Digital Image Processing

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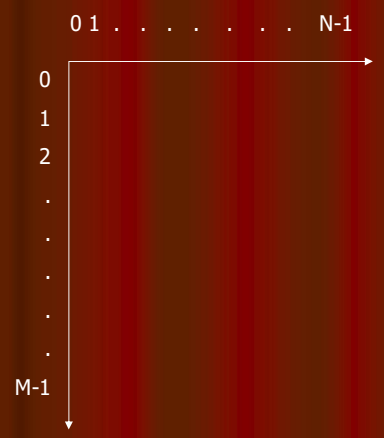
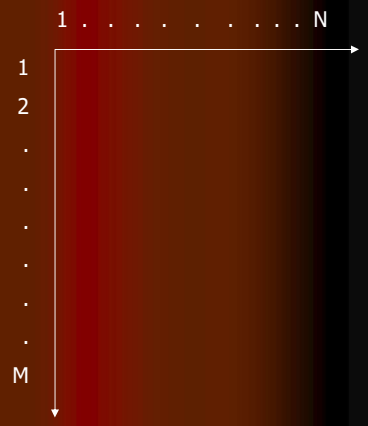
- What is Digital Image
- What is Image Processing
- History
- Computer Vision & Image Processing
- Applications of Image Processing
  - Gamma-Ray Imaging
  - X-Ray Imaging
  - Ultraviolet Band
  - Infrared Band
  - Microwave Bamd
  - Radiowave Bamd
  - Visible Bamd
- Components in Digital Image Processing
- Fundamental Steps in Digital Image Processing

What is Digital image

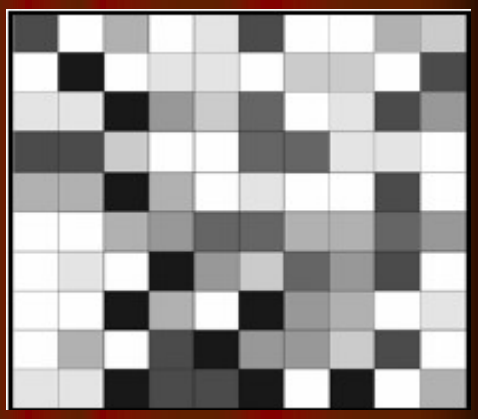
- An image may be defined as a 2-D function f (x. y) where x and y are plane co-ordinates and the amplitude of f at any pair of co-ordinates (x, y) is called the intensity of the image at that point.
- The term 'gray level' is used often to refer to the intensity of monochrome image.
- Color images are formed by a combination of individual 2-D images. For example, in RGB color system a color image consists of three individual component images.

What is Digital image





What is Digital image



254	107
255	165

Image Size

- This digitization process requires decisions about values for M, N, and for the number, L, of discrete gray levels allowed for each pixel. Where *M* and *N*, are positive integers. However, due to processing, storage, and sampling hardware considerations, the number of gray levels typically is an integer power of 2:

  $L = 2^K$

  Where k is number of bits require to represent a grey value

- The discrete levels should be equally spaced and that they are integers in the interval [0, L-1].
- The number, b, of bits required to store a digitized image is

  b=M*N*k.

Number of storage bits for various values of N and k

N/k	1 (L = 2)	2 (L = 4)	3 (L = 8)	4 (L = 16)	5 (L = 32)	6 (L = 64)	7 (L = 128)	8 (L = 256)
32	1,024	2,048	3,072	4,096	5,120	6,144	7,168	8,192
64	4,096	8,192	12,288	16,384	20,480	24,576	28,672	32,768
128	16,384	32,768	49,152	65,536	81,920	98,304	114,688	131,072
256	65,536	131,072	196,608	262,144	327,680	393,216	458,752	524,288
512	262,144	524,288	786,432	1,048,576	1,310,720	1,572,864	1,835,008	2,097,152
1024	1,048,576	2,097,152	3,145,728	4,194,304	5,242,880	6,291,456	7,340,032	8,388,608
2048	4,194,304	8,388,608	12,582,912	16,777,216	20,971,520	25,165,824	29,369,128	33,554,432
4096	16,777,216	33,554,432	50,331,648	67,108,864	83,886,080	100,663,296	117,440,512	134,217,728
8192	67,108,864	134,217,728	201,326,592	268,435,456	335,544,320	402,653,184	469,762,048	536,870,912

Digital Image Processing

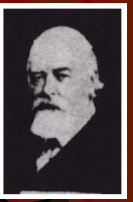
The field of digital image processing refers to processing of digital images by means of digital computer.

2-D image Representation

History

FIGURE 1.1 A digital picture produced in 1921 from a coded tape by a telegraph printer with special type faces. (McFarlane.)

FIGURE 1.2 A digital picture made in 1922 from a tape punched after the signals had crossed the Atlantic twice. Some errors are visible. (McFarlane.)



History

FIGURE 1.3 Unretouched cable picture of Generals Pershing and Foch, transmitted in 1929 from London to New York by 15-tone equipment. (McFarlane.)

FIGURE 1.4 The first picture of the moon by a U.S. spacecraft. *Ranger 7* took this image on July 31, 1964 at 9:09 A.M. EDT, about 17 minutes before impacting the lunar surface. (Courtesy of NASA.)

Image processing & Computer Vision

- In image processing we do things like
  - Removing noise from images
  - Finding edges and features in images
  - Filling in missing information in an image

- In computer vision we do things like
  - Finding moving objects in a scene
  - Recognising faces from a database
  - Build abstract models of the world from images

Image processing & Computer Vision

- Three processing levels:

Digital Image Processing

- Low-level process:
  - Primitive operations like noise reduction, contrast enhancement, image sharpening…
  - Input: image Output: image
- Mid-level process:
  - Tasks like segmentation, representation, description
  - Input: image Output: attributes extracted from images

Computer Vision

- High-level process
  - "Making sense" of an ensemble of recognized objects
  - Input: image (sequence) Output: interpretation

Image processing & Computer Vision

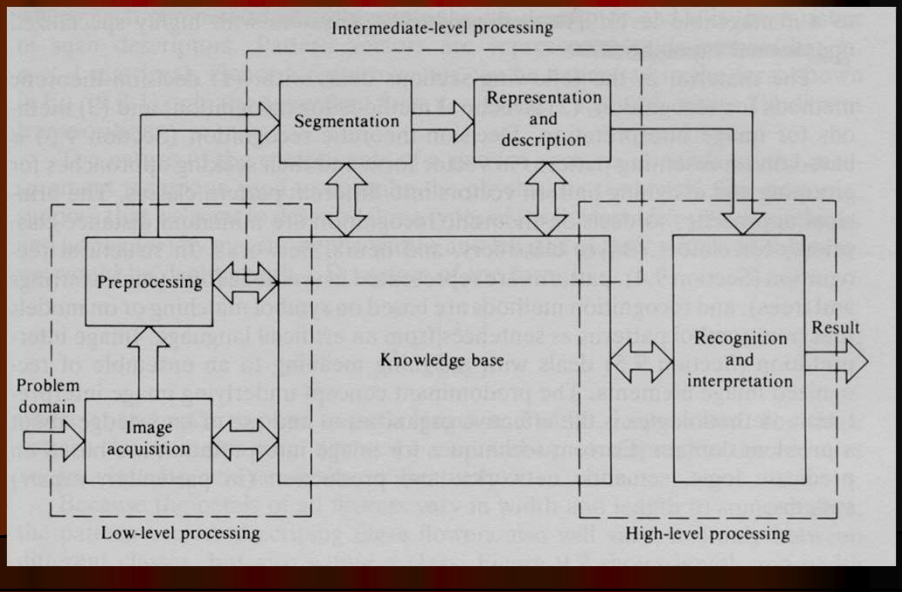


Image Processing Applications

Electromagnetic Spectrum

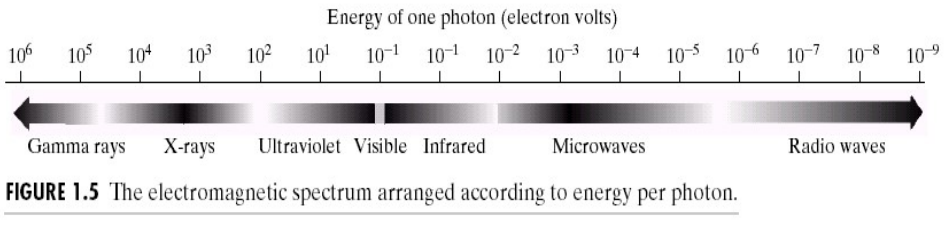


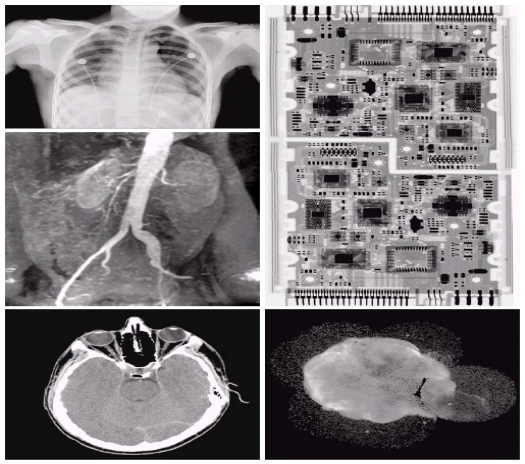
FIGURE 1.5 The electromagnetic spectrum arranged according to energy per photon.

Electromagnetic Spectrum (Gamma Ray Imaging)

a b
c d

FIGURE 1.6 Examples of gamma-ray imaging. (a) Bone scan. (b) PET image. (c) Cygnus Loop. (d) Gamma radiation (bright spot) from a reactor valve. (Images courtesy of (a) G.E. Medical Systems, (b) Dr. Michael E. Casey, CTI PET Systems, (c) NASA, (d) Professors Zhong He and David K. Wehe, University of Michigan.)

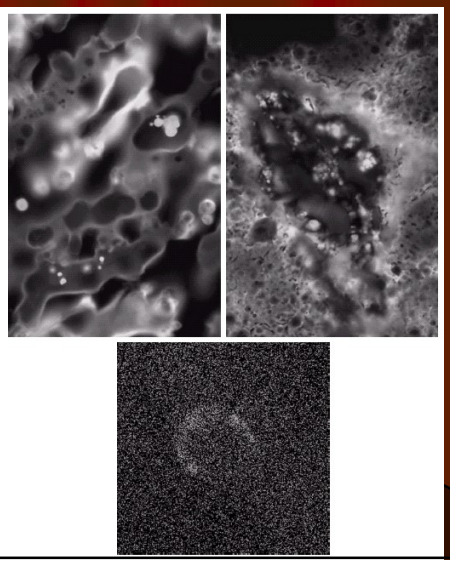
Electromagnetic Spectrum (X-Ray Imaging)



a d
b e
c

FIGURE 1.7 Examples of X-ray imaging. (a) Chest X-ray. (b) Aortic angiogram. (c) Head CT. (d) Circuit boards. (e) Cygnus Loop. (Images courtesy of (a) and (c) Dr. David R. Pickens, Dept. of Radiology & Radiological Sciences, Vanderbilt University Medical Center, (b) Dr. Thomas R. Gest, Division of Anatomical Sciences, University of Michigan Medical School, (d) Mr. Joseph E. Pascente, Lixi, Inc., and (e) NASA.)

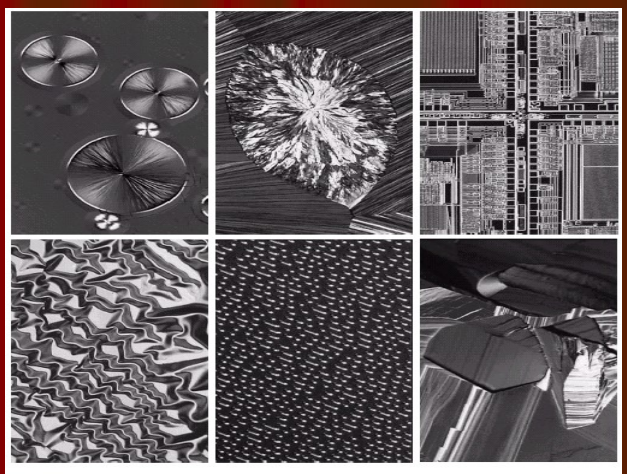
Electromagnetic Spectrum (Ultraviolet Imaging)



a b c

FIGURE 1.8 Examples of ultraviolet imaging. (a) Normal corn. (b) Smut corn. (c) Cygnus Loop. (Images courtesy of (a) and (b) Dr. Michael W. Davidson, Florida State University, (c) NASA.)

Electromagnetic Spectrum (Infrared Imaging)



a b c d e f

FIGURE 1.9 Examples of light microscopy images. (a) Taxol (anticancer agent), magnified 250×. (b) Cholesterol—40×. (c) Microprocessor—60×. (d) Nickel oxide thin film—600×. (e) Surface of audio CD—1750×. (f) Organic superconductor—450×. (Images courtesy of Dr. Michael W. Davidson, Florida State University.)

Electromagnetic Spectrum (Microwave Band)

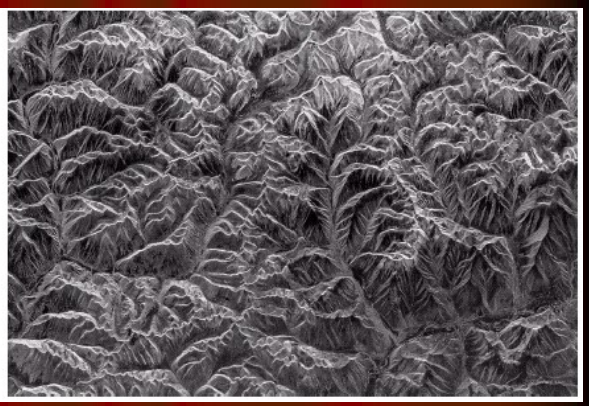
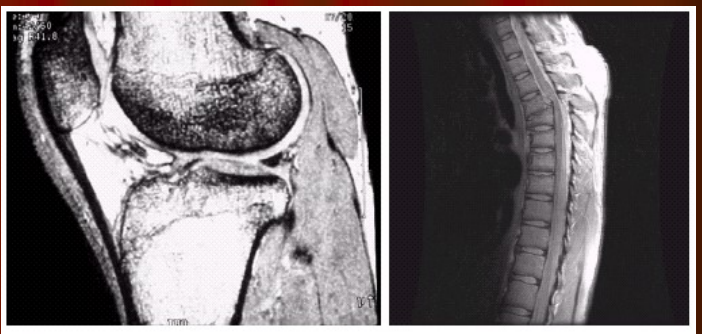


FIGURE 1.16 Spaceborne radar image of mountains in southeast Tibet. (Courtesy of NASA.)

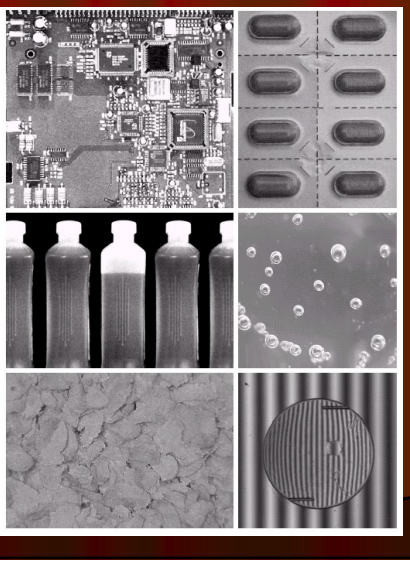
Electromagnetic Spectrum (Radio Wave)



a b

FIGURE 1.17 MRI images of a human (a) knee, and (b) spine. (Image (a) courtesy of Dr. Thomas R. Gest, Division of Anatomical Sciences, University of Michigan Medical School, and (b) Dr. David R. Pickens, Department of Radiology and Radiological Sciences, Vanderbilt University Medical Center.)

Electromagnetic Spectrum (Visible Band)



a b
c d
e f

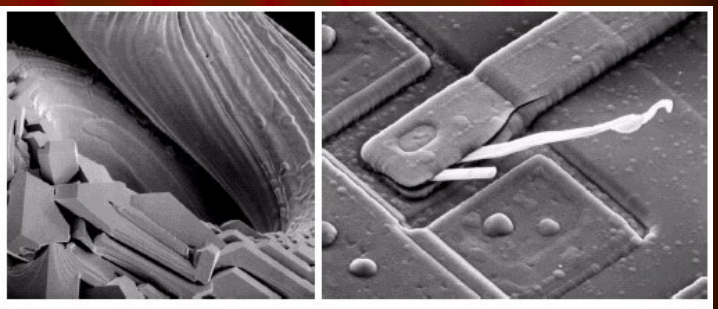
FIGURE 1.14
Some examples of manufactured goods often checked using digital image processing. (a) A circuit board controller. (b) Packaged pills. (c) Bottles. (d) Bubbles in clear-plastic product. (e) Cereal. (f) Image of intraocular implant. (Fig. (f) courtesy of Mr. Pete Sites, Perceptics Corporation.)

Electromagnetic Spectrum (Visible Band)

a b
c
d

FIGURE 1.15
Some additional examples of imaging in the visual spectrum. (a) Thumb print. (b) Paper currency. (c) and (d). Automated license plate reading. (Figure (a) courtesy of the National Institute of Standards and Technology. Figures (c) and (d) courtesy of Dr. Juan Herrera, Perceptics Corporation.)

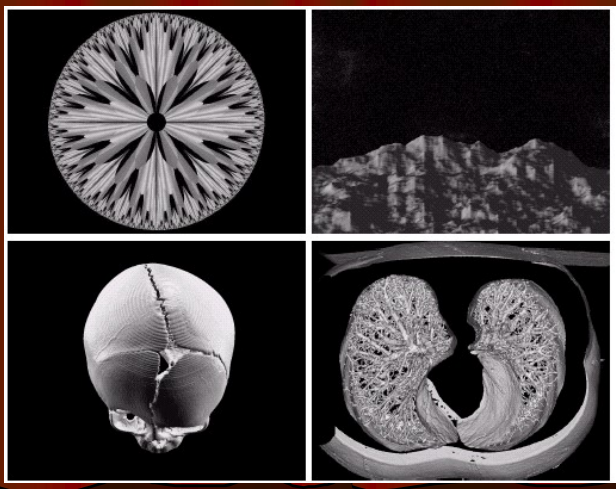
Other Applications



a b

FIGURE 1.21 (a) 250× SEM image of a tungsten filament following thermal failure. (b) 2500× SEM image of damaged integrated circuit. The white fibers are oxides resulting from thermal destruction. (Figure (a) courtesy of Mr. Michael Shaffer, Department of Geological Sciences, University of Oregon, Eugene; (b) courtesy of Dr. J. M. Hudak, McMaster University, Hamilton, Ontario, Canada.)

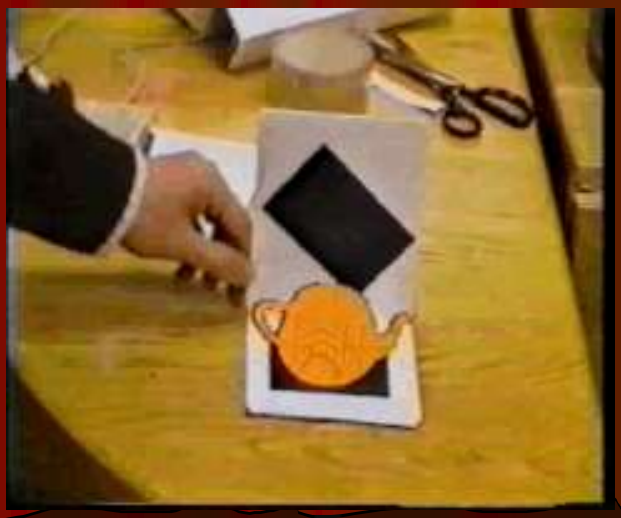
Fractal & 3-D Imaging



a b
c d

FIGURE 1.22 (a) and (b) Fractal images. (c) and (d) Images generated from 3-D computer models of the objects shown. (Figures (a) and (b) courtesy of Ms. Melissa D. Binde, Swarthmore College, (c) and (d) courtesy of NASA.)

Inserting Artificial Objects into a Scene



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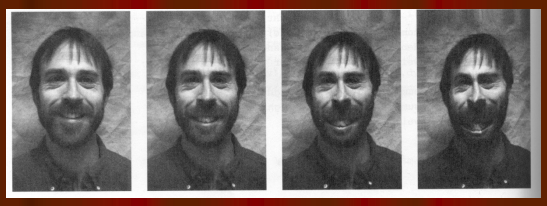
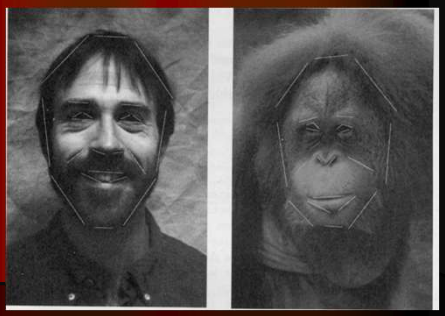
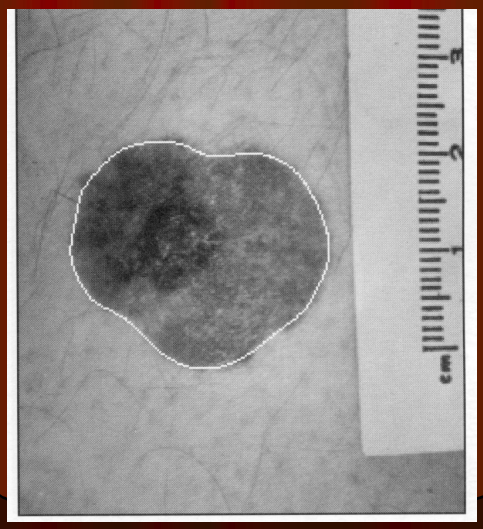
Morphing





Medical Applications



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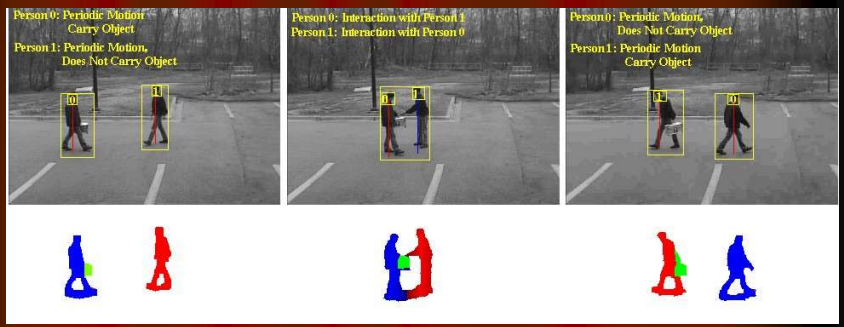
Human Activity Recognition

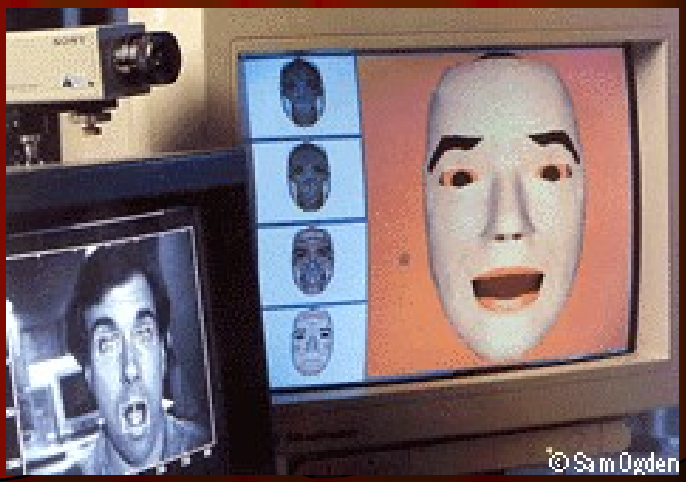


30

Hand Gesture Recognition

31

Facial Expression Recognition



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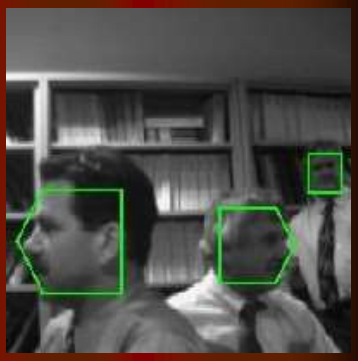
Face Detection



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Target Recognition

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Indexing into Databases

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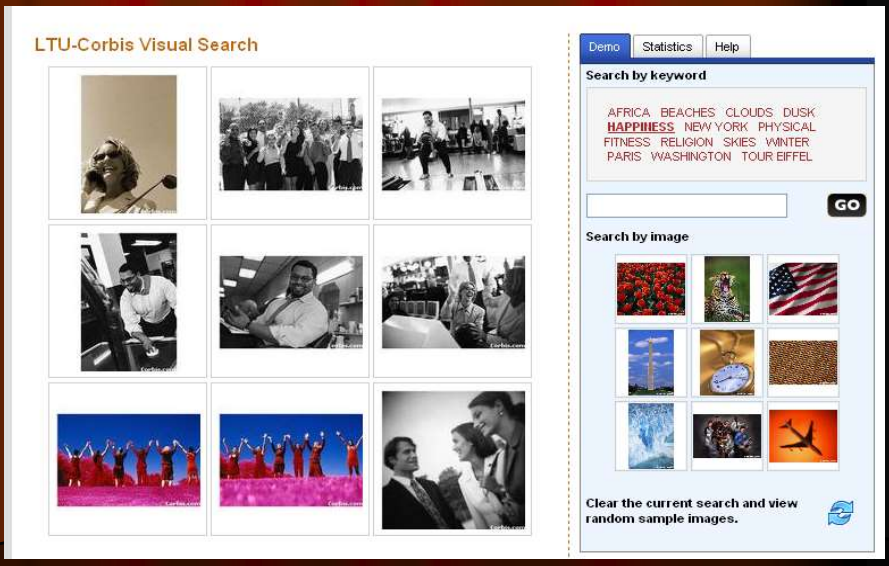
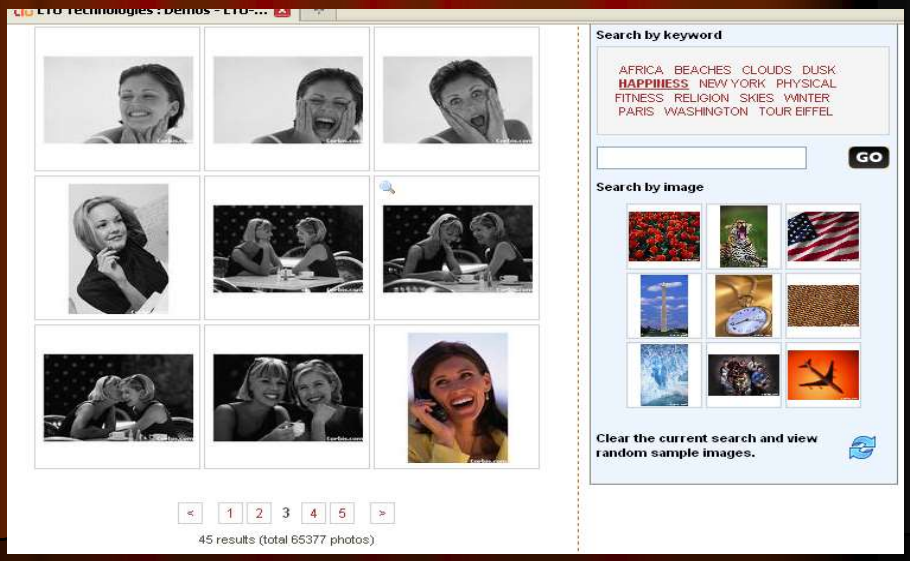
Keyword based Image Retrieval



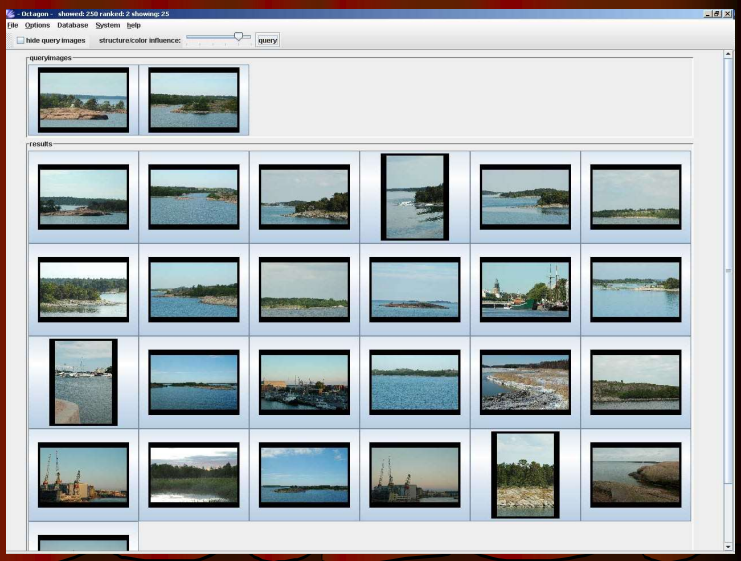
Keyword based Image Retrieval



Content Based Image Retrieval

- http://amazon.ece.utexas.edu/~qasim/samples/sample_transport1.html

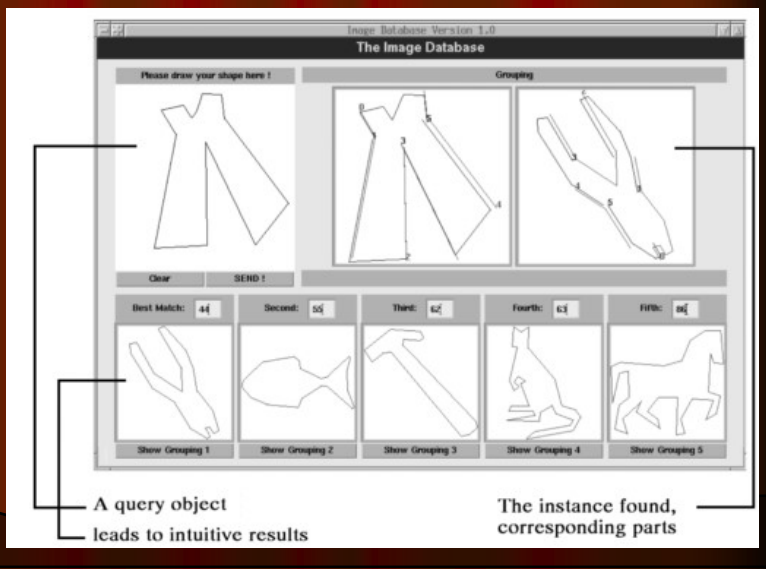
Content Based Image Retrieval : Octagon



Content Based Image Retrieval

40

Indexing into Databases



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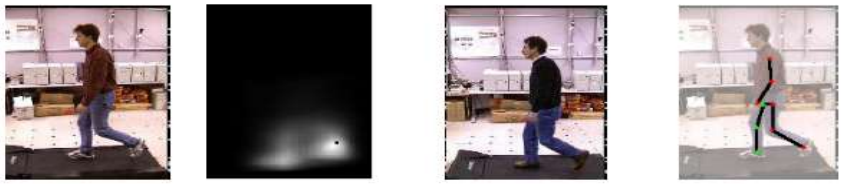
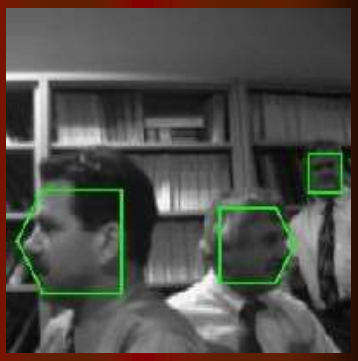
More Applications

Human Pose Estimation using Motion Exemplars



Human Body Pose Estimation

Face Detection



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Other Applications

- Fingerprint Recognition
- Biometrics
- Signature Verification
- Document Handling
- Object Recognition
- Color Image Processing

.....List is Endless

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Components in Digital Image Processing

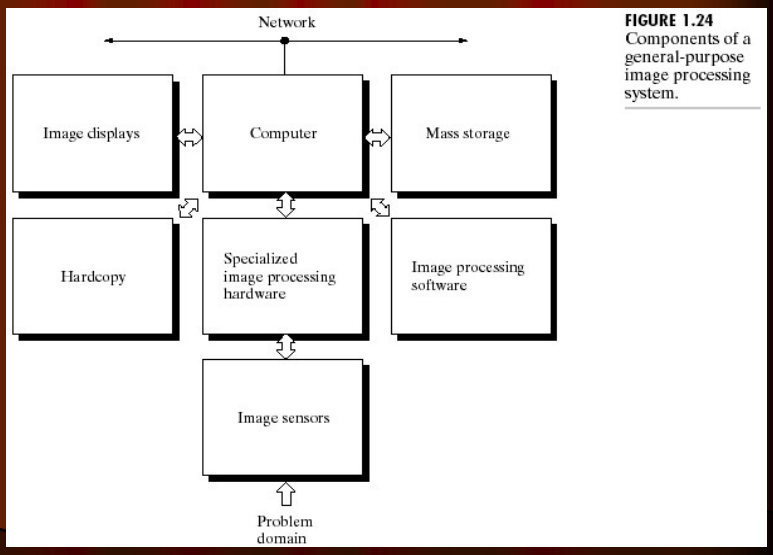


FIGURE 1.24 Components of a general-purpose image processing system.

Fundamental Steps in DIP

FIGURE 1.23 Fundamental steps in digital image processing.

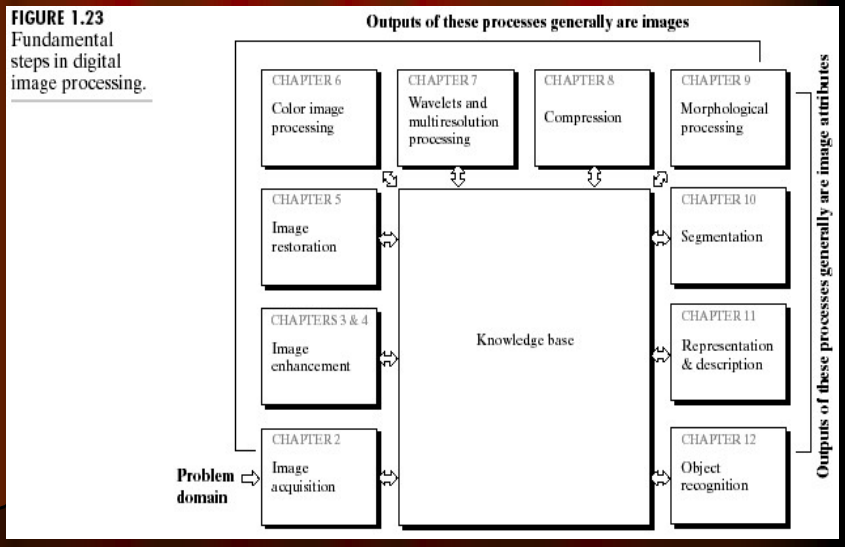
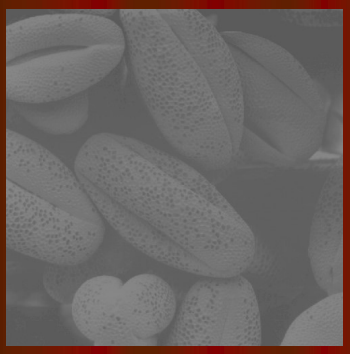


Image Enhancement

- Accentuate certain image features for subsequent analysis or for image display



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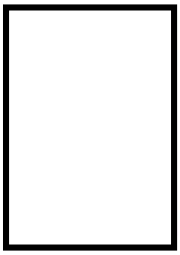
Sample Images

Lena Soderberg (Swedish)



Lena in 1997

A good test image !!
Nice mixture of detail,
flat regions, shading and texture

By W.K. Pratt (USC)

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Image Restoration

- To remove or minimize known/unknown degradations in an image

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Image Data Compression

- To reduce the amount of data required to represent images

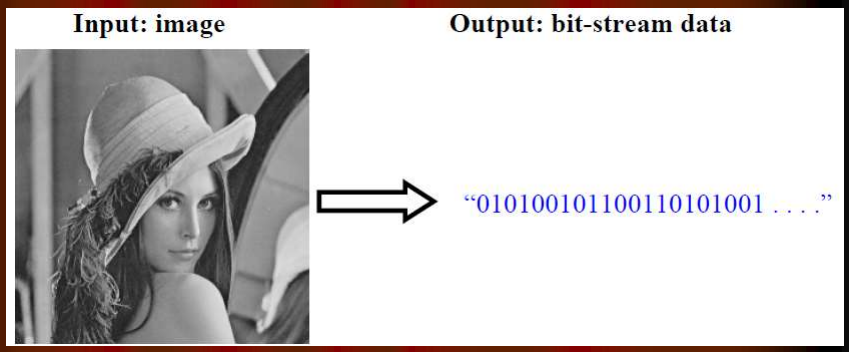
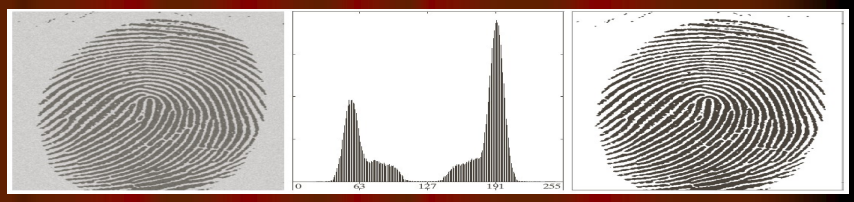


Image Segmentation



Color Image Processing

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THANK YOU