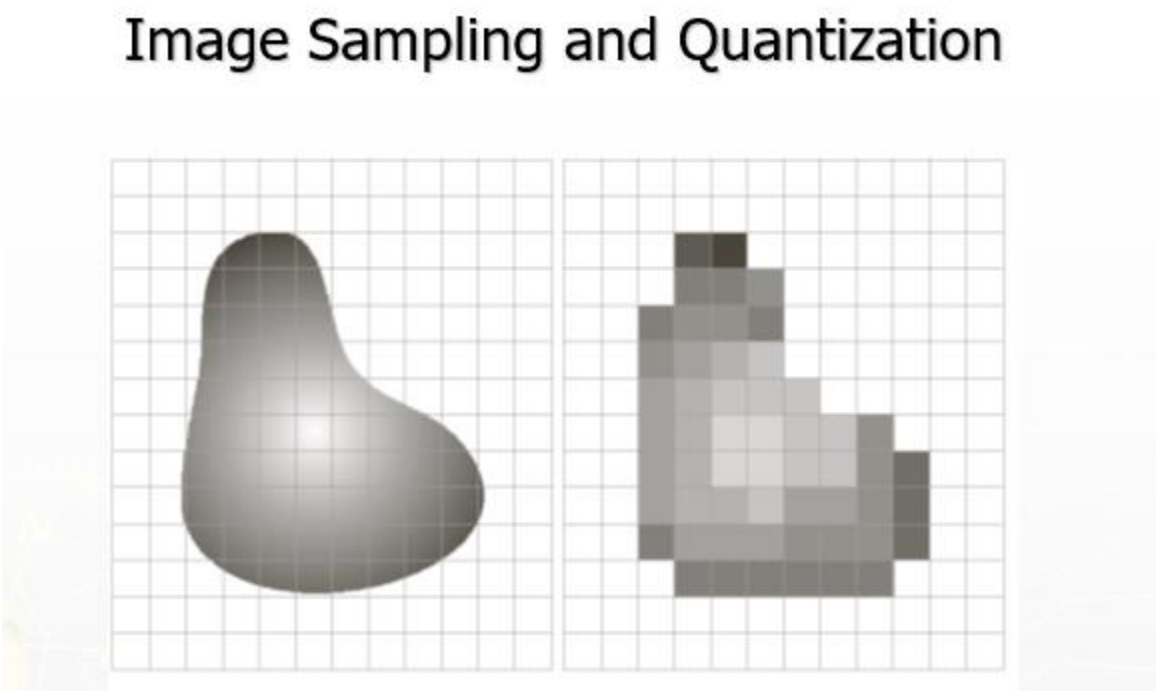
Coordinate Convention

The result of sampling and quantization is a matrix of real number. See figure 1. That means:

Digitization the coordinate values is called **sampling**; Digitization the amplitude values is called **quantization**



a b

Fig.(1): a) Continuous image projected onto a sensor array b) Result of image quantization and sampling.

Assume that an image f(x,y) is a sampled has M rows and N columns. We say the image size MxN. The values of the coordinates (x,y) are discrete quantities.

The image origin is define to be at (x,y)=(0,0) . The next coordinate values of the first row of the image (x,y)=(0,1); thus the range of x from 0 to M-1, and the range of y from 0 to N-1.

If (r,c)=(1,1); thus the range from 1 to M, and from 1 to N. Coordinate conventions used im image processing and in toolbox as shown in below figure:

y

x	0	1	2	3	.	.	N-1
	1	*	*	*	*	*	*
	2	*	*	*	*	*	*
	3	*	*	*	*	*	*
	.	*	*	*	*	*	*
	.	*	*	*	*	*	*
	M-1	*	*	*	*	*	*

Image processing

c

r	1	2	3	4	.	.	N
	2	*	*	*	*	*	*
	3	*	*	*	*	*	*
	4	*	*	*	*	*	*
	.	*	*	*	*	*	*
	.	*	*	*	*	*	*
	M	*	*	*	*	*	*

toolbox

Images as a matrices (Representing Digital Images):

The representation of an M×N numerical array in the coordinate system as:

$$f(x,y)=\begin{bmatrix} f(0,0) & f(0,1) & \dots & f(0,N-1) \\ f(1,0) & f(1,1) & \dots & f(1,N-1) \\ \dots & \dots & \dots & \dots \\ f(M-1,0) & f(M-1,1) & \dots & f(M-1,N-1) \end{bmatrix}$$

$$A = \begin{bmatrix} a_{0,0} & a_{0,1} & \dots & a_{0,N-1} \\ a_{1,0} & a_{1,1} & \dots & a_{1,N-1} \\ \dots & \dots & \dots & \dots \\ a_{M-1,0} & a_{M-1,1} & \dots & a_{M-1,N-1} \end{bmatrix}$$

The right side of this equation is a digital image by definition. Each element of this array is called image element, or pixel. The terms image and pixel are used.

A digital image can be represented naturally as a MATLAB matrix:

$$f(x,y) = \begin{bmatrix} f(1,1) & f(1,2) & \dots & f(1,N) \\ f(2,1) & f(2,2) & \dots & f(2,N) \\ \dots & \dots & \dots & \dots \\ f(M,1) & f(M,2) & \dots & f(M,N) \end{bmatrix}$$

Where f(1,1)=f(0,0),

Ex. F(6,2) is the element in sixth row and second column of the matrix.

- Matrix A (1,N) is called a row vector.
- (M,1) is called a column vector.
- (1,1) is called a scalar vector.

Electromagnetic Spectrum:

The electromagnetic spectrum is the range of frequencies (the spectrum) of electromagnetic radiation and their respective wave lengths and photon energies.

The electromagnetic spectrum covers electromagnetic waves with frequencies ranging from below one hertz to above 10^25 hertz, corresponding to wavelengths from thousands of kilometers down t o a fraction of the size of an atomic nucleus. This frequency range is divided into separate bands, and the electromagnetic waves within each frequency band are called by different names; beginning at the low frequency (long wavelength) end of the spectrum these are: radio waves, microwaves, terahertz waves, infrared, visible light, ultraviolet, X-rays, and gamma rays at the high-frequency (short wavelength) end as shown in figure (2). Thus digital image processing encompasses a wide and varied field of applications. Additionally, Electromagnetic (EM) energy spectrum there are sources to digital images as:

Acoustic
Ultrasonic
Electronic
Synthetic images produced by computer

.

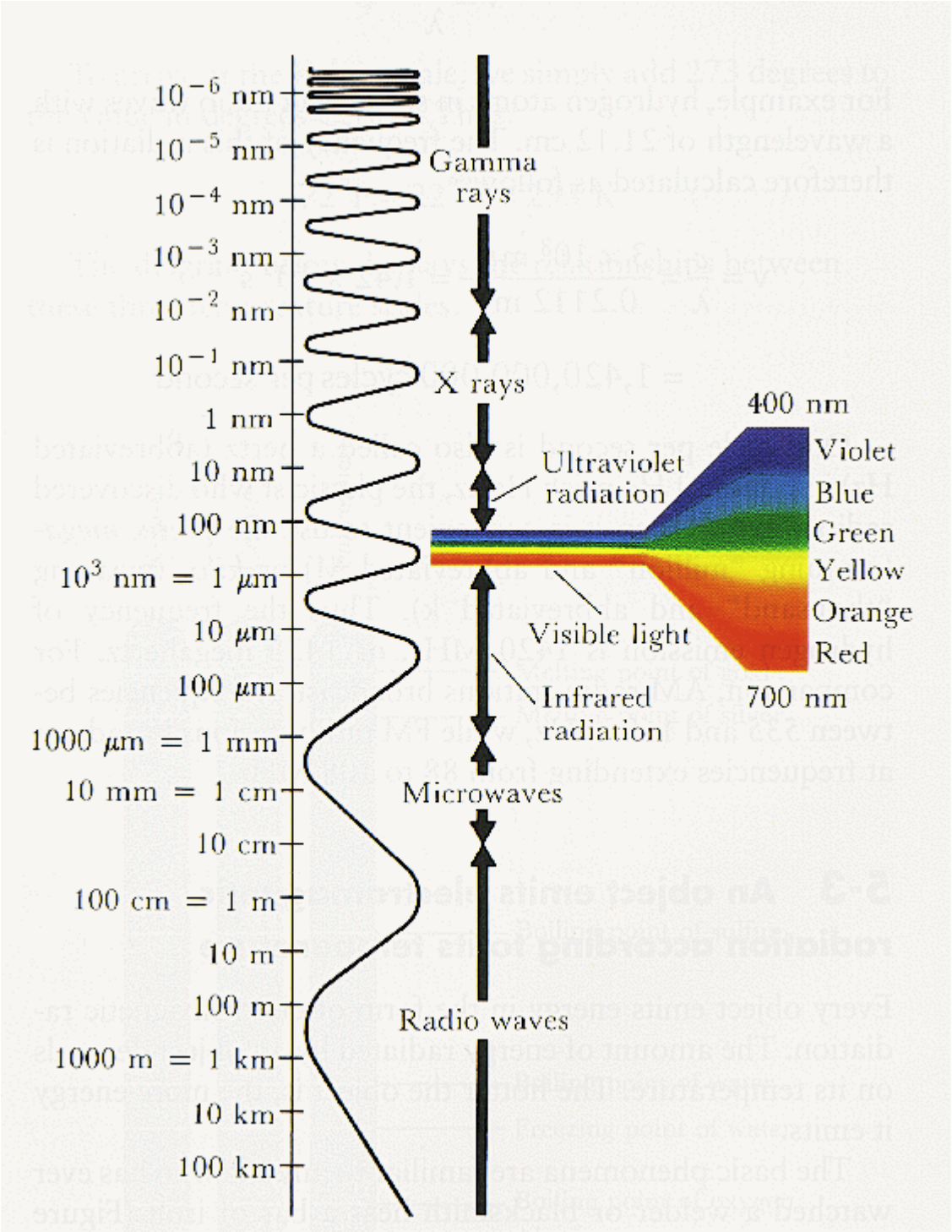
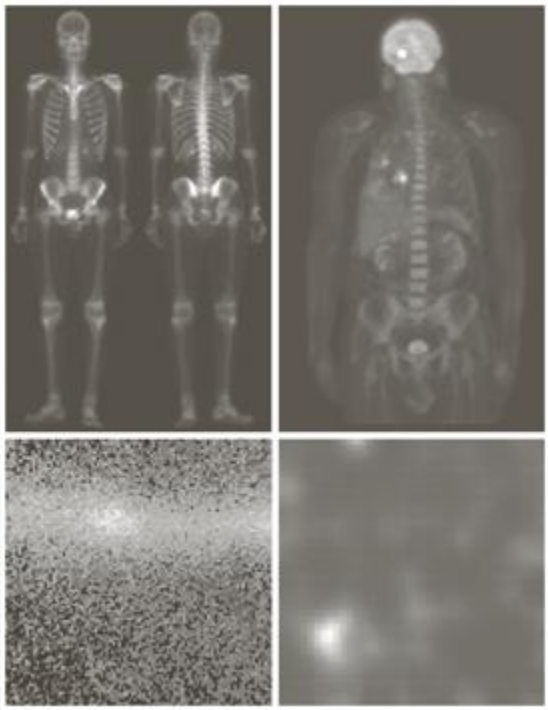


Figure (2) :Electromagnetic Spectrum (EM)

Major uses

Gamma-ray imaging: nuclear medicine and astronomical observations.
X-rays: medical diagnostics, industry, and astronomy, etc.
Ultraviolet: lithography, industrial inspection, microscopy, lasers, biological imaging, and astronomical observations.
Visible and infrared bands: light microscopy, astronomy, remote sensing, industry, and law enforcement.
Microwave band: radar.
Radio band: medicine (such as MRI) and astronomy.

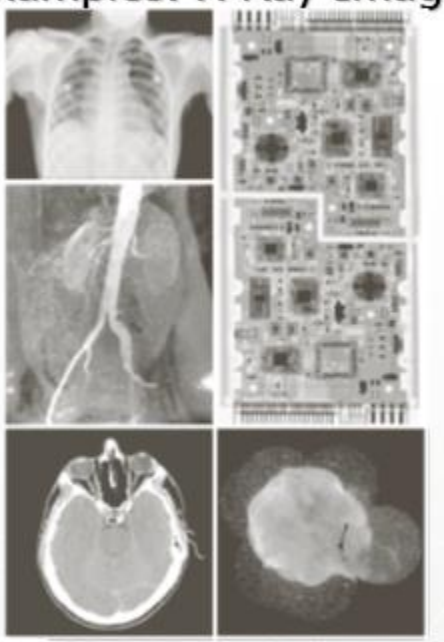
Examples: Gama-Ray Imaging



a b
c d

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.)

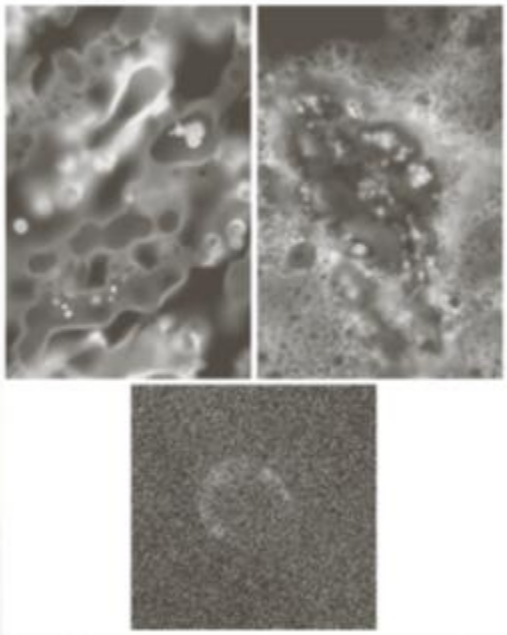
Examples: X-Ray Imaging



a b c d e

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.)

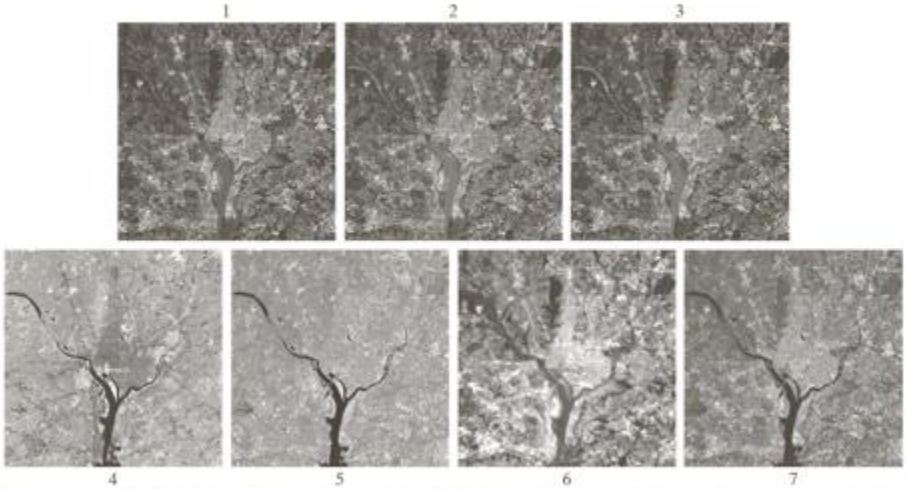
Examples: Ultraviolet Imaging



a b
c

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.)

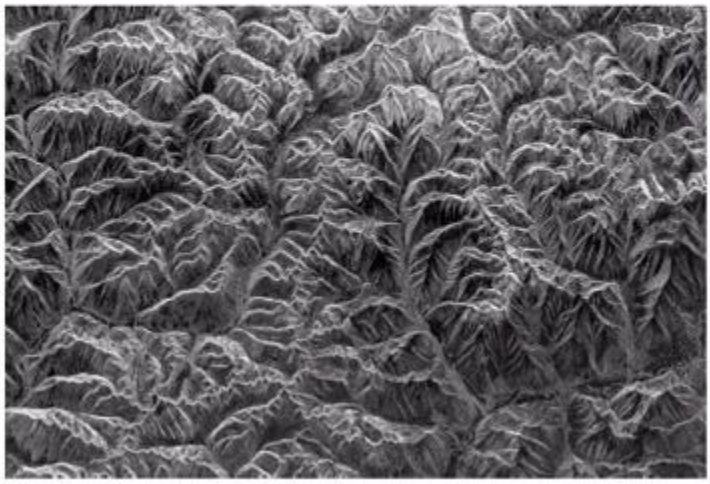
Examples: Visual and Infrared Imaging



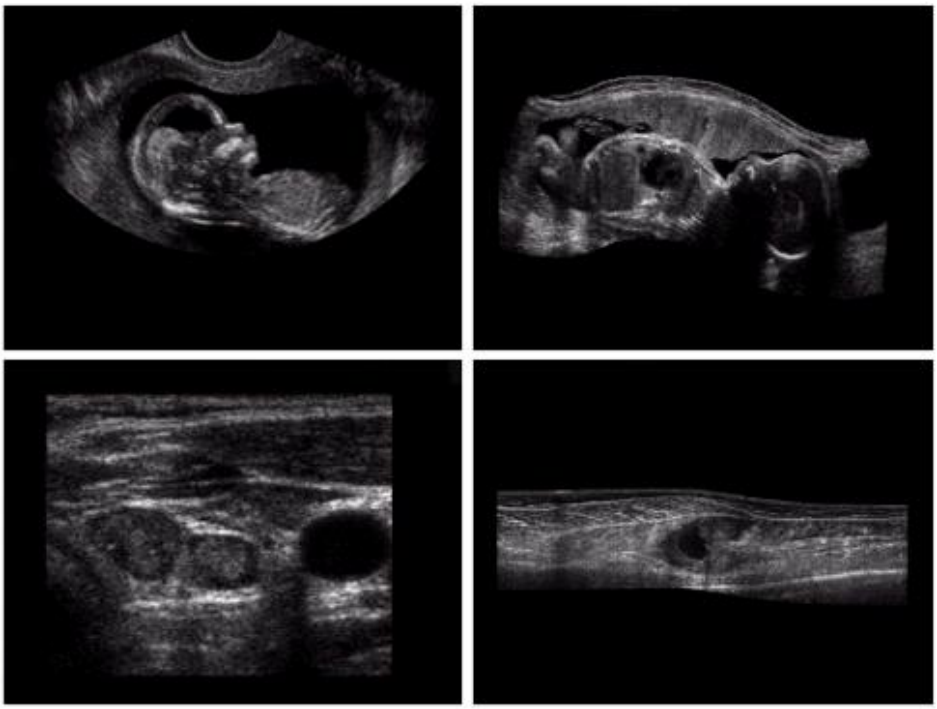
LANDSAT satellite images of the Washington, D.C. area. The numbers refer to the thematic bands in Table 1.1. (Images courtesy of NASA.)

Example of Radar Image

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



Examples: Ultrasound Imaging



a b
c d

Examples of ultrasound imaging. (a) Baby. (2) Another view of baby. (c) Thyroids. (d) Muscle layers showing lesion. (Courtesy of Siemens Medical Systems, Inc., Ultrasound Group.)