Image Processing

Lecture 1

Introducing Image Processing

? What Is An image

- An image is a two-dimensional function, *f(x,y)*, where *x* and *y* are *spatial* (plane) coordinates, and the amplitude of *f(x,y)* at any pair of coordinates *(x, y)* is called the *intensity* or *gray level* of the image at the point *(x,y)*.

Note: When x, y, and the amplitude values of *f* are all finite, discrete quantities, we call the image a digital image.

? What Is A digital Image

- A digital image is a two-dimensional matrix, *f(M,N)*, where the value at the location *(x,y)* is called the *intensity* or *gray level* of the image at the point *(x,y)*.

- So, the digital image is composed of a finite number of elements, each of which has a particular location and value.

The digital image elements are referred to *pels*, and *pixel*
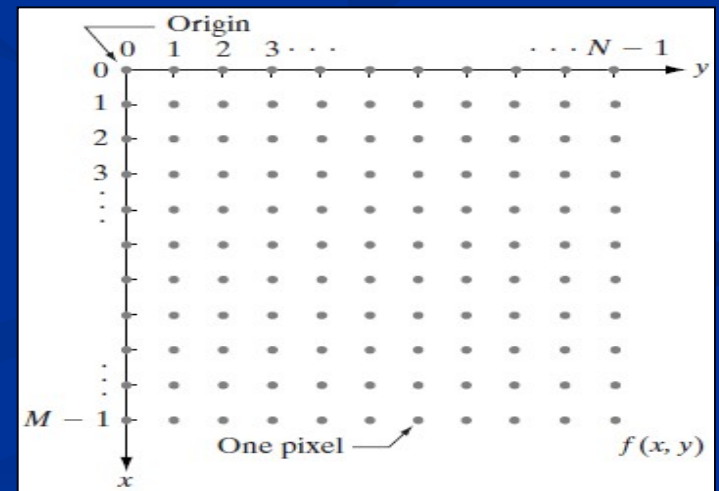
?What Is Digital Image Processing

- Digital image processing field, is a preprocessing step for other computerized processing fields such as *computer vision* and *pattern recognition*.

- In computer vision, the goal is to use computers to emulate human vision, including learning (understanding) and being able to make inferences and take actions based on visual inputs.

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- There are no clear-cut boundaries in the continuum from image processing at one end to computer vision at the other.

- So, we can consider three types of computerized processes in this continuum: low-, mid-, and high-level processes.

| Low-Level | → | Mid-Level | → | High-Level |

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- Low-level processes involve primitive operations such as noise reducing, contrast enhancement, and image sharpening.

- Mid-level processing on images involves tasks such as segmentation, description of those objects to reduce them to a form suitable for computer processing.

- Higher-level processing involves "making sense" of an ensemble of recognized objects, as in image analysis, and, at the far end of the continuum, performing the cognitive functions.

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■ Thus, *digital image processing* encompasses processes whose inputs and outputs are images and, in addition, encompasses processes that extract attributes from images, up to and including the recognition of individual objects.

The Origins of Digital Image Processing

■ One of the first applications of digital images was in the newspaper industry, when pictures were first sent by submarine cable between London and New York (*Bartlane cable*).

- produced in 1921 (telegraph)
- five distinct levels of gray

- produced in 1922 (telegraph)
- after the signals had crossed the Atlantic twice

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- produced in 1929 (telegraph)
- 15 distinct levels of gray

- The history of *digital image processing* is intimately tied to the development of the digital computer
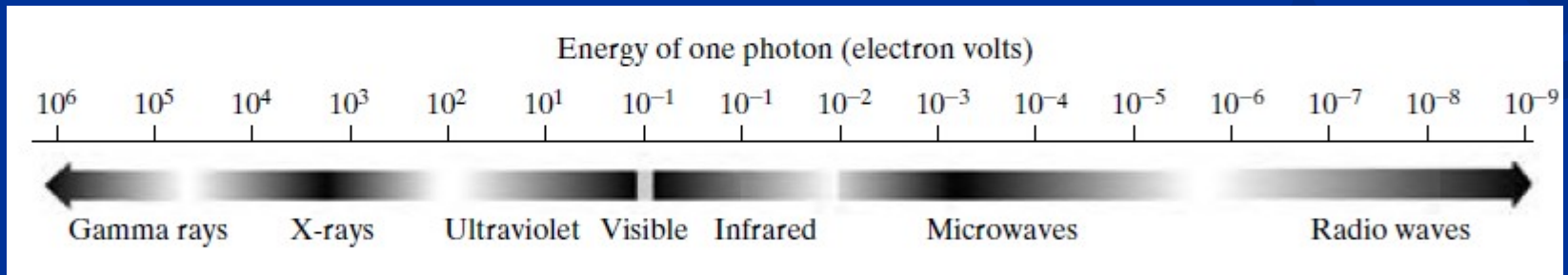
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- The first computers powerful enough to carry out meaningful image processing tasks appeared in the early 1960s.

- In 1964 when pictures of the moon transmitted by Ranger 7.
- processed by a computer to correct various types of image distortion inherent in the on-board television camera.

Electromagnetic spectrum (EM)

- Electromagnetic waves are sinusoidal waves of varying wavelengths, or are a stream of massless particles, each traveling in a wavelike pattern and moving at the speed of light.

- Each massless particle contains a certain amount (or bundle) of energy (photon)

Energy of one photon (electron volts)

| 10^6 | 10^5 | 10^4 | 10^3 | 10^2 | 10^1 | 10^{-1} | 10^{-1} | 10^{-2} | 10^{-3} | 10^{-4} | 10^{-5} | 10^{-6} | 10^{-7} | 10^{-8} | 10^{-9} |

Gamma rays   X-rays   Ultraviolet Visible Infrared   Microwaves   Radio waves

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Energy of one photon (electron volts)

| 10^6 | 10^5 | 10^4 | 10^3 | 10^2 | 10^1 | 1 | 10^{-1} | 10^{-2} | 10^{-3} | 10^{-4} | 10^{-5} | 10^{-6} | 10^{-7} | 10^{-8} | 10^{-9} |

Frequency (Hz)

| 10^{21} | 10^{20} | 10^{19} | 10^{18} | 10^{17} | 10^{16} | 10^{15} | 10^{14} | 10^{13} | 10^{12} | 10^{11} | 10^{10} | 10^9 | 10^8 | 10^7 | 10^6 | 10^5 |

Wavelength (meters)

| 10^{-12} | 10^{-11} | 10^{-10} | 10^{-9} | 10^{-8} | 10^{-7} | 10^{-6} | 10^{-5} | 10^{-4} | 10^{-3} | 10^{-2} | 10^{-1} | 1 | 10^1 | 10^2 | 10^3 |

Hard X-rays   Ultraviolet   Infrared   Radio waves

Gamma rays   Soft X-rays   Visible spectrum   Microwaves

0.4×10^{-6} 0.5×10^{-6} 0.6×10^{-6} 0.7×10^{-6}

Ultraviolet   Violet   Blue   Green   Yellow   Orange   Red   Infrared
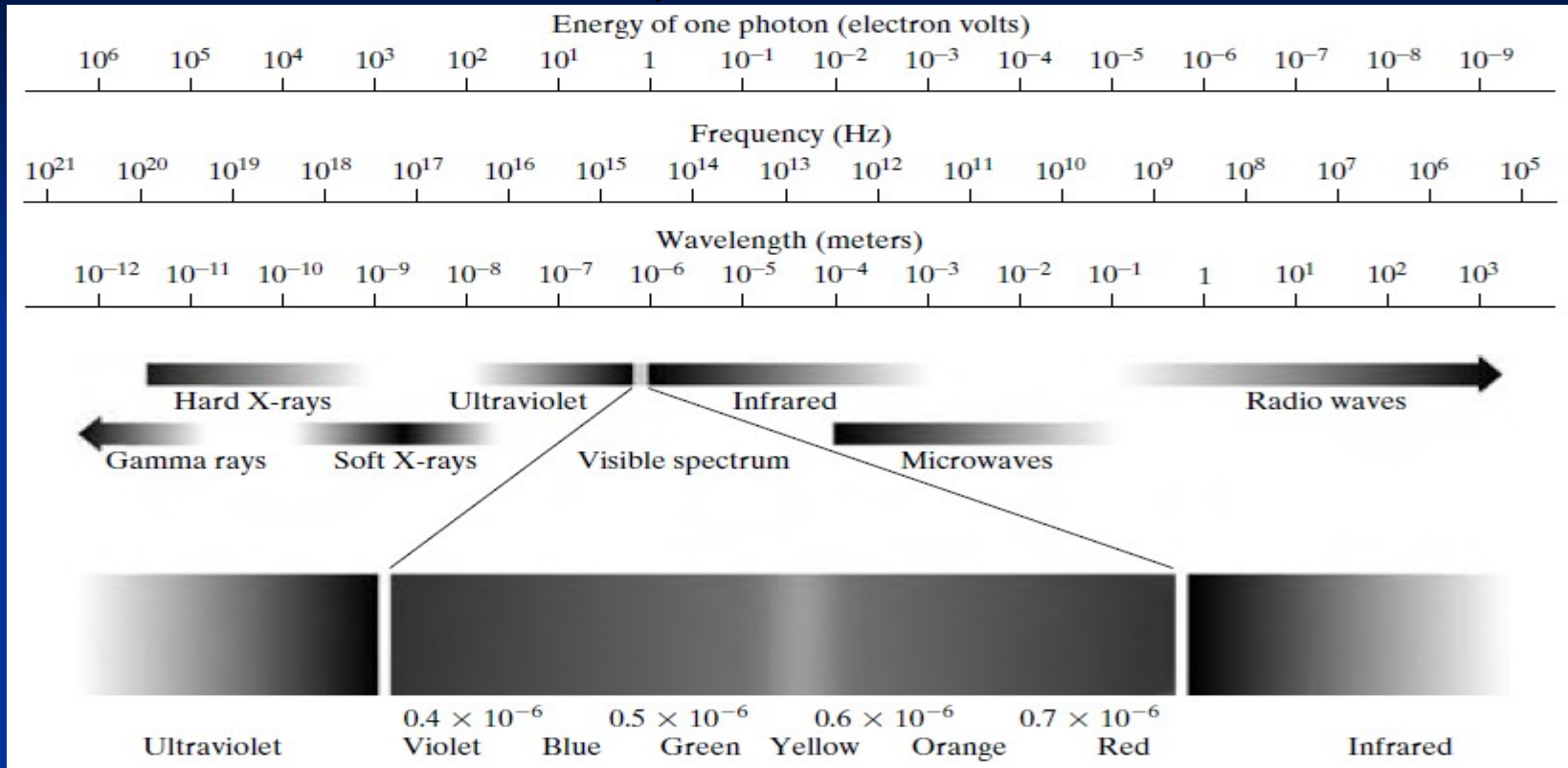
FIGURE 2.11
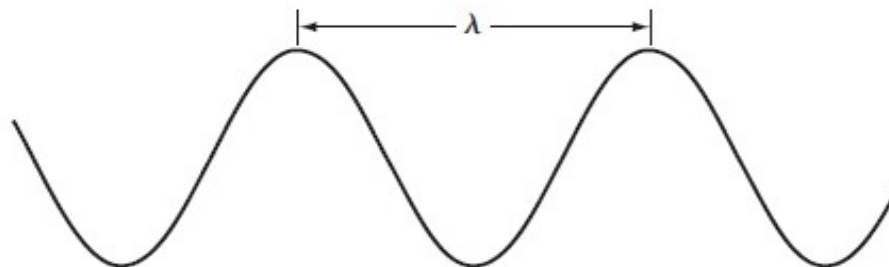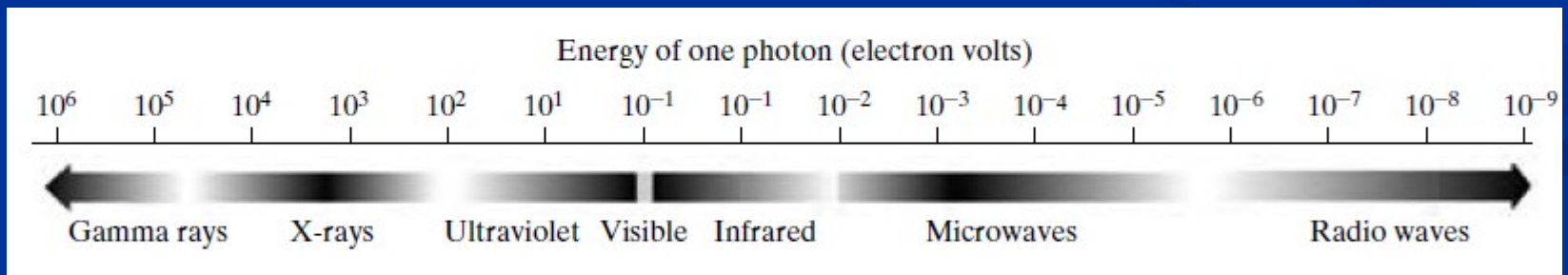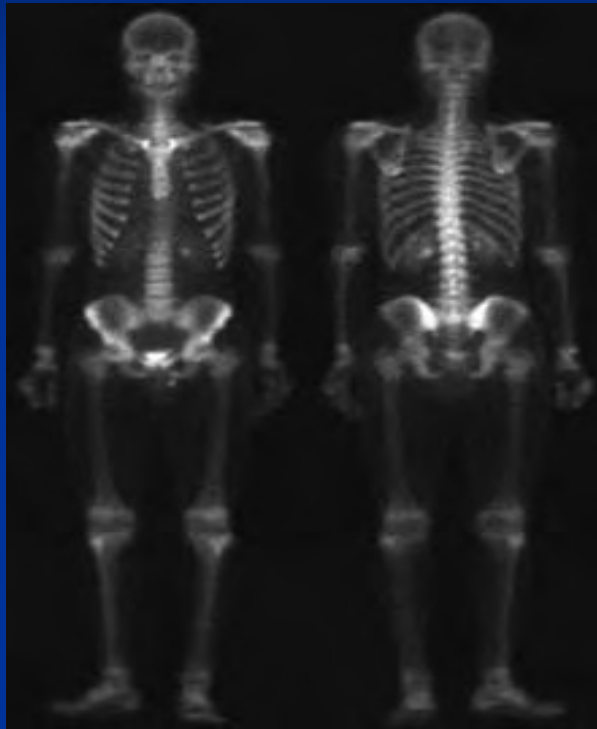Graphical representation of one wavelength.

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Image Types

- Image types according to energy source:
  - 1- Electromagnetic energy spectrum images
  - 2- Acoustic & ultrasonic images
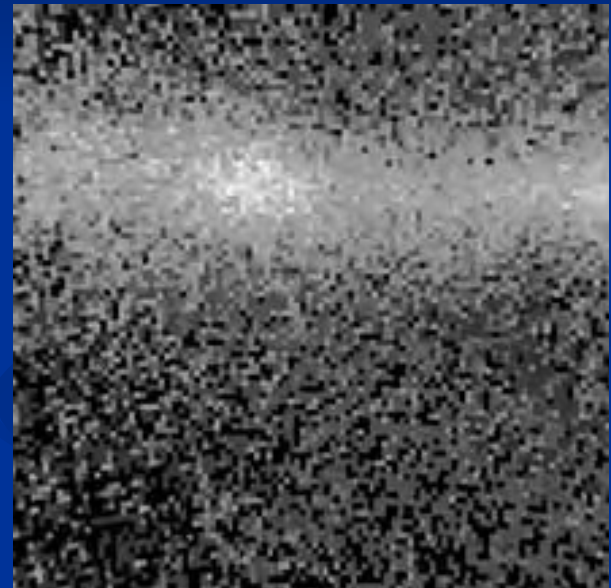 - 3- Electronic images
  - 4- Computer modeling images

Energy of one photon (electron volts)

| 10^6 | 10^5 | 10^4 | 10^3 | 10^2 | 10^1 | 10^{-1} | 10^{-1} | 10^{-2} | 10^{-3} | 10^{-4} | 10^{-5} | 10^{-6} | 10^{-7} | 10^{-8} | 10^{-9} |

Gamma rays   X-rays   Ultraviolet Visible Infrared   Microwaves   Radio waves

Examples of Fields that Use Digital Image Processing

- **1- Gamma-Ray Imaging**

Medicine System

Astronomical observations
(Cygnus Loop))

Fundamental steps in digital image processing.