Lecture No. #1

Digital Image Processing

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References:

1. Digital Image processing by gonzales and woods 2nd edition.
2. Digital Image processing by gonzales and woods 3rd edition.p
3. Image Processing Using MATLAB by TechSource Systems Sdn. Bhd.
4. Digital Image processing Using MATLAB by gonzales & woods & Eddins .

Chapter One

>>" Introduction to Digital Image Processing"

® ***Define the field.***

® ***Data Classes.***

® ***Component of Digital Image Processing system.***

® ***Applications and Techniques.***

What is digital Image?

- A **digital image** differs from a photo in that the values are all **discrete**.
- Usually they take on only **integer** values.
- A digital image can be considered as a large array of discrete dots, each of which has a brightness associated with it. These dots are called picture elements, or more simply **pixels**.
- The pixels surrounding a given pixel constitute its **neighborhood** A neighborhood can be characterized by its shape in the same way as a matrix: we can speak of a 3x3 neighborhood, or of a 5x7 neighborhood.

1920's Picture Transmission Systems

One of the first applications of digital images was in the newspaper industry. Pictures were sent by submarine cable between London and New York. Introduction of the Bartlane cable picture transmission system in the early 1920s reduced the time required to transport a picture across the Atlantic from more than a week to less than three hours.

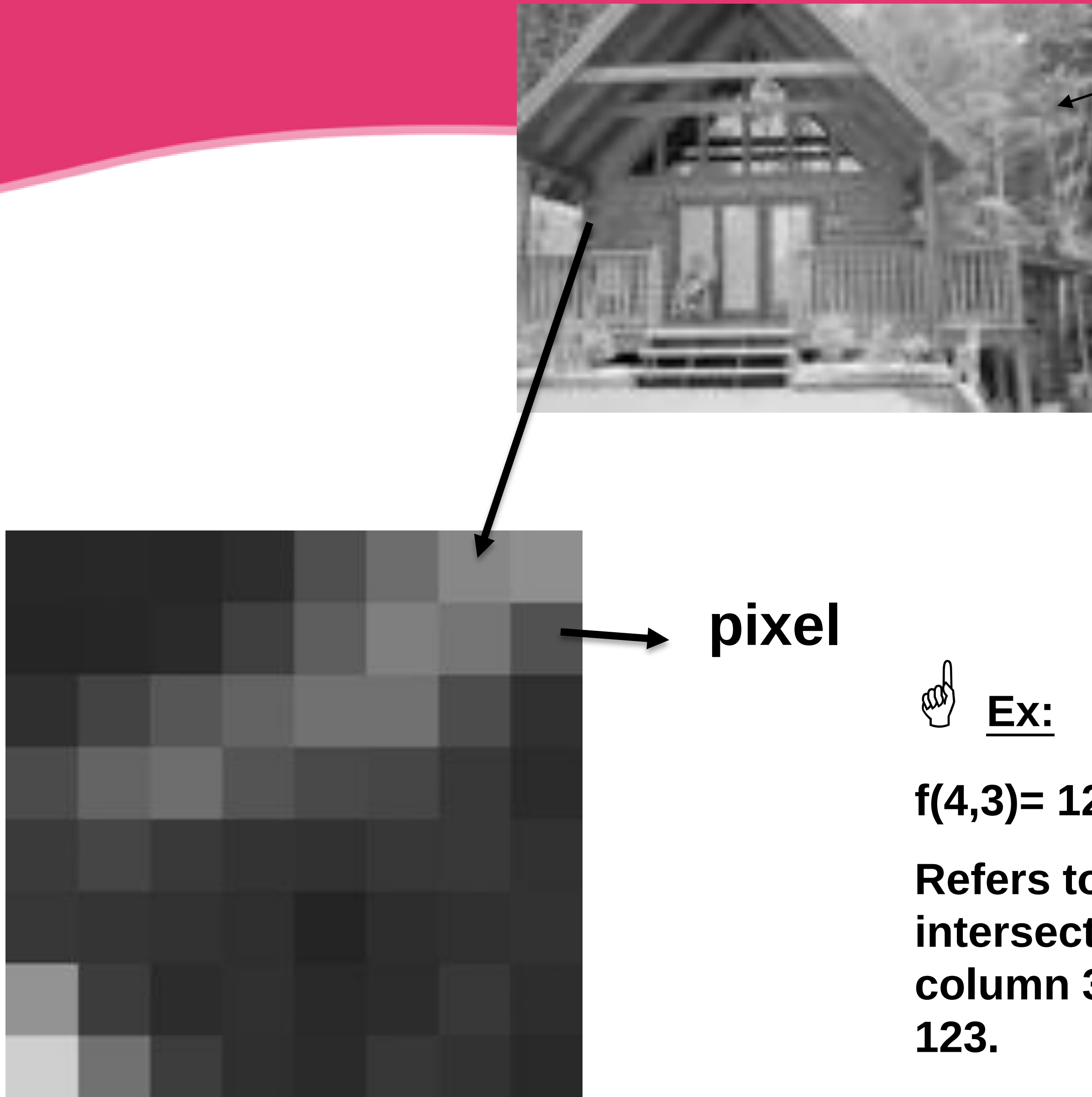
A digital picture produced in 1921 from a coded tape by a telegraph printer with special type faces.

Birth of Digital Image Processing (DIP)

- **The first computers powerful enough to do meaningful image processing appeared in the early 1960s for the space program.**
- **DIP techniques began in the late 1960s and early 1970s to be used in medical imaging, remote Earth resources observations, and astronomy.**
- **The invention in the early 1970s of computerized axial tomography (CAT), also called computerized tomography (CT) for short, is one of the most important events in the application of image processing in medical diagnosis.**

The first picture of the moon by the U.S. spacecraft *Ranger 7* , July 31,1964

What is digital image?



The image consists of finite number of pixels (f(x,y))

Every pixel Is an intersection تقاطع between a row and a column.

every pixel has intensity كثافة

<u>Ex:</u>

f(4,3)= 123

Refers to a pixel existing on the intersection between row 4 with column 3, and its intensity is 123.

Remember: images can be: binary, grayscale, color.

"Binary Images"

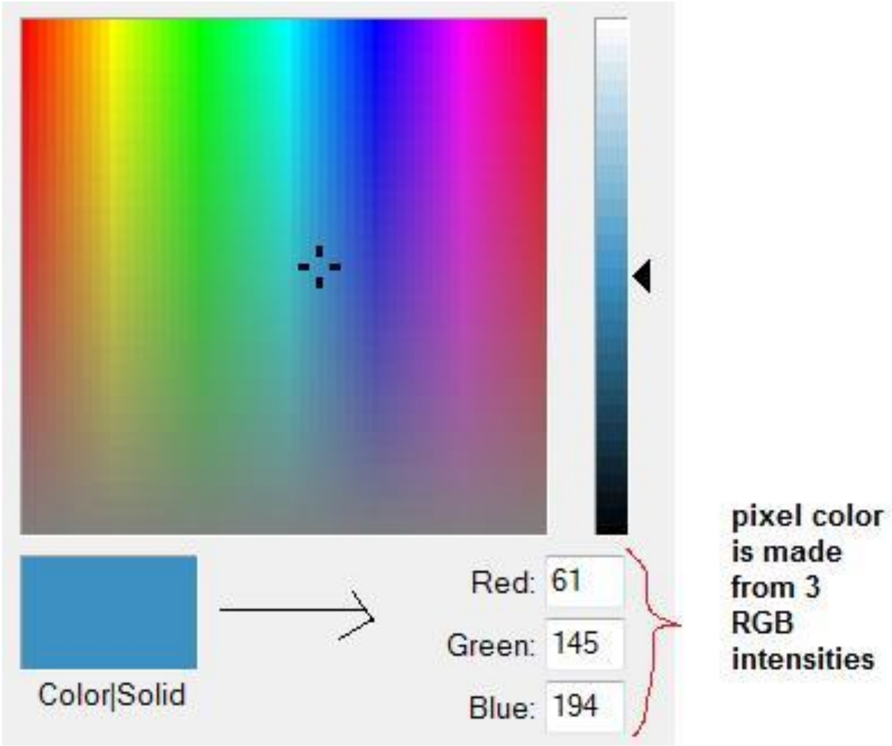
<u>Binary images:</u> are images that have been quantized to two values, usually denoted 0 and 1, but often with pixel values 0 and 255, representing black and white.

"Grayscale Images"

- **<u>A grayscale (or graylevel) image:</u>** is simply one in which the only colors are shades of gray (0 – 255)

"Color Images"

- **<u>Color image:</u>** A color image contains pixels each of which holds three intensity values corresponding to the red, green, and blue or(RGB)



Digital image processing levels

- **low level processes:** primitive operations ex: reduce noise, enhance contrast enhancement and sharpening.

مثال صورة قديمة نريد تحسينها

- **Mid:** segmentation (partitioning image as regions and objects).

مثال: صورة لكرسي نريد تعديلها حاسوبيا لنبرز حوافه

- **High –level:** recognizing objects

مثال: صورة لمشتبه فيه نريد الحاسوب ان يتعرف عليه

Types of Imaging Systems

- Imaging systems depend on energy sources
- Sources of energy include:
  - the electromagnetic energy (EM) spectrum,
  - Ultrasonic,
  - acoustic, and
  - electronic
- Accordingly there are different types of imaging systems and an ever growing list of applications.
- Multi-spectrum imaging is also available

Types of Imaging systems:

Imaging systems are varying depending on their energy source (e.g. visual, X-ray, and so on). The principal energy source for images in use today is the *electromagnetic (EM) spectrum* illustrated in Figure 1.1. Other important sources of energy include acoustic, ultrasonic, and electronic (in the form of electron beams used in electron microscopy). Synthetic images, used for modeling and visualization, are generated by computer. In this section we discuss briefly how images are generated in these various categories and the areas in which they are applied.

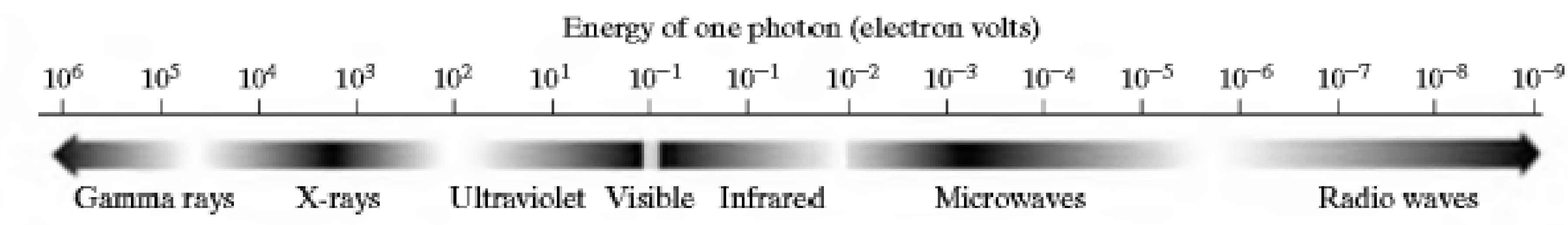
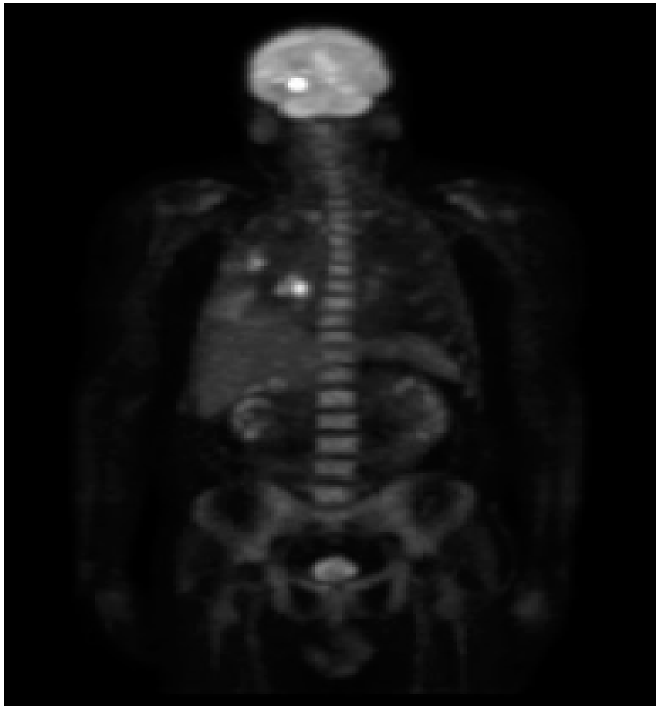


Figure 1.1 the electromagnetic spectrum arranged according to energy per photon.

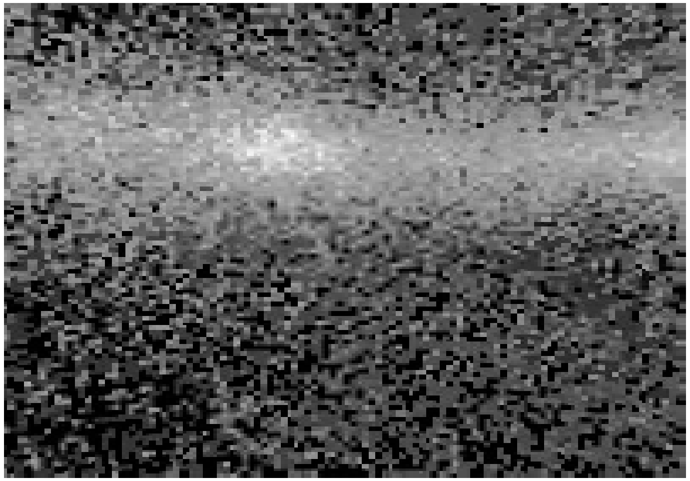
1. Gamma-ray Imaging

Gamma rays are emitted as a result of collision of certain radioactive isotopes (a positron and an electron). This occurs naturally around exploding stars, and can be created easily. Images are produced from the emissions collected by gamma ray detectors.

Major uses of gamma ray imaging include nuclear medicine and astronomical observations. In nuclear medicine, a patient is injected with a radioactive isotope that emits gamma rays as it decays. Figure 1.2(a) shows a major modality of nuclear imaging called positron emission tomography (PET) obtained by using gamma-ray imaging. The image in this figure shows a tumor in the brain and one in the lung, easily visible as small white masses.



(a)



(b)

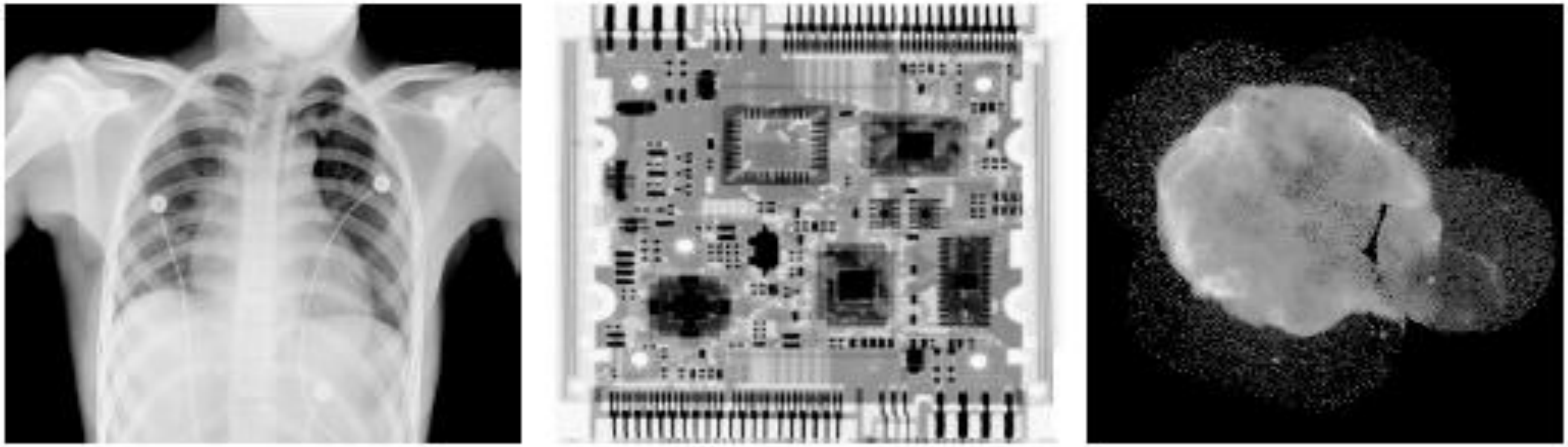
Figure 1.2 Examples of Gamma-Ray imaging a) PET image b) Star explosion 15,000 years ago

Figure 1.2(b) shows a star exploded about 15,000 years ago, imaged in the gamma-ray band. Unlike the previous example shown in Figure 1.2(a), this image was obtained using the natural radiation of the object being imaged.

2. X-ray Imaging

X-rays are generated using an X-ray tube (a vacuum tube with a cathode and anode). The cathode is heated, causing free electrons to be released and flowing at high speed to the positively charged anode. When the electrons strike a nucleus, a modified energy is released in the form of X-ray radiation. Images are either generated by: 1) dropping the resulting energy on a film, then digitizing it or 2) dropping directly onto devices that convert X-rays to light. The light signal in turn is captured by a light-sensitive digitizing system.

X-rays are widely used for imaging in medicine, industry and astronomy. In medicine, chest X-ray, illustrated in Figure 1.3(a), is widely used for medical diagnostics.



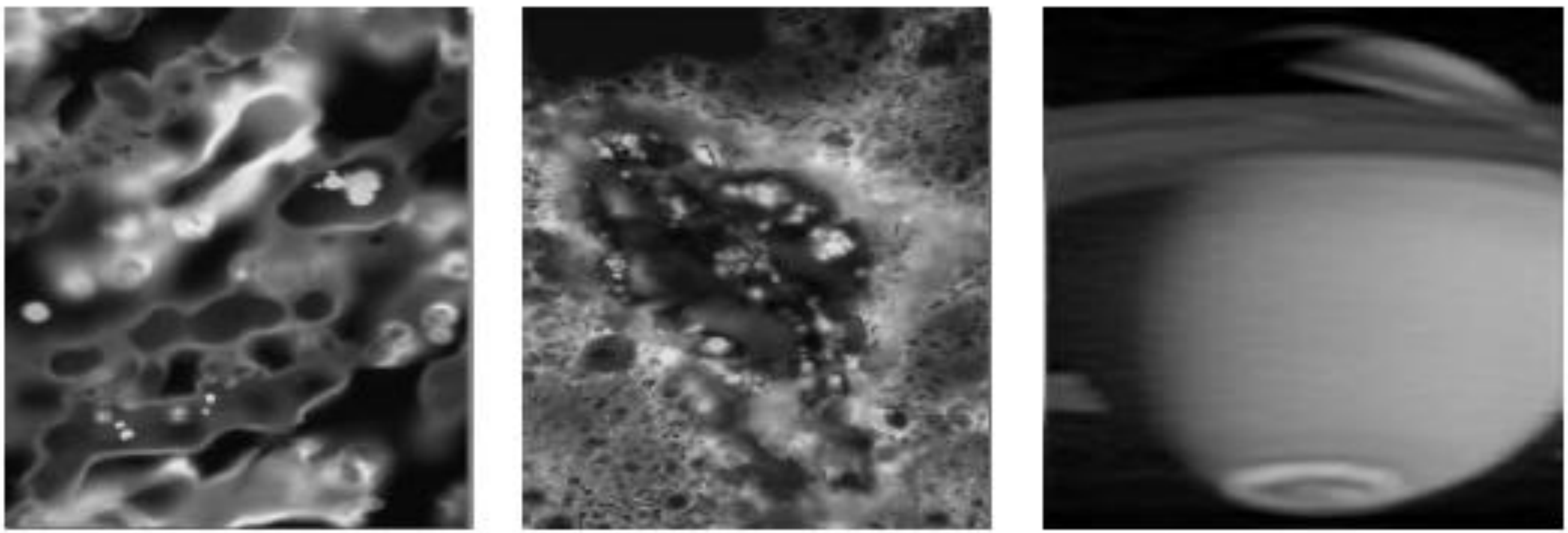
(a) (b) (c)

Figure 1.3 Examples of X-Ray imaging. a) Chest X-ray. b) Circuit board. c) Star explosion

In industrial processes, X-rays are used to examine circuit boards, see Figure 1.3(b), for flaws in manufacturing, such as missing components or broken traces. Figure 1.3(c) shows an example of X-ray imaging in astronomy. This image is the star explosion of Figure 1.2 (b), but imaged this time in the X-ray band.

3.Ultraviolet Imaging

Applications of ultraviolet "light" are varied. They include industrial inspection, fluorescence microscopy, lasers, biological imaging, and astronomical observations. For example, Figure 1.4(a) shows a fluorescence microscope image of normal corn, and Figure 1.4(b) shows corn infected by "smut," a disease of corn. Figure 1.4(c) shows the entire "oval" of the auroral emissions at Saturn's South Pole captured with Cassini's ultraviolet imaging spectrograph.

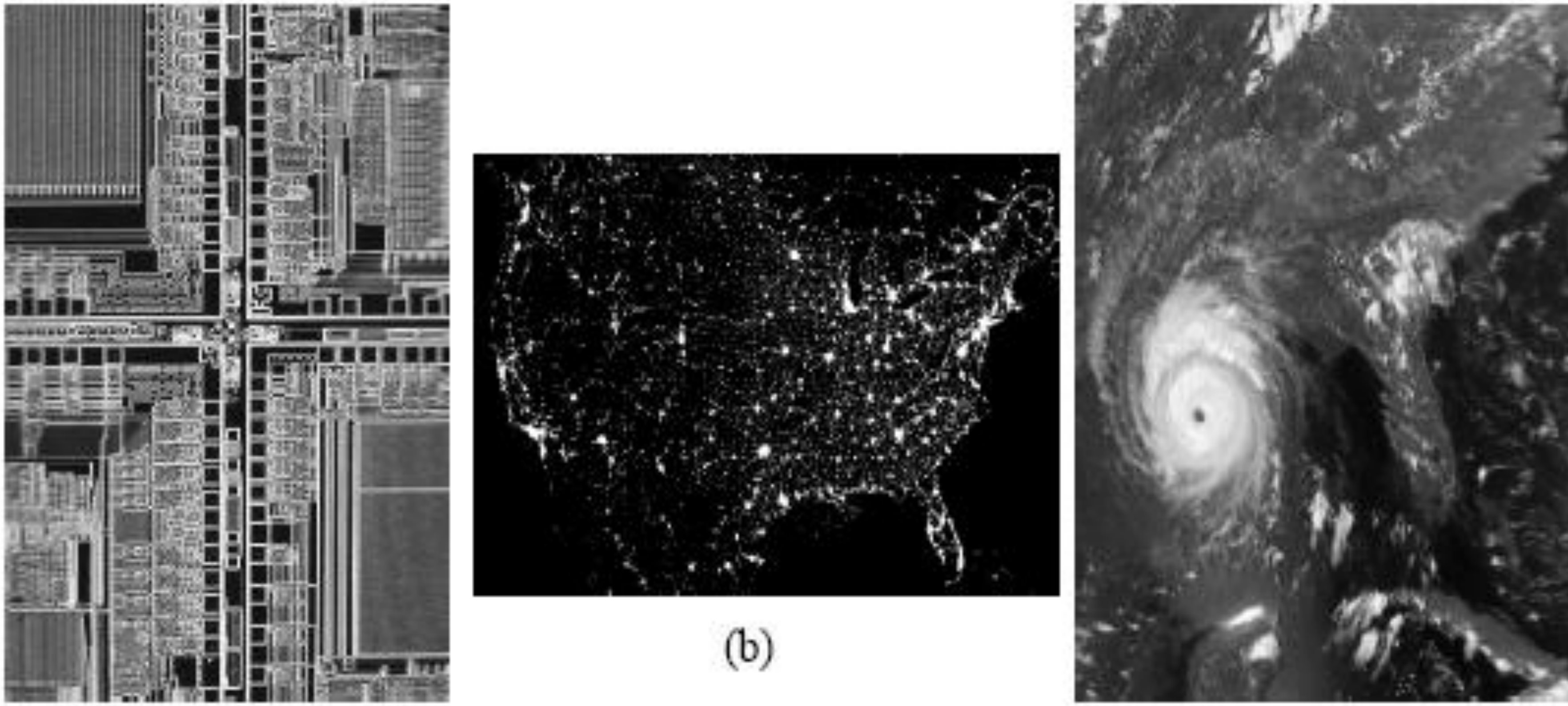


(a) (b) (c)

Figure 1.4 Examples of ultraviolet imaging (a) Normal corn (b) Smut corn (c) Emissions at Saturn's South Pole

4.Imaging in the Visible and Infrared bands

The visual band of the EM spectrum is the most familiar in all activities and has the widest scope of application. The infrared band often is used in conjunction with visual imaging (Multispectral Imaging). Applications include light microscopy, astronomy, remote sensing, industry, and law enforcement. Figure 1.5(a) shows a microprocessor image magnified 60 times with a light microscope, and Figure 1.5(b) illustrates infrared satellite image of the Americas. Figure 1.5(c) shows a multispectral image of a hurricane taken by a weather satellite.



(b)

(a) (c)

Figure 1.5 Examples of visible and infrared imaging. a) Microprocessor magnified 60 times. b) Infrared satellite image of the US. c) Multispectral image of Hurricane

5.Imaging in the Microwave band

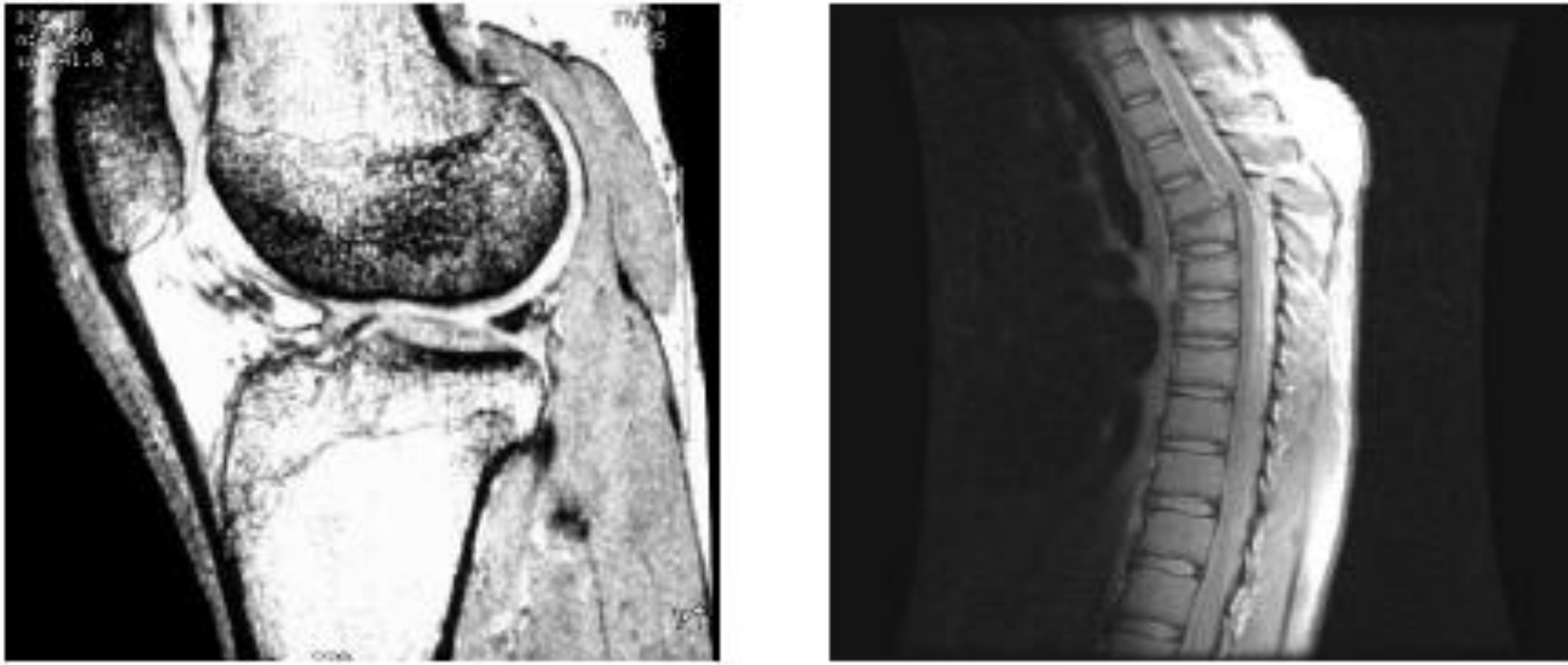
The dominant application of imaging in the microwave band is radar. Imaging radar works like a flash camera in that it provides its own illumination (microwave pulses) to illuminate an area on the ground and take a snapshot image. Instead of a camera lens, radar uses an antenna and digital computer processing to record its images. In a radar image, one can see only the microwave energy that was reflected back toward the radar antenna. Figure 1.6 shows a radar image covering a rugged mountainous area.

Figure 1.6

Radar image of mountainous region

6. Imaging in the Radio band

The major applications of imaging in the radio band are in medicine and astronomy. In medicine radio waves are used in magnetic resonance imaging (MRI). For MRI, a powerful magnet passes radio waves through the patient body in short pulses. Patient's tissues respond by emitting pulses of radio waves. The location and strength of these signals are determined by a computer, which produces a 2D picture of a section of the patient. Figure 1.7 shows MRI images of a human knee and spine.



(a) (b)

Figure 1.7 MRI images of a human (a) knee, and (b) spine.

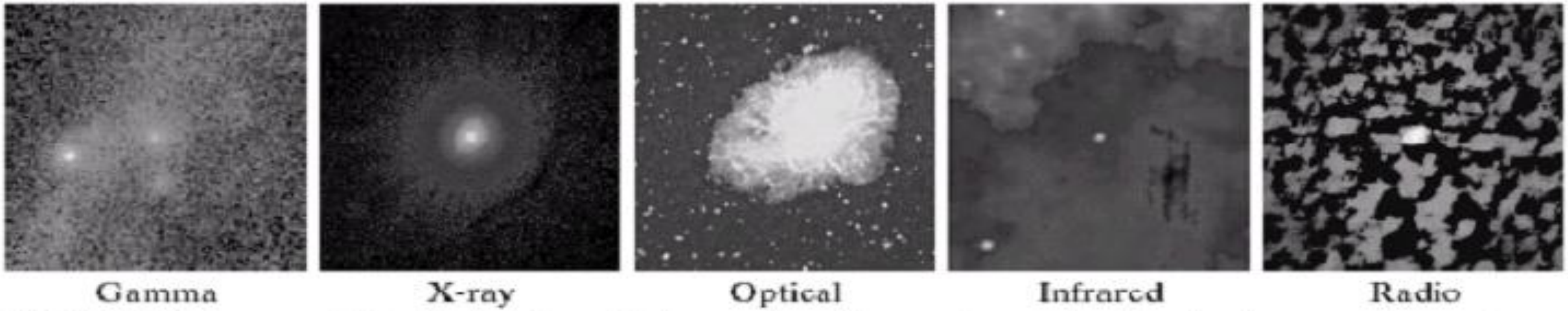


FIGURE 1.18 Images of the Crab Pulsar (in the center of images) covering the electromagnetic spectrum. (Courtesy of NASA.)

Many images in many bands for exactly the same object; totally different images!!

Which one of these is the object? The question is wrong, because all of these (and other images in other bands) are the interaction among three things:

1- the wave hitting the object.
2- the quality of the object and how it reacts with the wave.
3- the receiver quality, whether it is the human eye or a special purpose camera.

No one knows the essence of anything; we cannot prove anything in science. We just observe indicators and understand in terms of these indicators. (More on this in Ch. 2).
We really do not know and cannot know but very little.
Even, we can use other modalities for the same object than the EM-based modality:

7.Other Imaging Modalities

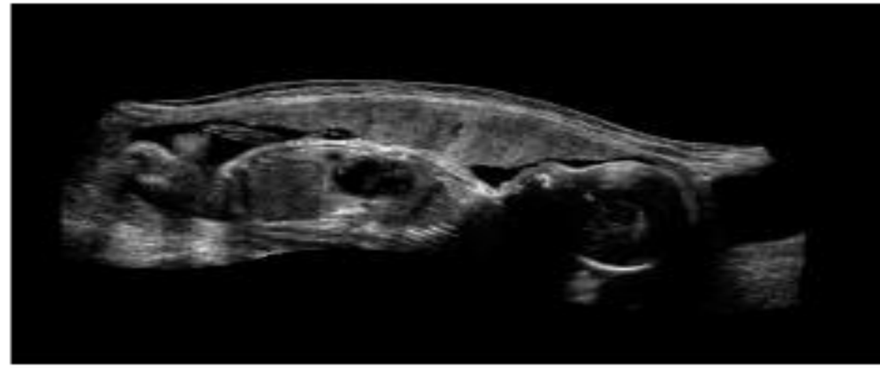
There are a number of other imaging modalities that also are important. Examples include acoustic imaging, electron microscopy, and synthetic (computer-generated) imaging.

Imaging using "sound waves" finds application in medicine, industry and geological exploration. In medicine, ultrasound imaging is used in obstetrics where unborn babies are imaged to determine the health of their development. A byproduct of this examination is determining the sex of the baby. Figure 1.8 shows examples of ultrasound imaging.

The procedure of generating ultrasound images is as follows:

1. The ultrasound system (a computer, ultrasound probe consisting of a source and receiver, and a display) transmits high-frequency (1 to 5 MHz) sound pulses into the body.
2. The sound waves travel into the body and hit a boundary between tissues. Then, they are reflected back and picked up by the probe and relayed to the computer.
3. The computer calculates the distance from the probe to the tissue or organ boundaries, and then it displays the distances and intensities of the echoes on the screen, forming a two-dimensional image.

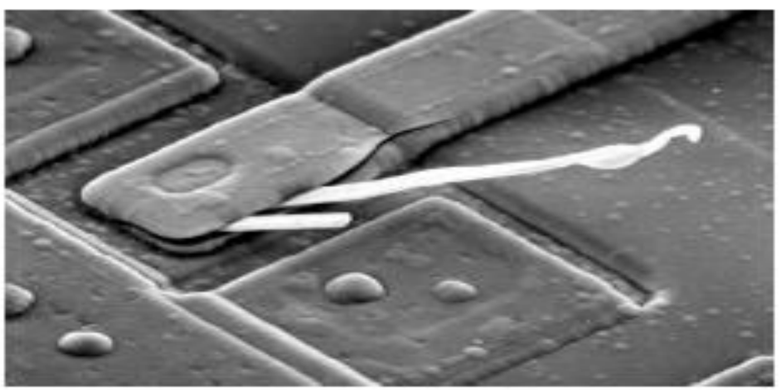
(a)



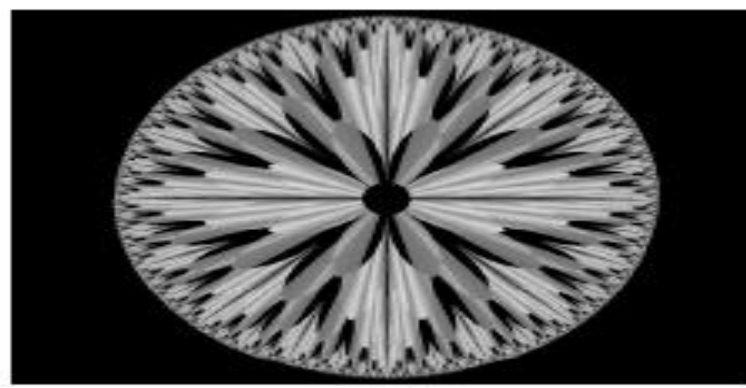
(b)

Figure 1.8 Examples of ultrasound imaging. a) Baby b) another view of baby

Finally, Figure 1.9(a) shows an image of damaged integrated circuit magnified 2500 times using an electron microscope. Figure 1.9(b) shows a fractal image generated by a computer.



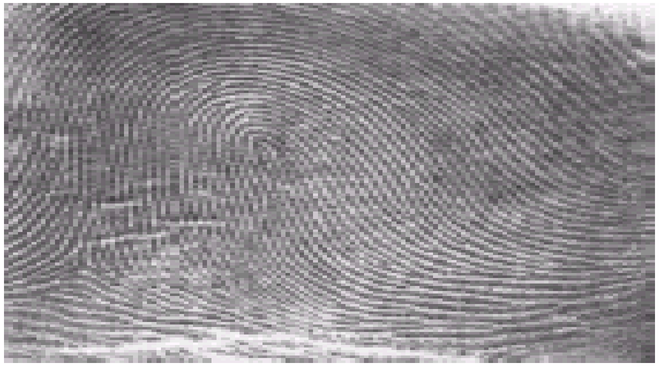
(a)

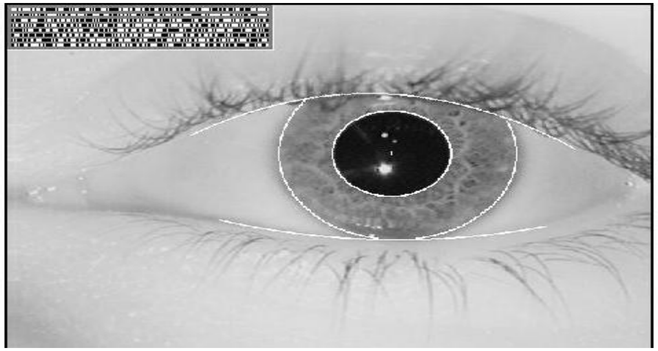


(b)

Figure 1.9 (a) image of damaged integrated circuit magnified 2500 times (b) fractal image

Security applications





Most current Mobile Phones are equipped with digital cameras Here we are showing image preprocessing procedure used for face recognition system for PDA developed at Buckingham University.

Surveillance

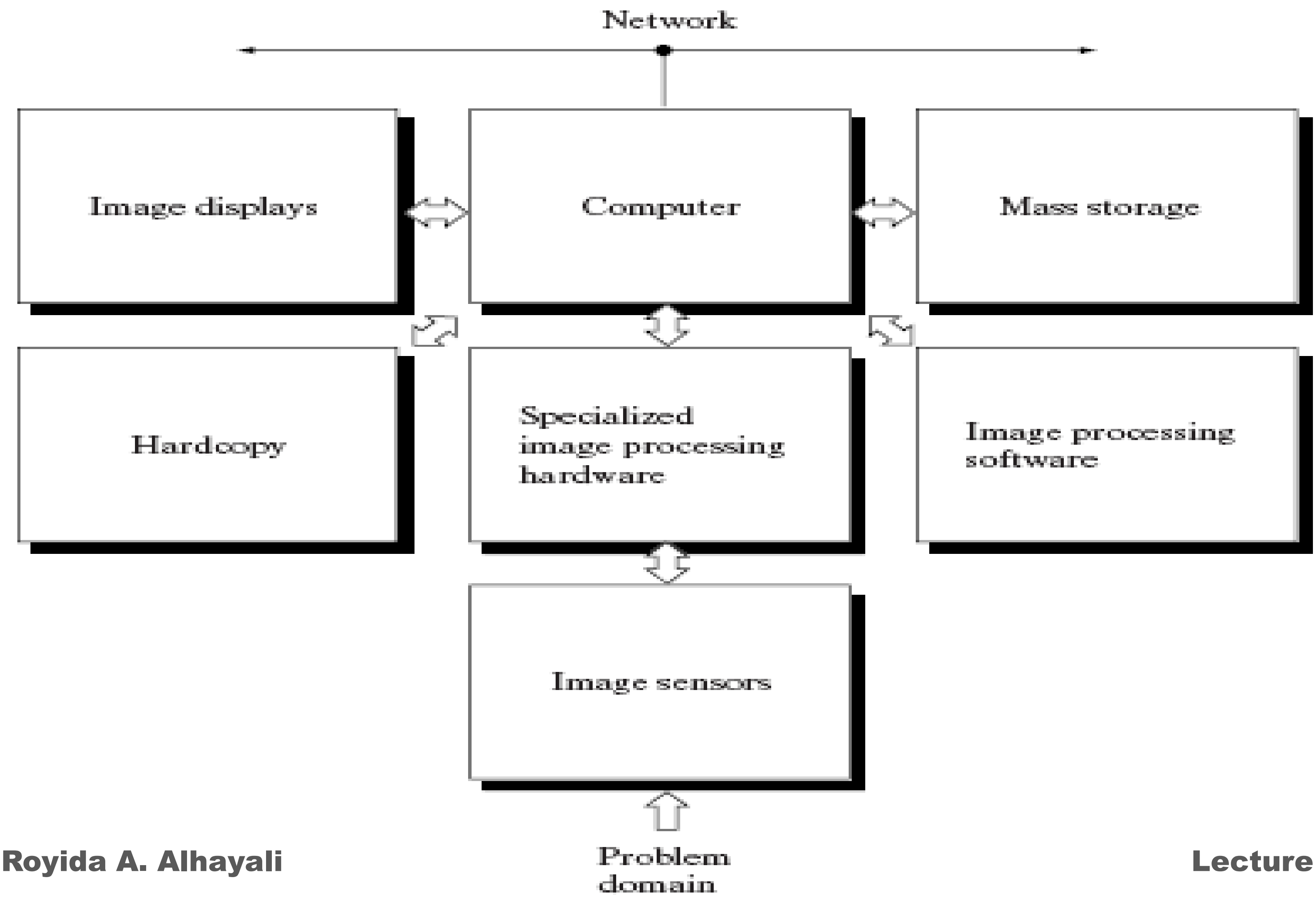
Surveillance (e.g. car number plate recognition)

Car number plate recognition

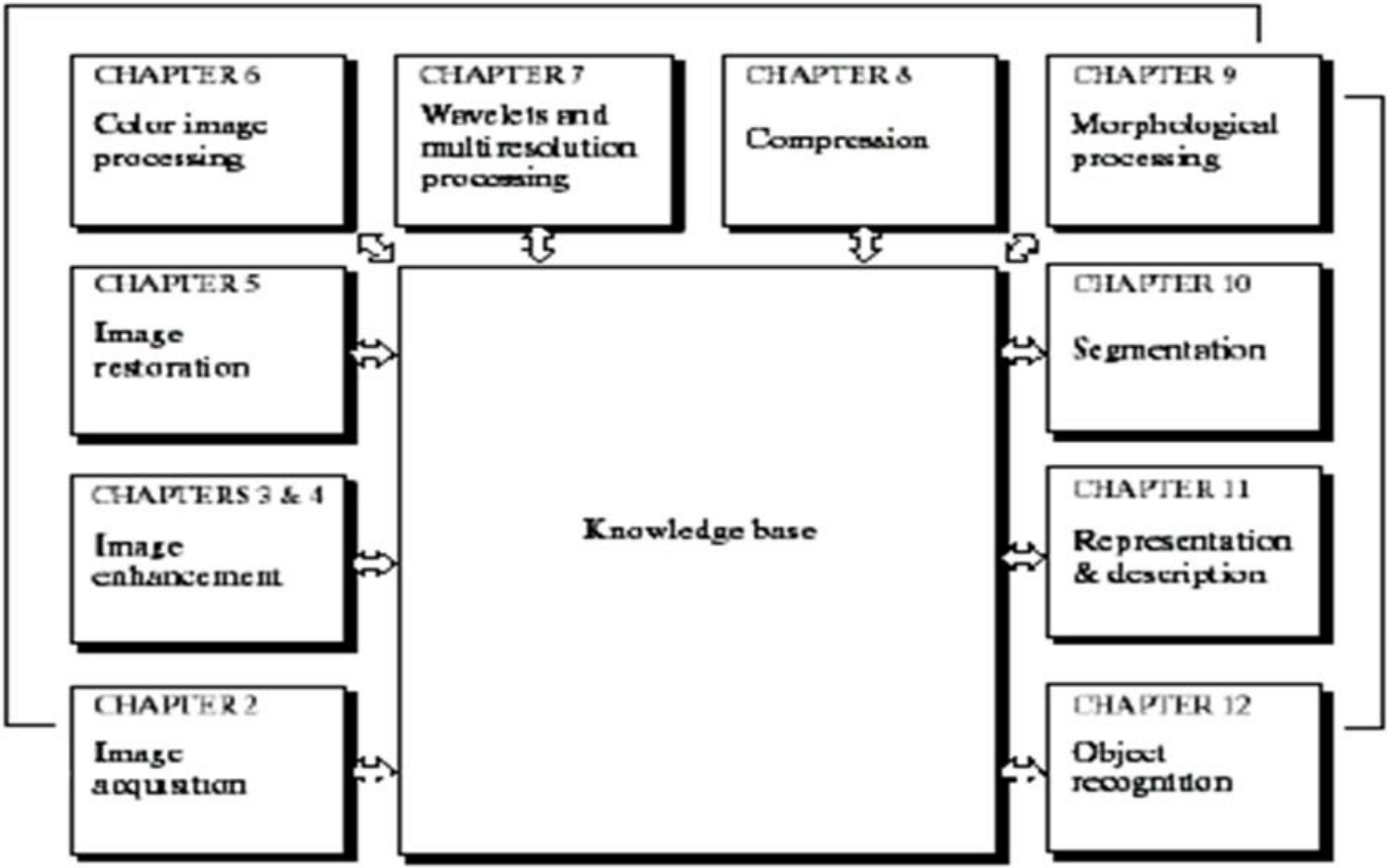
Digital Image Processing system components

- Digital Image Processing assumes the existence of a **source of energy**, a **sensor devise** to detect the emitted/reflected energy, a **coding system** for the range of measurements, and a **display device.**
- However, a modern DIP system requires powerful computing hardware, specialised software, large storage systems and communication devices.

Digital Image Processing system components



Fundamental steps in digital image processing



Fundamentals steps in digital image processing

- **Image acquisition (ch2):** capturing an image in digital form.
- **Image enhancement (ch3,4):** making an image look better in a subjective way.
- **Image restoration (ch5):** improving the appearance of any image objectively**.**
- **Color image processing (ch6):** color models and basic color processing
- **Wavelets and multiresolution processing (ch7):** Wavelet transform in one and two dimensions.
- **Image compression (ch8):** reducing the stored and transmitted image data**.**
- **Morphological image processing (ch9):** extracting image components that are useful in the representation and description of shape.
- **Image segmentation (ch10):** partitioning an image into its constituent parts or objects.
- **Representation and description (ch11) :** boundary representation vs. region representation. Boundary descriptors vs. region descriptors.
- **Recognition (ch12):** assigning a label to an object based on its descriptors