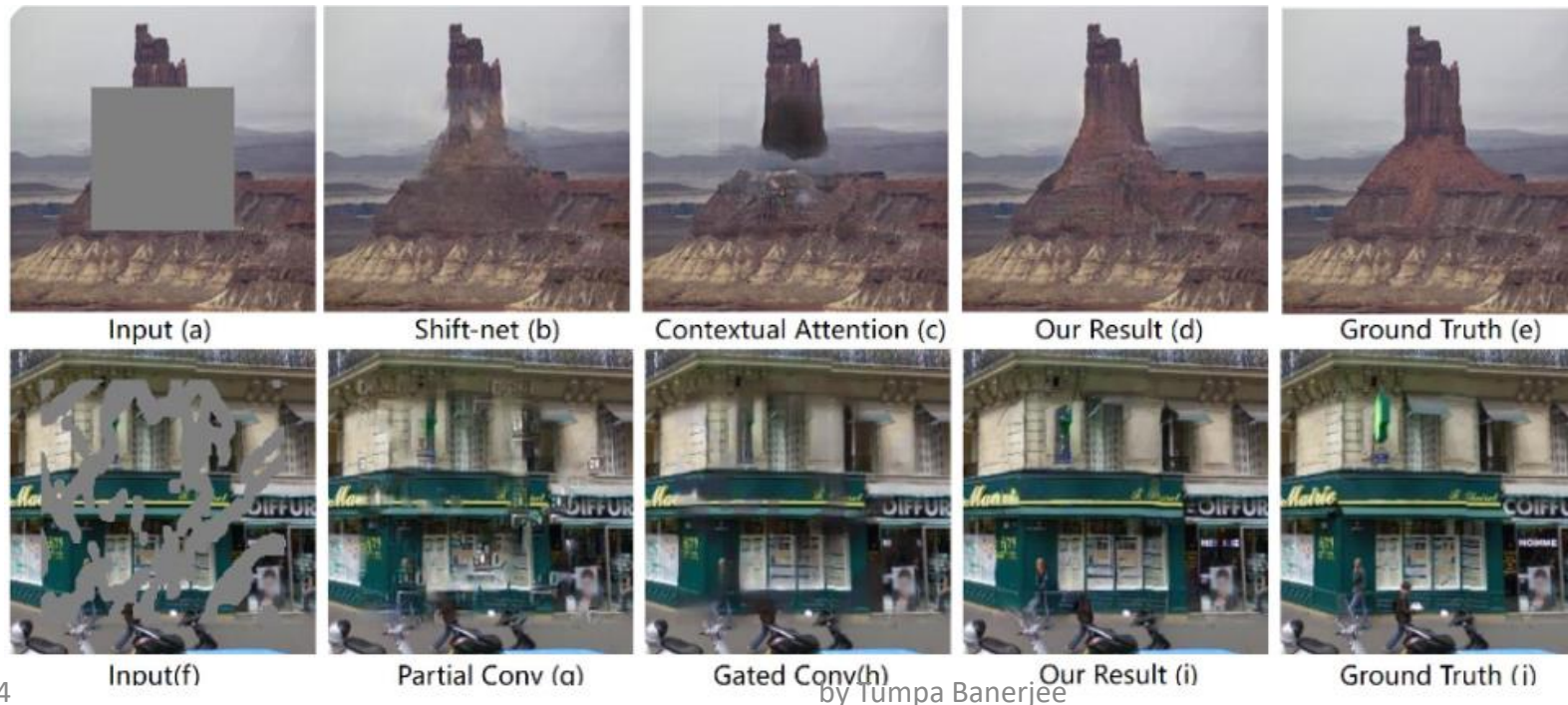# Introduction to Digital Image Processing

Origins, Pixels, Applications, and Fundamental step of Digital Image Processing

Motivation of Image Processing

- improvement of pictorial information for human interpretation

- processing of image data for storage, transmission, and representation for autonomous machine perception.

Input (a)   Shift-net (b)   Contextual Attention (c)   Our Result (d)   Ground Truth (e)

Input(f)   Partial Conv (g)   Gated Conv(h)   Our Result (i)   Ground Truth (j)

by Tumpa Banerjee

What is Digital Image Processing

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

- Image:

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

- When x, y and the intensity values of f are all finite, discrete quantities, we call the image a digital image

Pixels

- A digital image is composed of a finite number of elements, each of which has a particular location and value. These elements are called picture elements, image elements, pels, and pixels. Pixel is the term used most widely to denote the elements of a digital image.

by Tumpa Banerjee
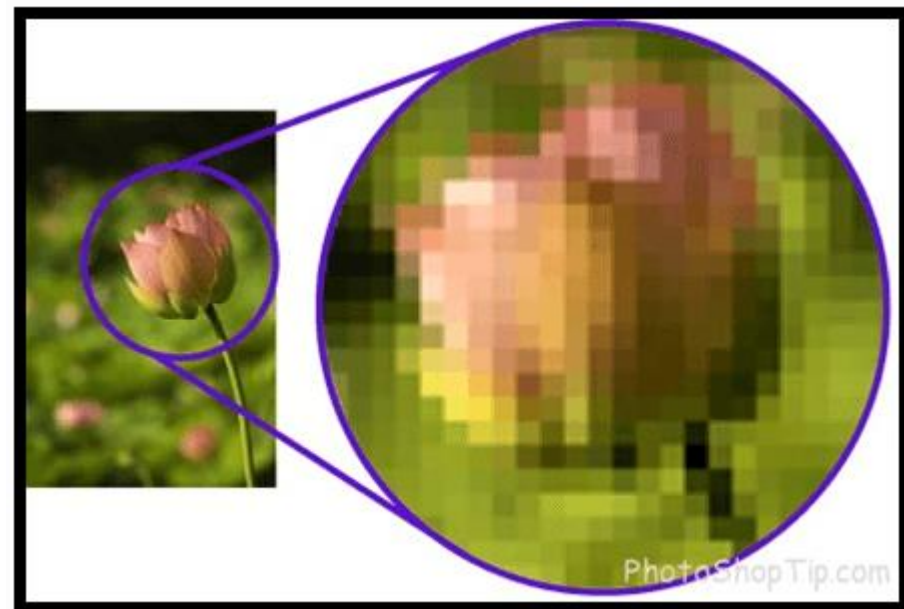
The Origins of Digital Image Processing

- The first application of digital images was in the newspaper industry, where pictures were sent by submarine cable between London and New York in 1920.

- specialized printing equipment coded pictures for cable transmission and reconstructed them at the receiving end.

- The early Bartlane systems were capable of coding images in five distinct levels of gray.

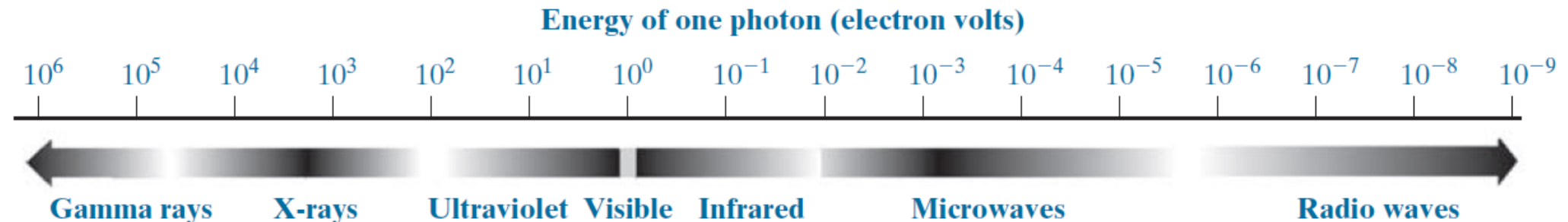- this capability was increased to 15 levels in 1929.

The Origins of Digital Image Processing

- The first computers powerful enough to carry out meaningful image-processing tasks appeared in the early 1960s.

Application of Digital Image Processing

- Categorize images according to the source (X-ray, visual, infrared and so on).

- The principal energy source for images in use today is the electromagnetic energy spectrum.

- Other sources of energy include acoustic, ultrasonic, and electronic.

- EM waves can be conceptualized as propagating sinusoidal waves of varying wavelengths, or they can be thought of as 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 of energy. Each bundle of energy is called a photon. Spectral bands are grouped according to energy per photon as follows

Energy of one photon (electron volts)

| 10^6 | 10^5 | 10^4 | 10^3 | 10^2 | 10^1 | 10^0 | 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

Application of Digital Image Processing

- The field of image processing has applications in medicine and the space program.

- Computer procedures are used to enhance the contrast or code the intensity levels into color for easier interpretation of X-rays and other images used in industry, medicine, and the biological sciences.

- Geographers use the same or similar techniques to study pollution patterns from aerial and satellite imagery

- Image enhancement and restoration procedures are used to process degraded images of unrecoverable objects.

Fundamental steps of Image Processing

- Image Acquisition
- Image enhancement
- Image restoration
- Color Image Processing
- Wavelets and other image transforms
- Compression and watermarking
- Segmentation
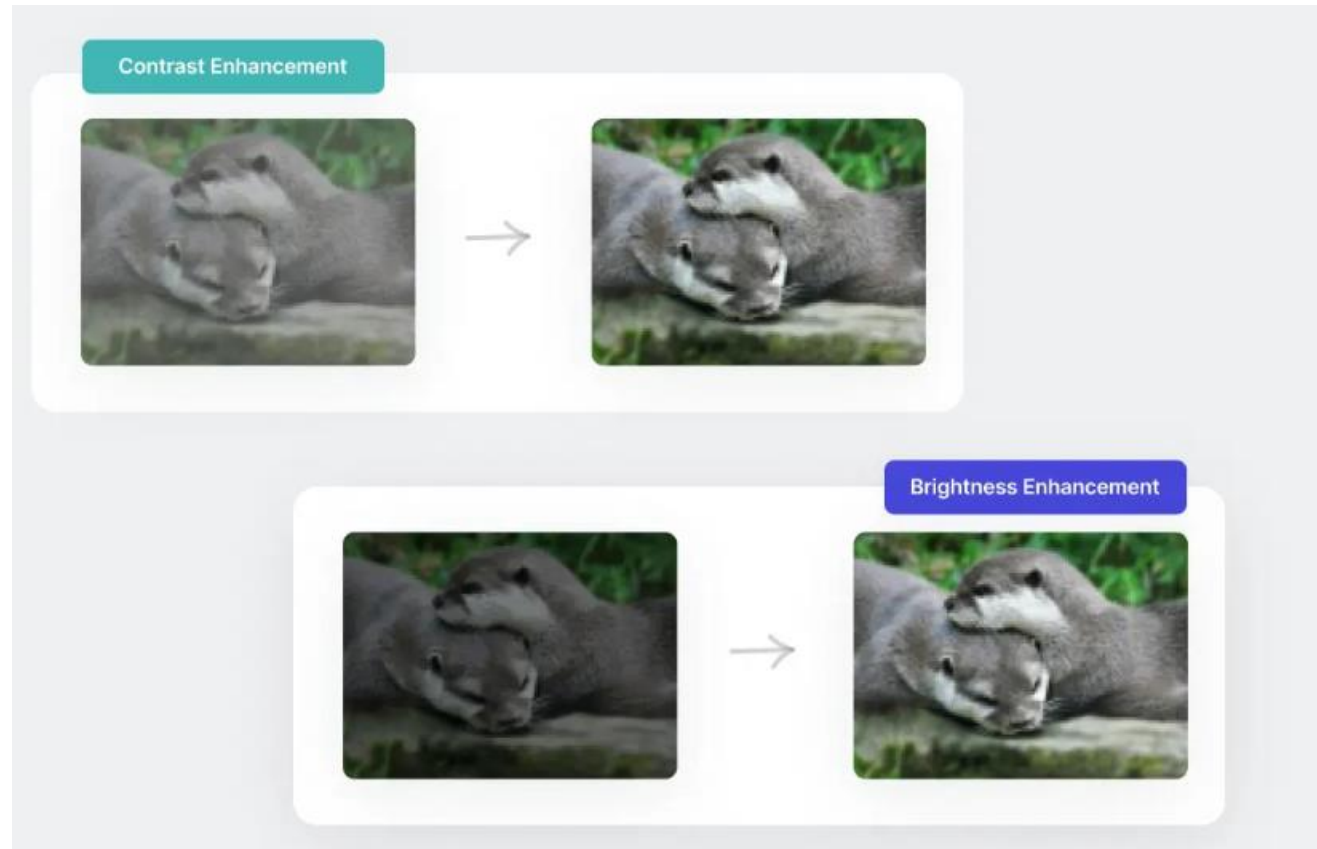- Feature extraction
- Image pattern classification

Image Acquisition

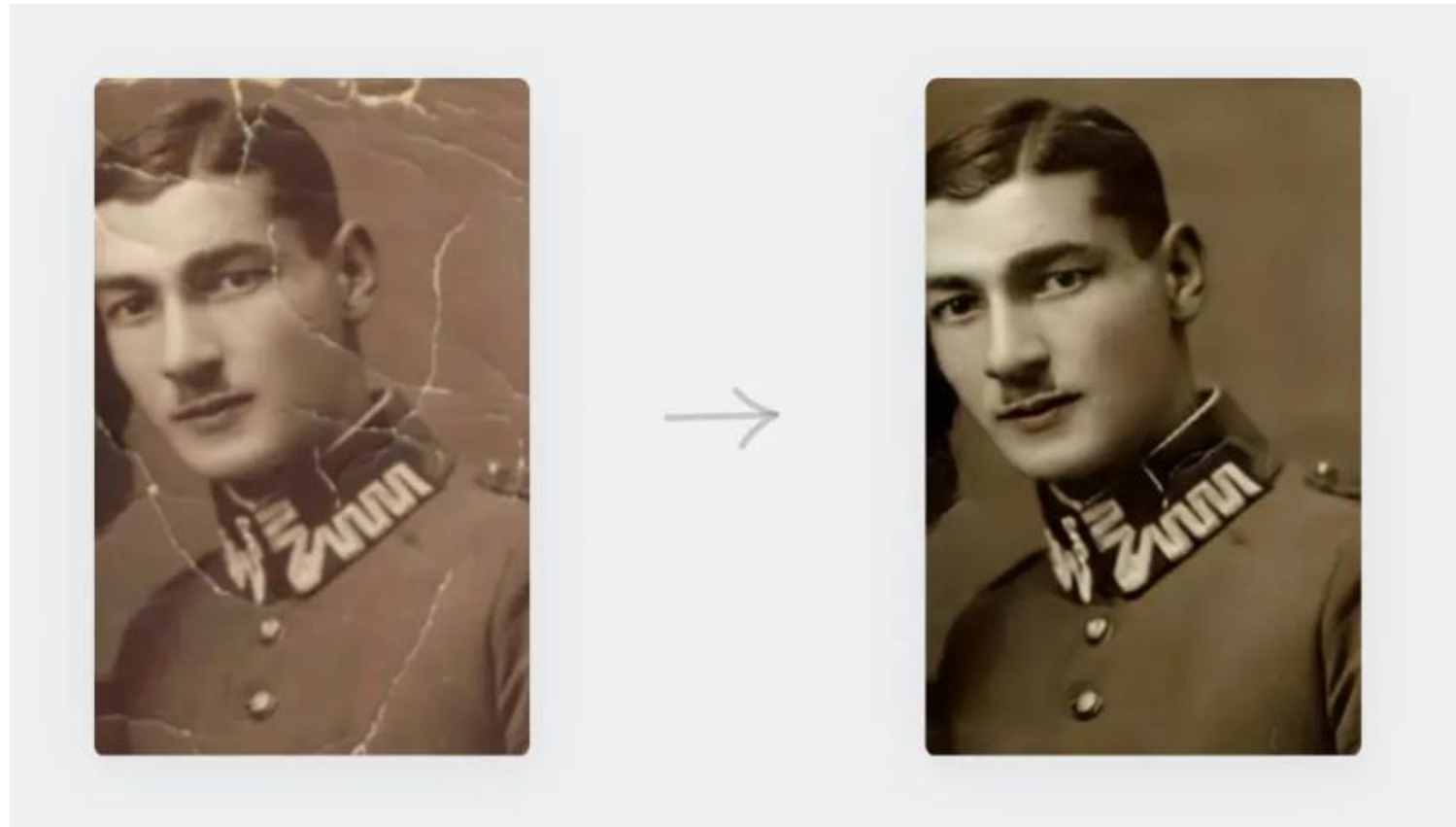- Image acquisition stage involves preprocessing, such as scaling.
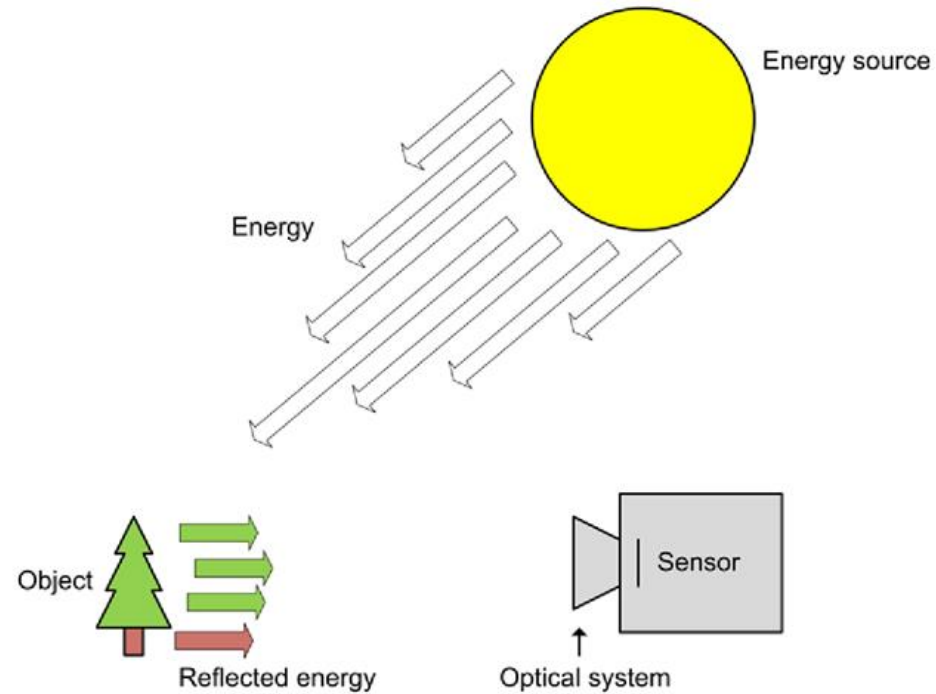
Image Enhancement

- Image enhancement is the process of manipulating an image so the result is more suitable than the original for a specific application.

Image Restoration

- Image restoration is an area that also deals with improving the appearance of an image.

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Color Image Processing

- Color image processing is an area that has been gaining in importance because of the significant increase in the use of digital images over the internet.

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Wavelet Transformation

- Wavelets are the foundation for representing images in various degrees of resolution. we will study wavelet transformation for image data compression and for pyramidal representation, in which images are subdivided successively into smaller regions.
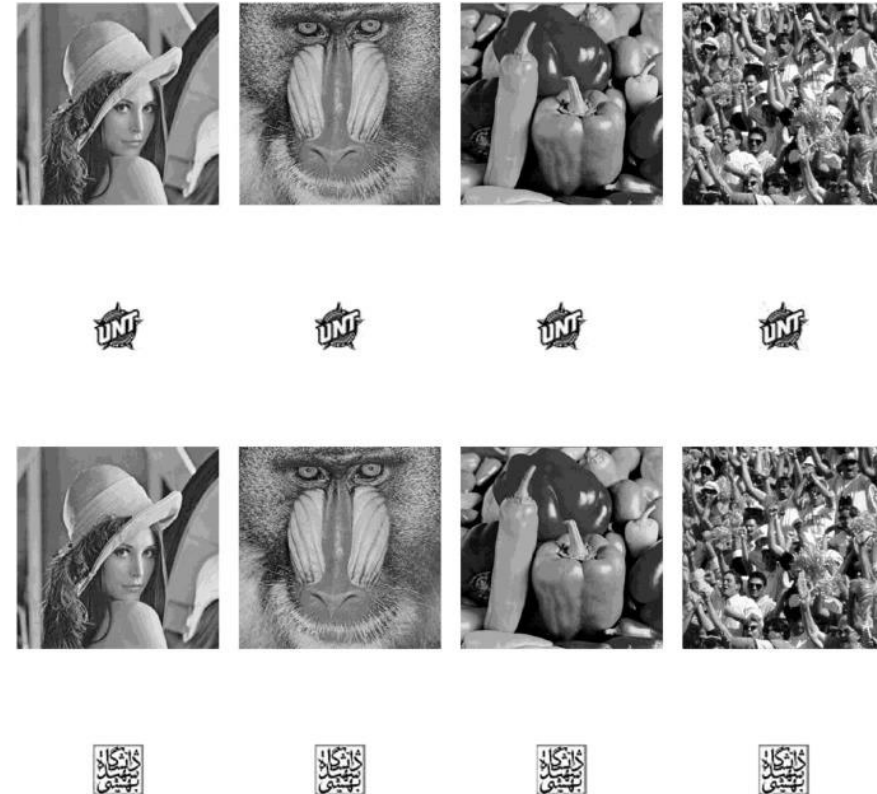

Original Image

Denoised Image

Compression and watermarking

- Compression, as the name implies, deals with techniques for reducing the storage required to save an image, or the bandwidth required to transmit it.

Image Segmentation

- Segmentation partitions an image into its constituent parts or objects.

Feature Extraction

- Feature extraction almost always follows the output of a segmentation stage, which usually is raw pixel data, constituting either the boundary of a region (i.e., the set of pixels separating one image region from another) or all the points in the region itself.
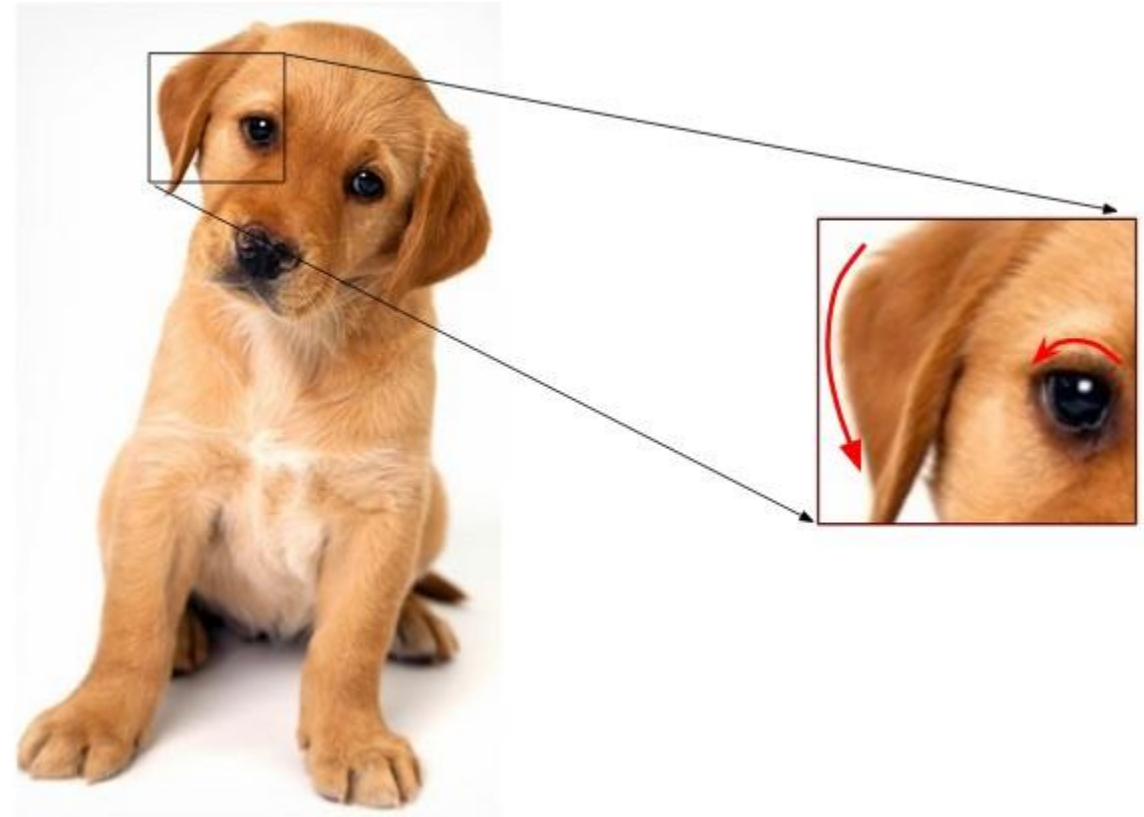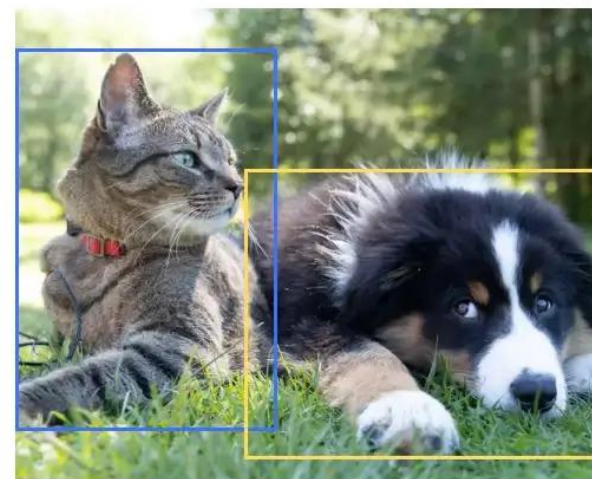
Image Classification

- Image pattern classification is the process that assigns a label (e.g., "vehicle") to an object based on its feature descriptors.

Classification
Cat

Classification, Localization
Cat

Object Detection
Cat, Dog

Components of Image Processing System

- Two subsystems are required to acquire digital images.

  - ➢ Physical sensor that responds to the energy radiated by the object we wish to image

  - ➢ Digitizer is a device for converting the output of the physical sensing device into digital form

Components of Image Processing System
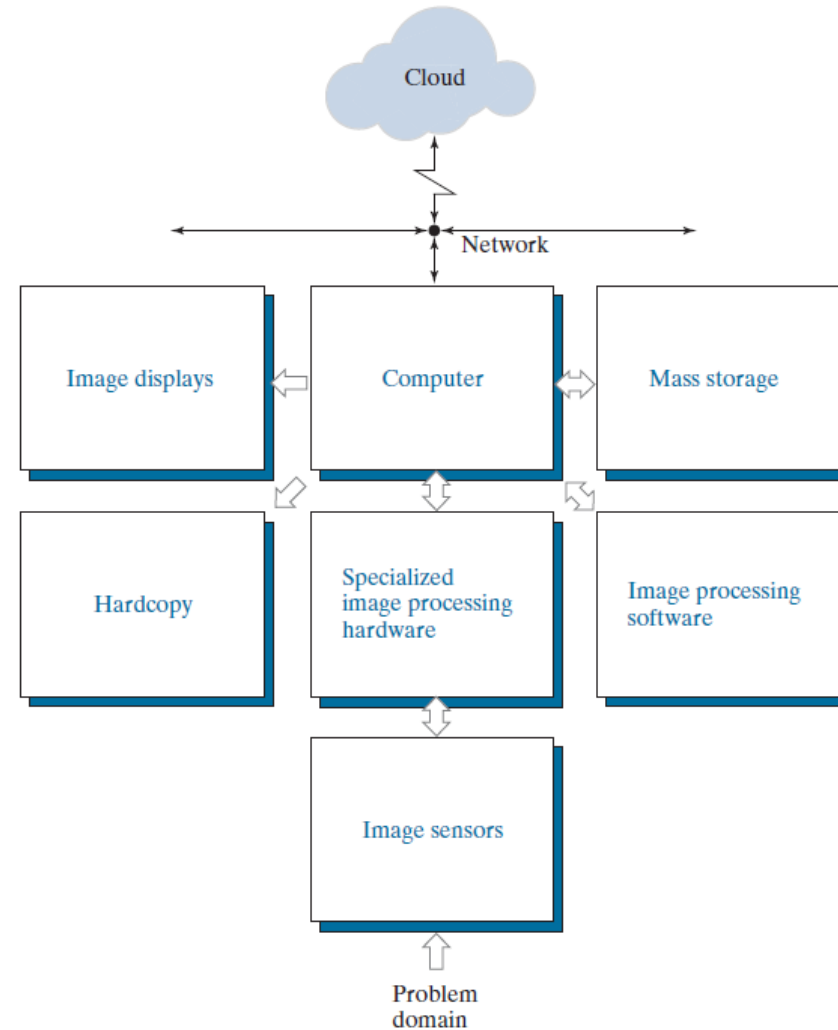
Reference

- E Woods, Richard, and Rafael C Gonzalez. "Digital image processing." (2008).