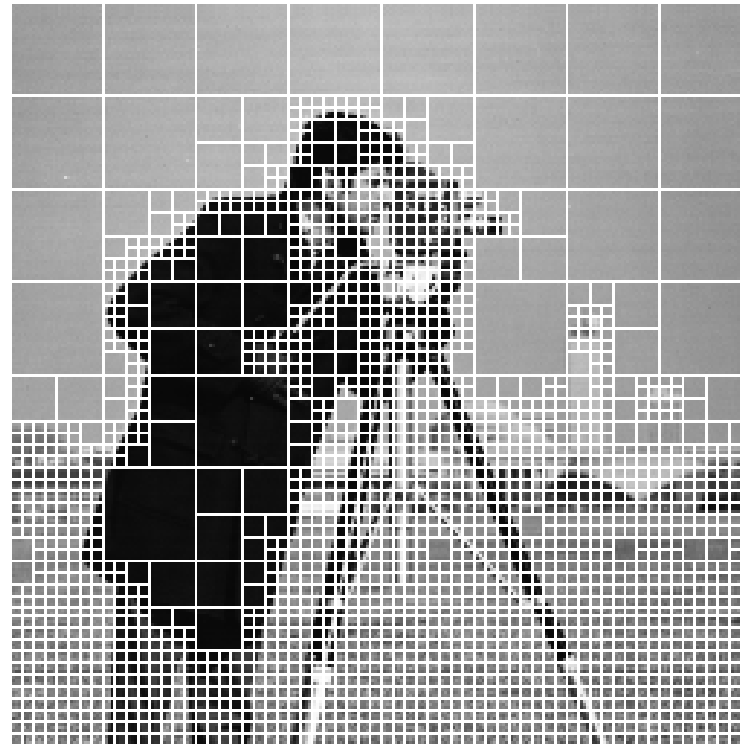


- Separate objects from the image background
- It is one of the most difficult tasks in DIP.
- Output of the segmentation stage is raw pixel data, constituting either the boundary of a region or all the points in the region itself.

Digital Image Processing

Chapter 1: Introduction

Image Segmentation:

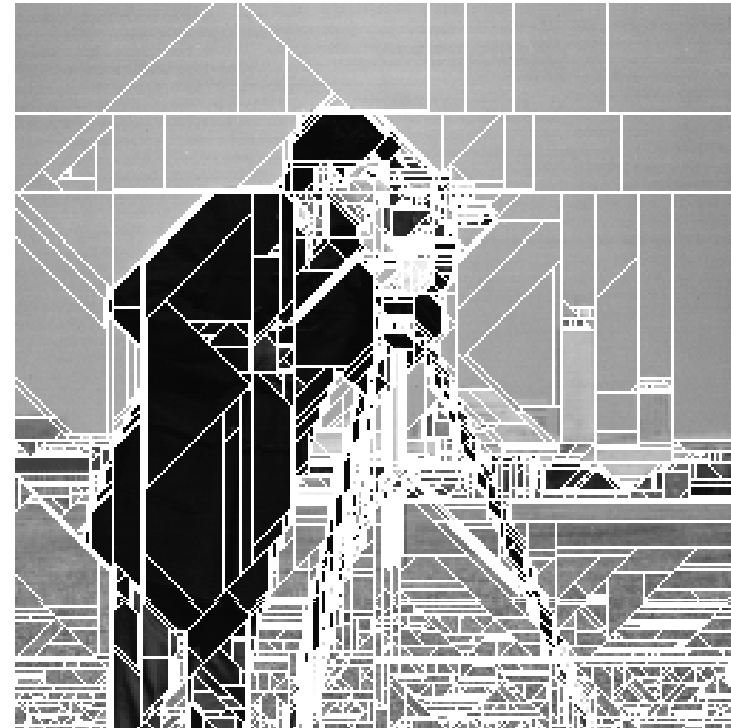


Quadtree segmentation based on variance criterion.

Digital Image Processing

Chapter 1: Introduction

Image Segmentation:

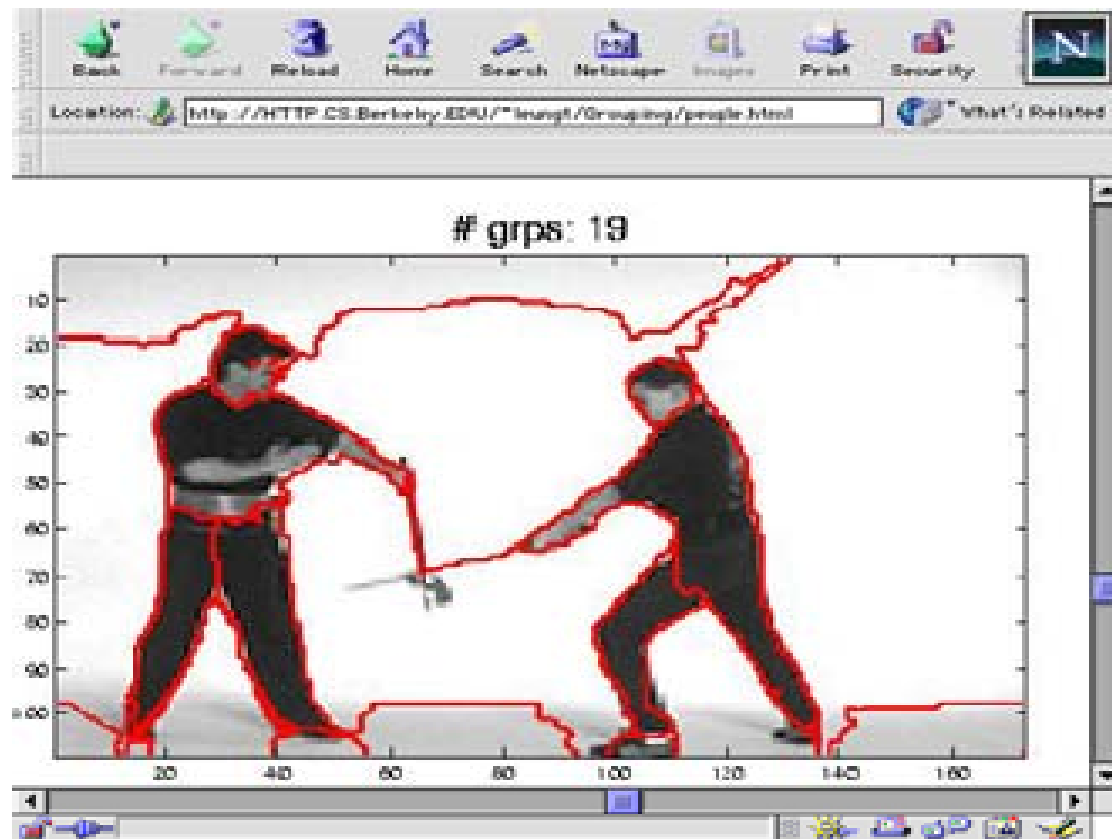


Polygon segmentation based on variance criterion.

Digital Image Processing

Chapter 1: Introduction

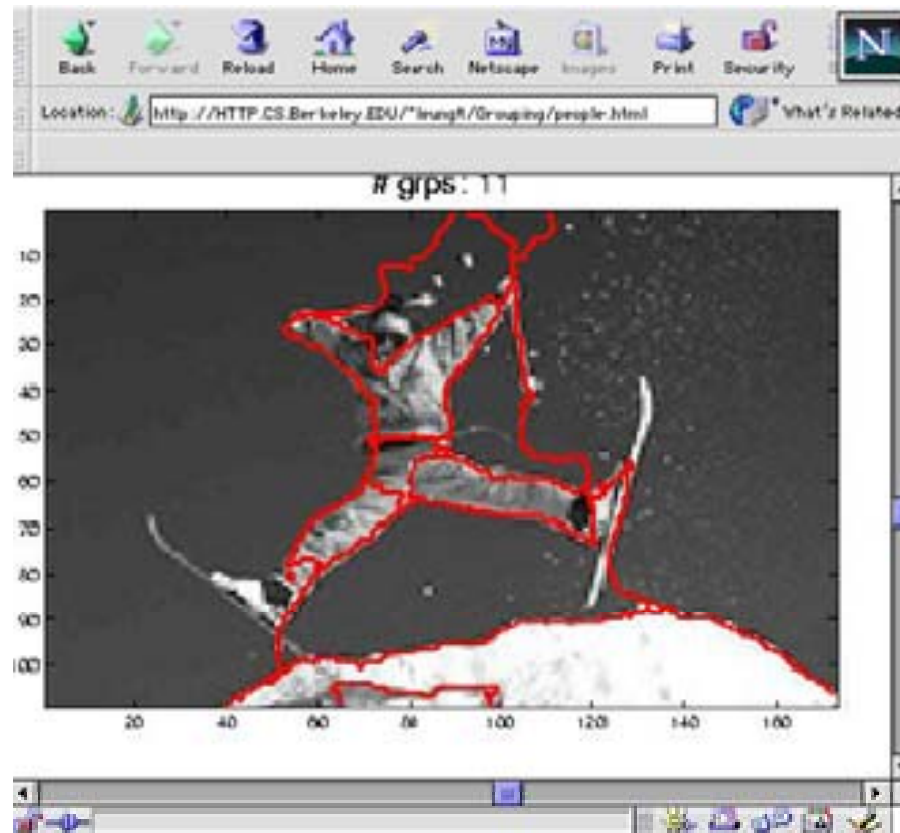
Image segmentation



Digital Image Processing

Chapter 1: Introduction

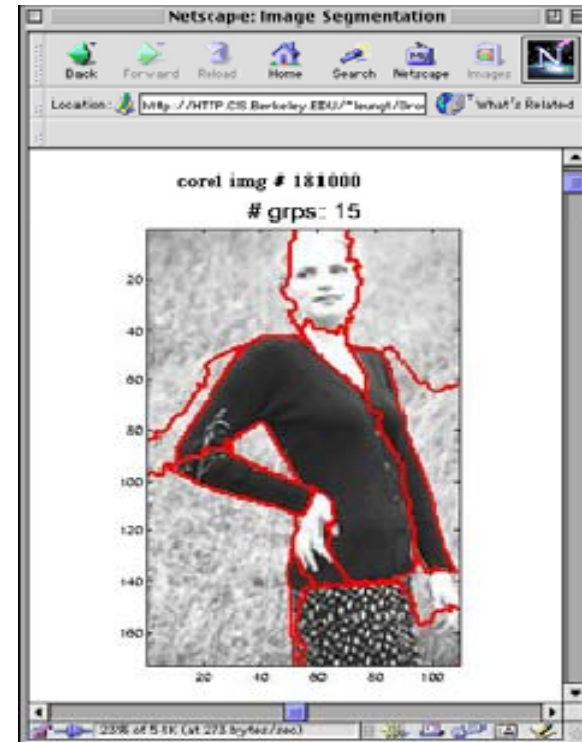
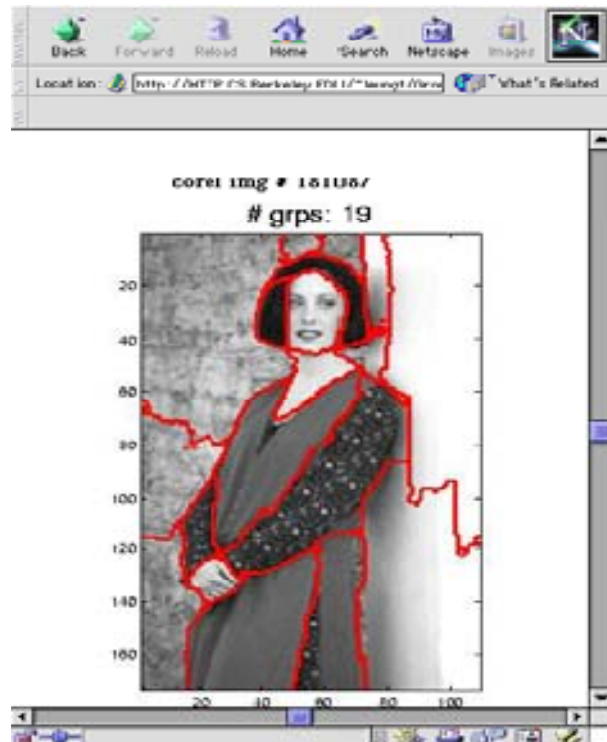
Image segmentation



Digital Image Processing

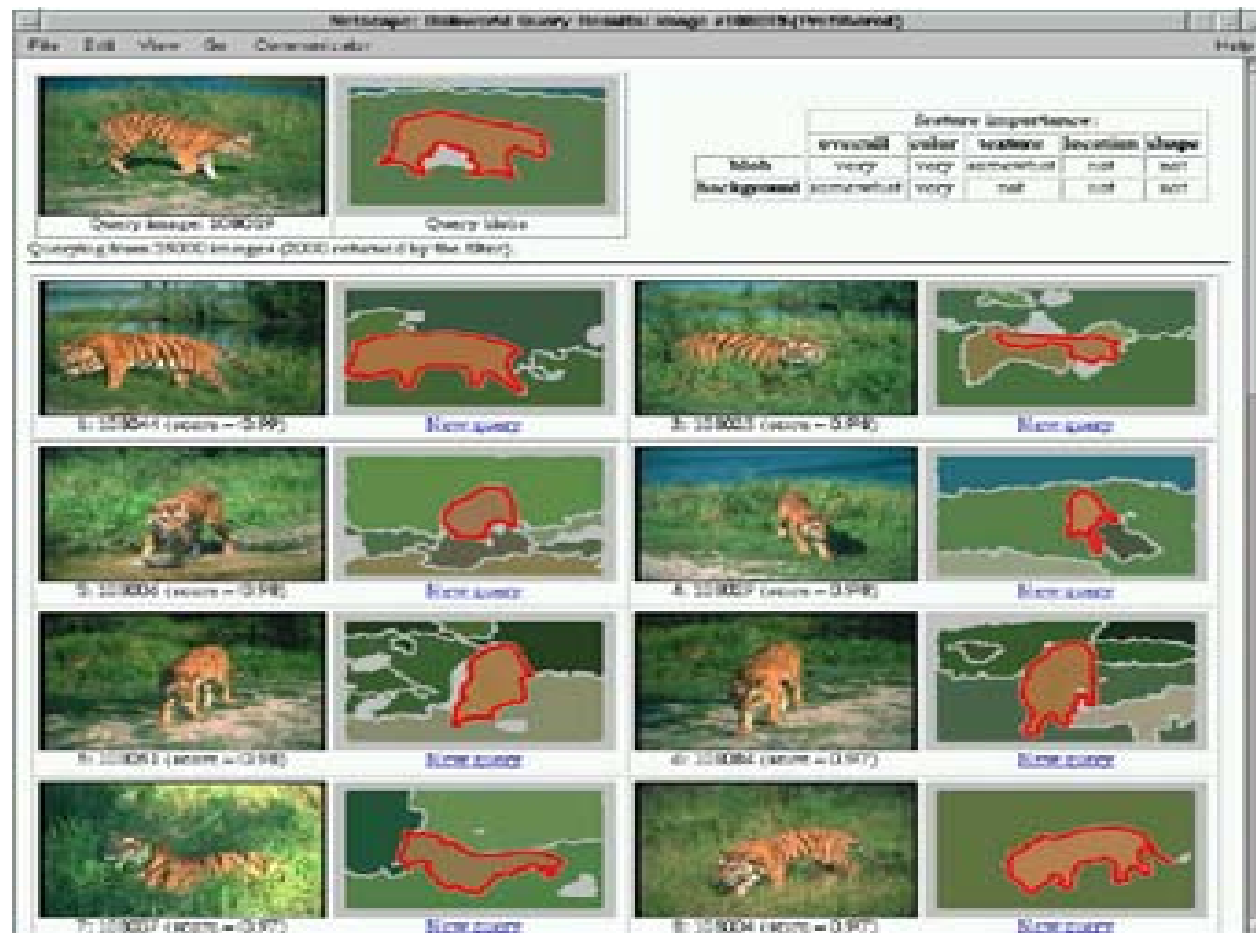
Chapter 1: Introduction

Image segmentation



Digital Image Processing

Chapter 1: Introduction



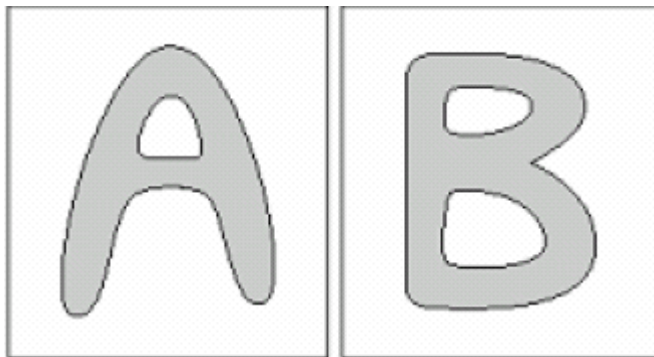
Digital Image Processing

Chapter 1: Introduction

Representation & Description:

Recognition; the process that assigns a label to an object based on the information provided by its descriptors.

Interpretation; assigning meaning to an ensemble of recognized objects.



**1 connected,
1 hole**

**1 connected
2 holes**

**Representation & Description;
Transform raw data a form suitable
for the recognition processing**

Digital Image Processing

Chapter 1: Introduction

Image Compression & JPEG:



original

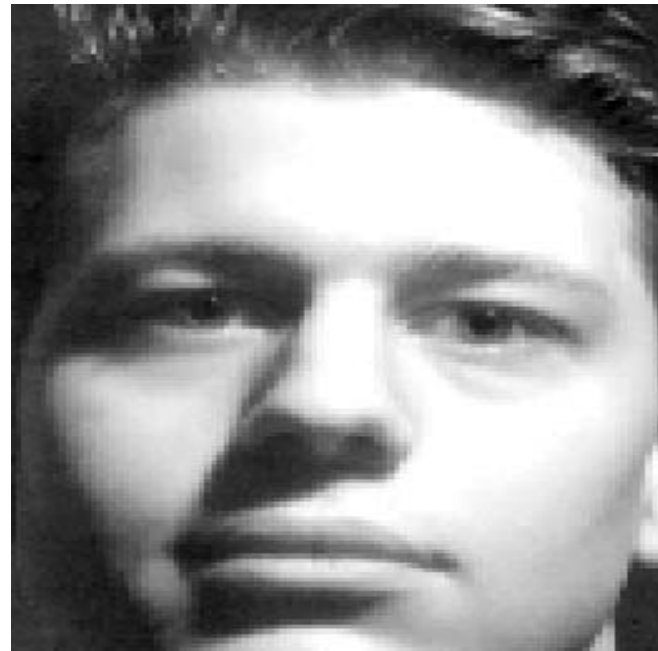


compression=16

Digital Image Processing

Chapter 1: Introduction

Recognition – Shading:



Lighting affects appearance

Digital Image Processing

Chapter 1: Introduction

Recognition – Shading:



Digital Image Processing

Chapter 1: Introduction

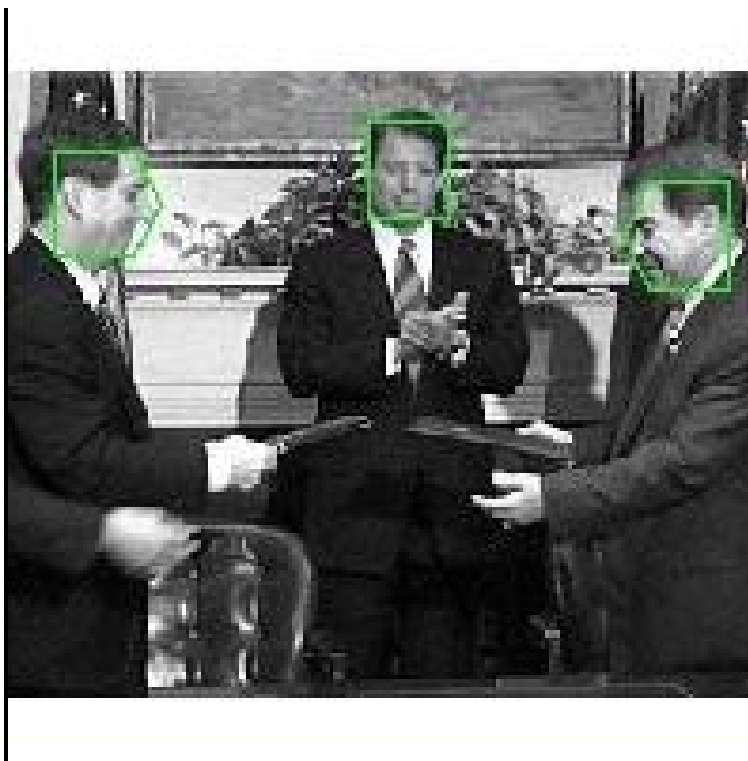
Recognition – Shading:



Digital Image Processing

Chapter 1: Introduction

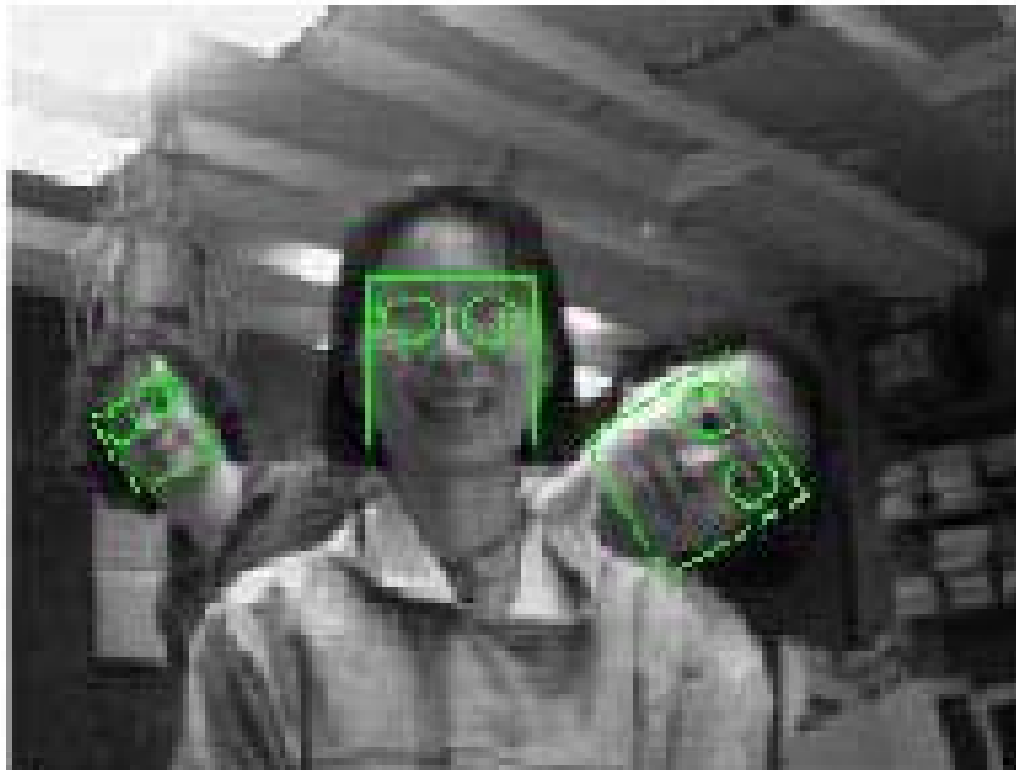
Face detection



Digital Image Processing

Chapter 1: Introduction

Face & eye recognition



Digital Image Processing

Chapter 1: Introduction

Face, eye, & nose recognition



Digital Image Processing

Chapter 1: Introduction

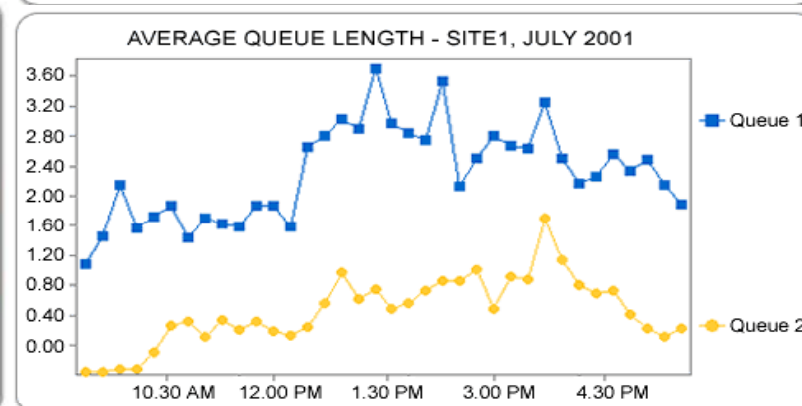
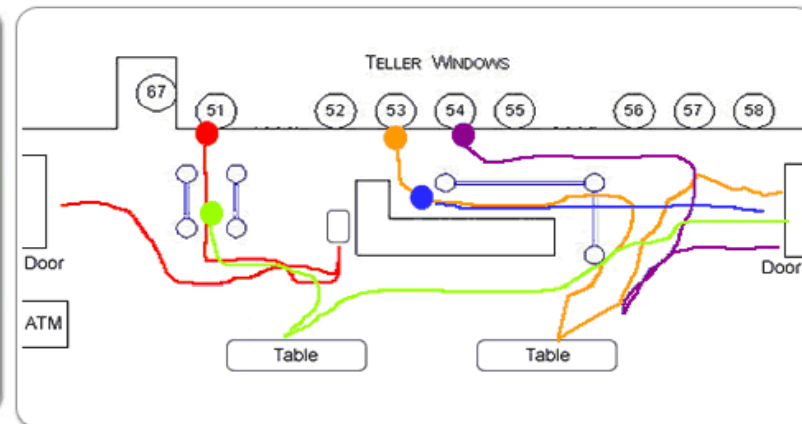
Tracking:



Digital Image Processing

Chapter 1: Introduction

Tracking:



Digital Image Processing

Chapter 1: Introduction

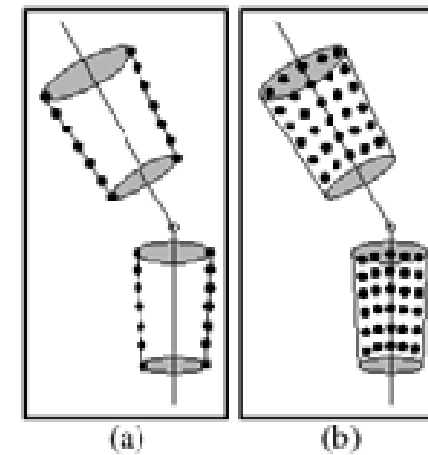
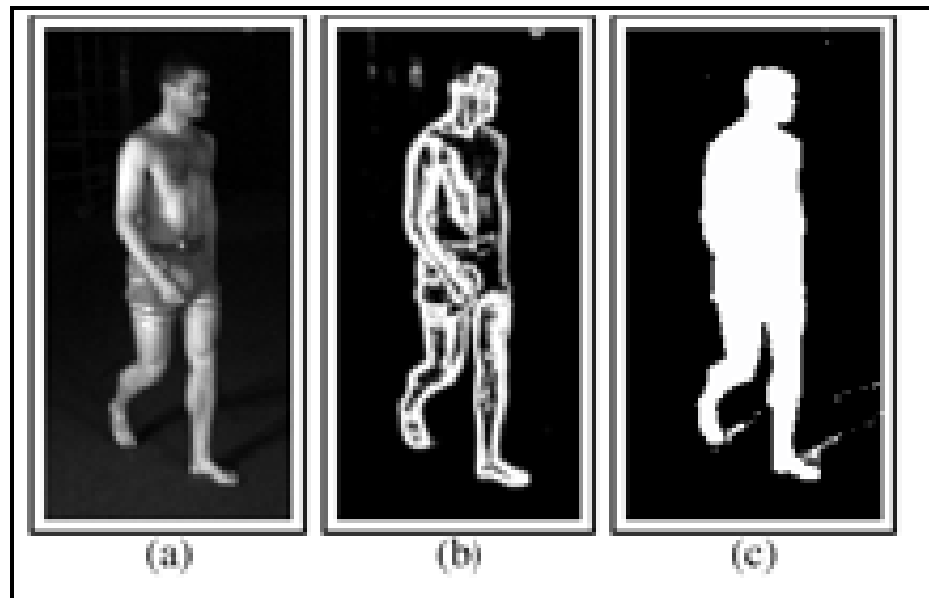
Object tracking



Digital Image Processing

Chapter 1: Introduction

Model based tracking



Digital Image Processing

Chapter 1: Introduction



Image type	Typical bpp	No. of colors	Common file formats
Binary image	1	2	JBIG, PCX, GIF, TIFF
Gray-scale	8	256	JPEG, GIF, PNG, TIFF
Color image	24	$16.6 \cdot 10^6$	JPEG, PNG, TIFF
Color palette image	8	256	GIF, PNG
Video image	24	$16.6 \cdot 10^6$	MPEG

Sample Image with different gray levels

**6 bits
(64 gray levels)**



**4 bits
(16 gray levels)**



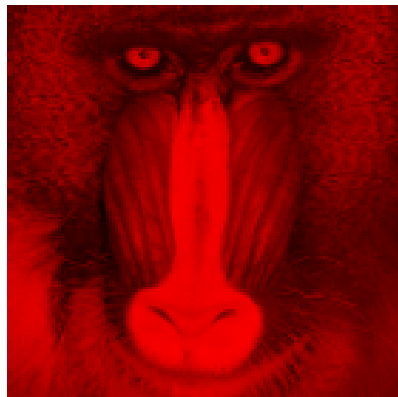
**2 bits
(4 gray levels)**



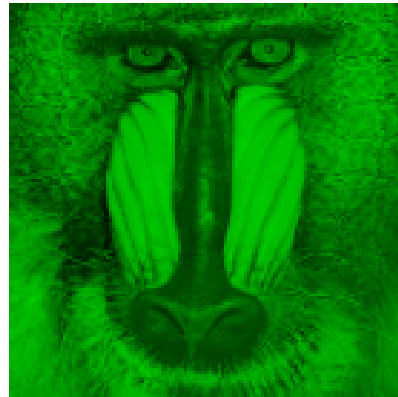
Digital Image Processing

Chapter 1: Introduction

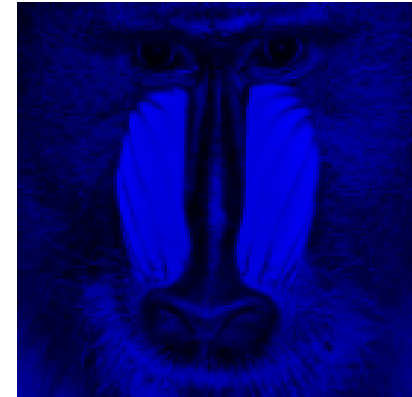
Color Images:



Red



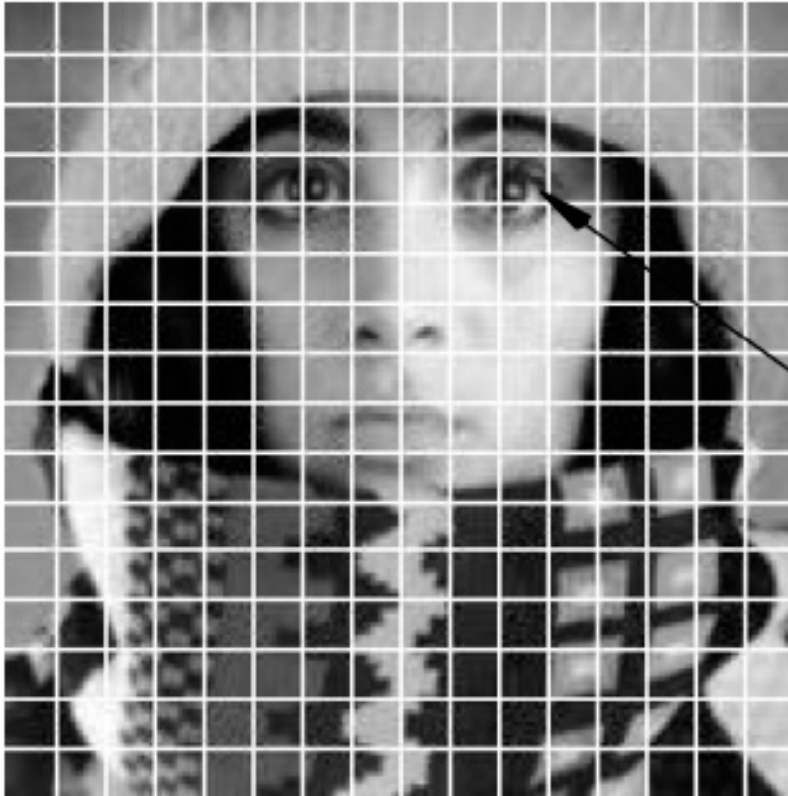
Green



Blue

Digital Image Processing

Chapter 1: Introduction

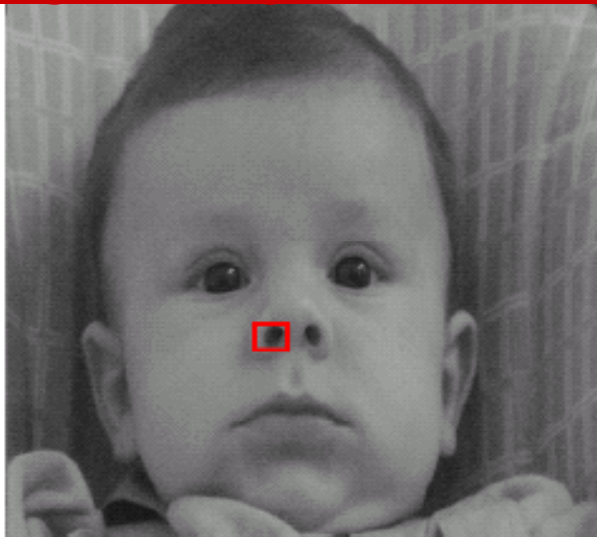


Digitization of a continuous image. The pixel at coordinates $[m=10, n=3]$ has the integer brightness value 110.

Digital Image Processing

Chapter 1: Introduction

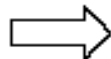
Digital Image Representation:



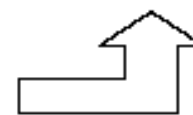
Pixel values in highlighted region

99	71	61	51	49	40	35	53	86	99
93	74	53	56	48	46	48	72	85	102
101	69	57	53	54	52	64	82	88	101
107	82	64	53	59	50	81	90	93	100
114	93	76	69	72	85	94	99	95	99
117	108	94	92	97	101	100	108	105	99
116	114	109	106	105	108	108	102	107	110
115	113	109	114	111	111	113	108	111	115
110	119	111	109	106	108	110	115	120	122
103	107	106	108	109	114	120	124	124	132

CAMERA



DIGITIZER



A set of number
in 2D grid

Digital Image Processing

Chapter 1: Introduction

From Acquisition to Interpretation:

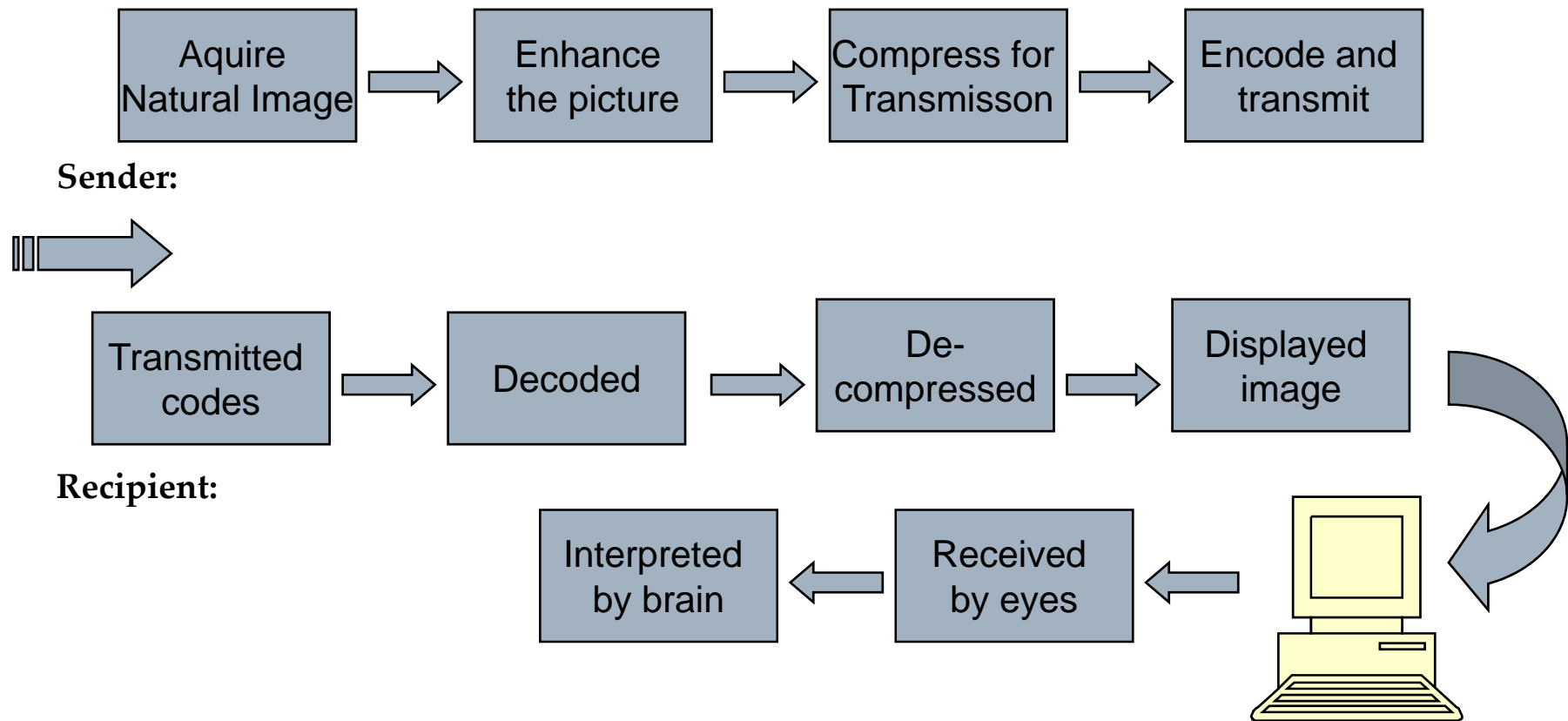


Image Categorization by source

- Principal energy source in use today is electromagnetic energy spectrum
- Synthetic images are generated by computer.
- Other sources : acoustic, ultrasonic, electronic (electron microscopy)

Electromagnetic spectrum

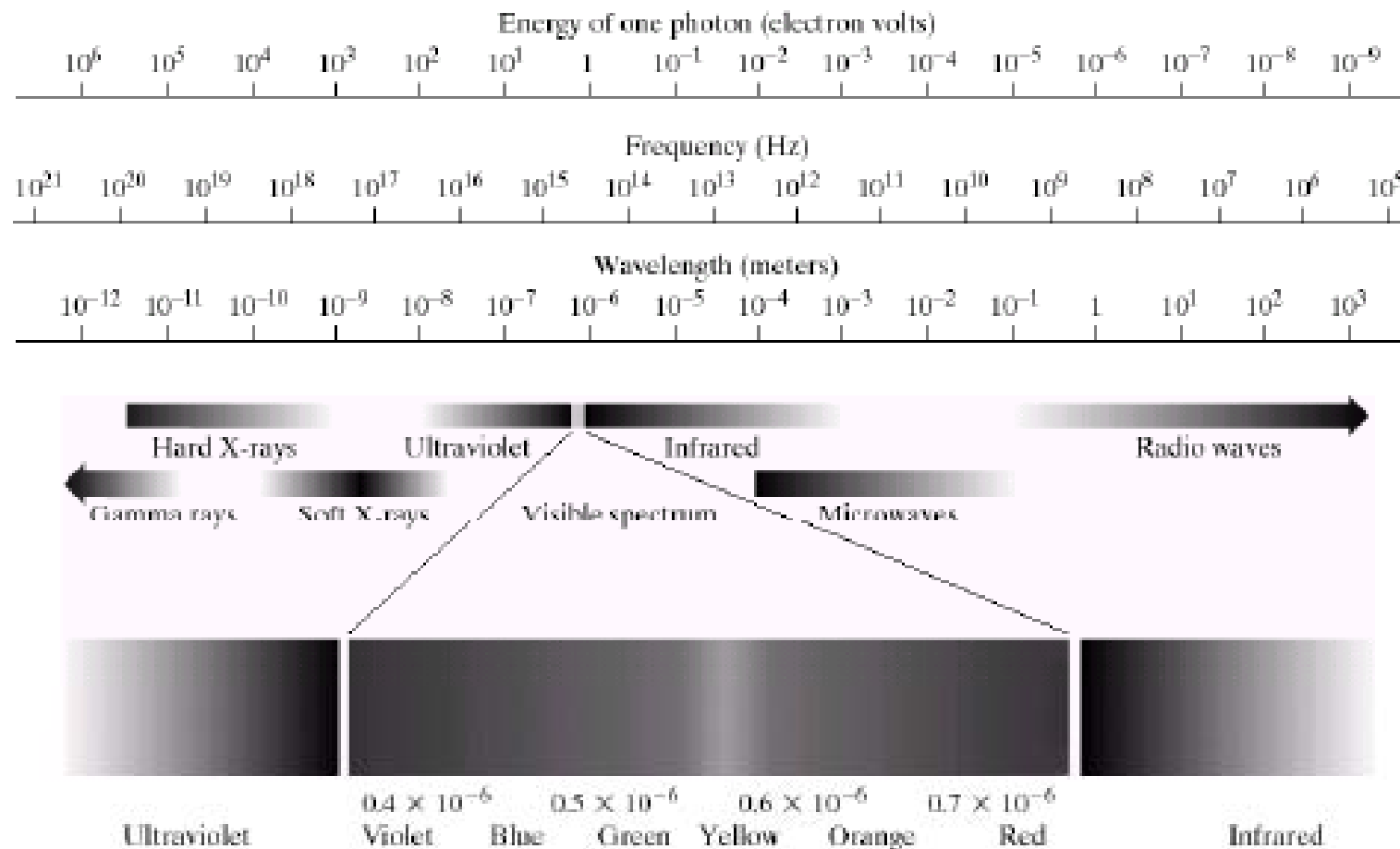


FIGURE 2.10 The electromagnetic spectrum. The visible spectrum is shown zoomed to facilitate explanation, but note that the visible spectrum is a rather narrow portion of the EM spectrum.

Digital Image Processing

Chapter 1: Introduction

Categorize by image sources:

- Radiation from electromagnetic spectrum
 - Gamma-Ray imaging
 - Maging in ultraviolet band
 - Imaging in microwave band
 - X-Ray imaging
 - Imaging in visible & infrared band
 - Imaging in radio band
- Acoustic
- Ultrasonic
- Electronic (electronic beams used in electron microscopy)
- Computer (synthetic images used for modeling and visualization)