1.1 Motivation and Perspective

Digital image processing deals with manipulation of digital images through a digital computer. It is a subfield of signals and systems but focus particularly on images. DIP focuses on developing a computer system that is able to perform processing on an image. The input of that system is a digital image and the system process that image using efficient algorithms, and gives an image as an output. The most common example is **Adobe Photoshop**. It is one of the widely used application for processing digital images.

1.2 Computer imaging

It is a fascinating and exciting area to be involved today. Visual information, transmitted in the form of digital image, is becoming a major method of communication in the modern age.

Computer imaging Can be defined a acquisition and processing of visual information by computer. **The importance of computer imaging** is derived from the fact that our primary sense is our visual sense, and the information that be conveyed in images has been known throughout the centuries to be extraordinary (one picture is worth a thousand words). Computer representation of an image requires the equivalent of many thousands of words of data, so the massive amount of data required for image is a primary reason for the development of many sub areas with field of computer imaging, such as image compression and segmentation .Another important aspect of computer imaging involves the ultimate “receiver” of visual information in some case the human visual system and in some cases the human visual system and in others the computer itself.

Computer imaging can be separate into two primary categories:

1. Computer Vision.
2. Image Processing.

In computer vision application the processed images output for use by a computer, whereas in image processing applications the output images are for human consumption.

These two categories are not totally separate and distinct. The boundaries that separate the two are fuzzy, but this definition allows us to explore the differences between the two and to explore the difference between the two and to understand how they fit together (Figure 1.1). Historically, the field of image processing grew from electrical engineering as an

extension of the signal processing branch, whereas are the computer science discipline was largely responsible for developments in computer vision.

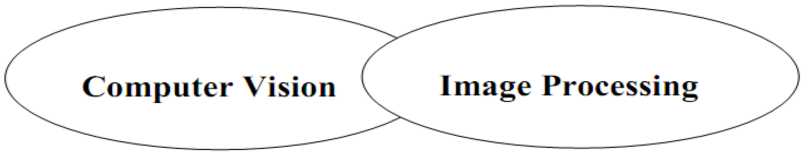


Fig.(1.1) computer imaging

Computer vision is computer imaging where the application doses not involve a human being in visual loop. One of the major topics within this field of computer vision is image analysis.

Image Analysis: involves the examination of the image data to facilitate solving vision problem.

Computer vision systems are used in many and **various types of environments, such as:**

1. Manufacturing Systems
2. Medical Community
3. Law Enforcement
4. Infrared Imaging
5. Satellites Orbiting.

Image processing is computer imaging where application involves a human being in the visual loop. In other words the image are to be examined and a acted upon by people.

There are two categories of the steps involved in the image processing –

(1) Methods whose **outputs are input** are **images**.
(2) Methods whose outputs are attributes extracted from those images.

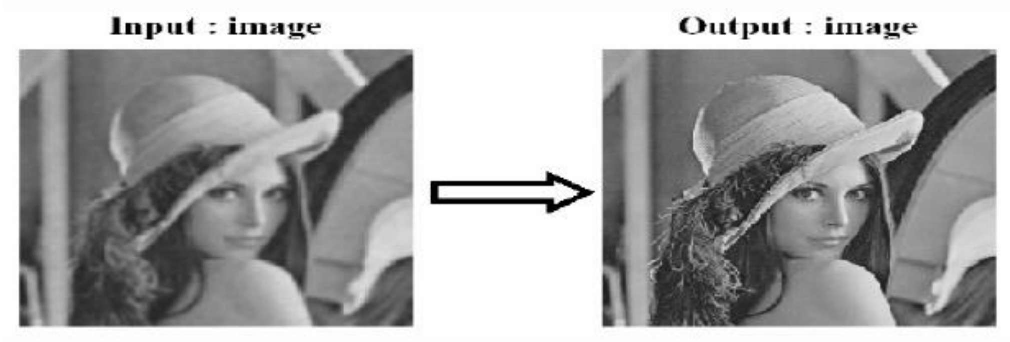
The major topics within the **field of image processing include**:

1. Image restoration.
2. Image enhancement.
3. Image compression.

1. Image restoration.

Is the process of taking an image with some known, or estimated

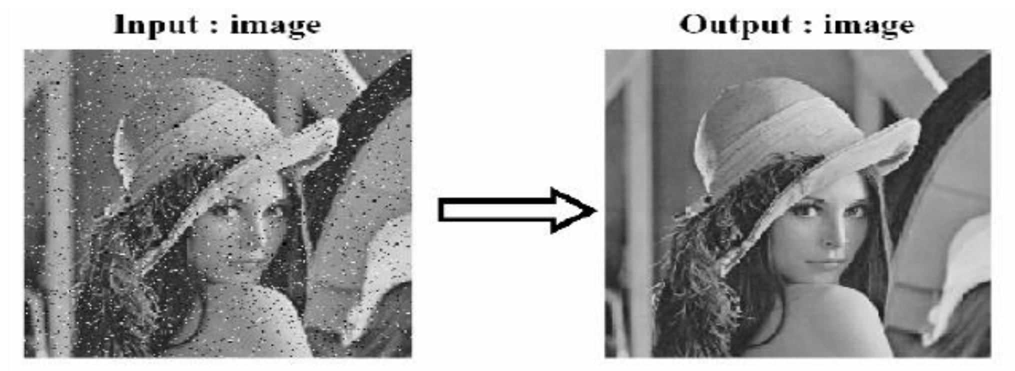
degradation, and restoring it to its original appearance. Image restoration is often used in the field of **photography or publishing** where an image was somehow degraded but needs to be improved before it can be printed.



2. Image enhancement.

Involves taking an image and improving it visually, typically by taking advantages of human Visual Systems responses. One of the simplest enhancement techniques is to simply **stretch the contrast of an image**. Enhancement methods tend to be problem specific. For example, a method that is used to enhance satellite images may not suitable for enhancing medical images.

Although enhancement and restoration are similar in aim, to make an **image look better**. They differ in how they approach the problem. **Restoration method** attempt to model the distortion to the image and reverse the degradation, where **enhancement methods** use knowledge of the human visual systems responses to improve an image visually.



3. Image compression.

Involves reducing the typically massive amount of data needed to represent an image. This done by eliminating data that are visually

unnecessary and by taking advantage of the redundancy that is inherent in most images. **It has to major approaches**

a) Lossless Compression

b) Lossy Compression

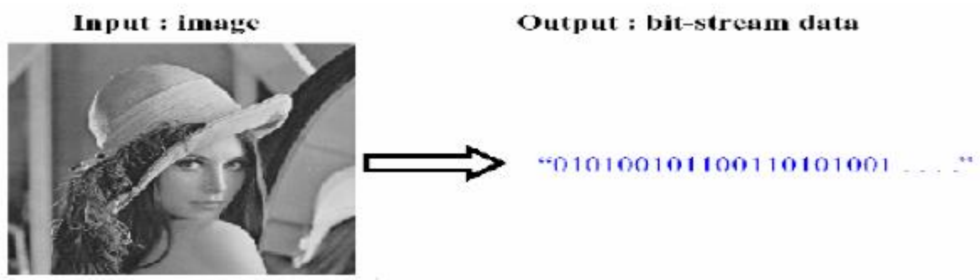
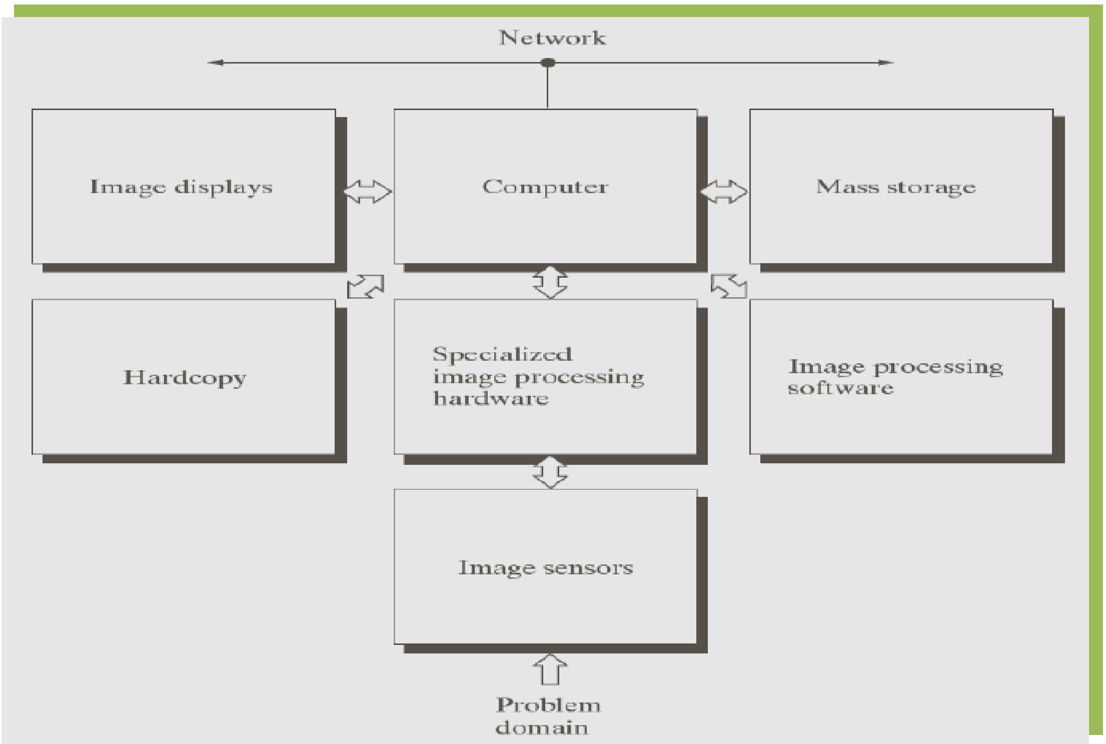


Image processing systems are used in many and various types of environments, such as:

1. Medical community
2. Computer – Aided Design
3. Virtual Reality
4. Image Processing.

2. Components of Image Processing System



Computer imaging systems are comprised of two primary components types, **Hardware and Software**. The hardware components can be divided into image acquiring sub system (computer, scanner, and camera) and display devices (monitor, printer).The software allows us to manipulate the image and perform any desired processing on the image data.

i) Image Sensors

With reference to sensing, two elements are required to acquire digital image. The first is a physical device that is sensitive to the energy radiated by the object we wish to image and second is specialized image processing hardware.

ii) Specialized image processing hardware

It consists of the digitizer just mentioned, plus hardware that performs other primitive operations such as an arithmetic logic unit, which performs arithmetic such addition and subtraction and logical operations in parallel on images.

iii) Computer

It is a general purpose computer and can range from a PC to a supercomputer depending on the application. In dedicated applications, sometimes specially designed computer are used to achieve a required level of performance.

iv) Software

It consist of specialized modules and designed package that perform specific tasks, also includes capability for the user to write code utilizes the specialized module. More sophisticated software packages allow the integration of these modules.

v) Mass storage

This capability is important in image processing applications. An image of size 1024x1024 pixels ,in which the intensity of each pixel is an 8-bit quantity requires one megabytes of storage space if the image is not compressed .

vi) Image displays

Image displays in use today are mainly color TV monitors. These monitors are driven by the outputs of image and graphics displays cards that are an integral part of computer system

vii) Hardcopy devices

The devices for recording image includes laser printers, film cameras, heat sensitive devices and digital units such as optical and CD ROM disk. Films provide the highest possible resolution, but paper is the obvious medium of choice for written applications.

viii) Networking

It is almost a default function in any computer system in use today because of the large amount of data inherent in image processing applications. The key consideration in image transmission bandwidth.

3 Human Visual System (HVS)

The Human Visual System (HVS) has two primary components:

- Eye.
- Brian.

* The structure that we know the most about is the image receiving sensors (the human eye). **The brain** can be thought as being an **information processing unit** analogous **to the computer in our computer** imaging system. These two are connected by the optic nerve, which is really a bundle of nerves that contains the path ways for visual information to travel from the receiving sensor (the eye) to the processor (the brain).

4 A Simple Image Model

An image is denoted by a two dimensional function of the form f(x, y). The value or amplitude of ***f*** at spatial coordinates {x,y} is a **positive** scalar quantity whose physical meaning is determined by the source of the image.

When an image is generated by a physical process, its values are proportional to energy radiated by a physical source. As a consequence, f(x,y) must be nonzero and finite; that is

$0 < f(x,y) < \infty$

The function f(x,y) may be characterized by two components: The amount of the source illumination incident on the scene being viewed. The amount of the source illumination reflected back by the objects in the scene. These are called illumination and reflectance components and are denoted by **i(x,y)** and **r(x,y)**, respectively. The functions combine as a product to form f(x,y).We call the intensity of a monochrome image at any coordinates (x,y) the **gray level (l)** of the image at that point

l= f (x, y)
L min ≤ l ≤ Lmax
Lmin is to be positive and Lmax must be finite
Lmin = imin rmin
Lmax = imax rmax

The interval [Lmin, Lmax] is called ***gray scale***. Common practice is to shift this interval numerically to the interval [0, L-l] where l=0 is considered black and l= L-1 is considered white on the gray scale. All

intermediate values are shades of gray of gray varying from black to white.

5 Digitization

To create a digital image, we need to convert the continuous sensed data into digital form. This involves **two processes** – sampling and quantization. An image may be continuous with respect to the x and y coordinates and also in amplitude. To convert it into digital form we have to sample the function in both coordinates and in amplitudes.

Digitalizing the coordinate values is called sampling (spatial resolution)

Digitalizing the amplitude values is called quantization(Gray level resolution)

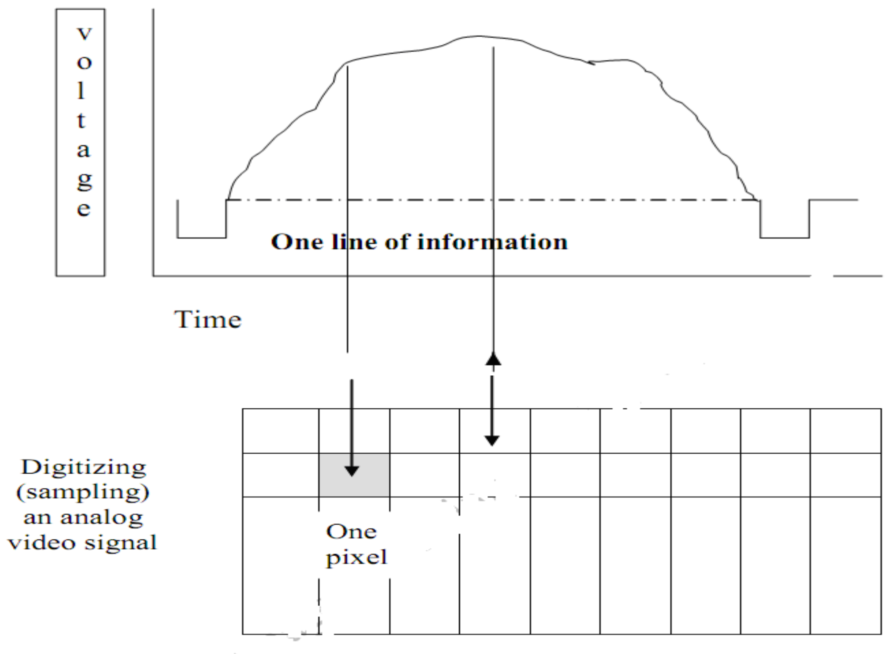
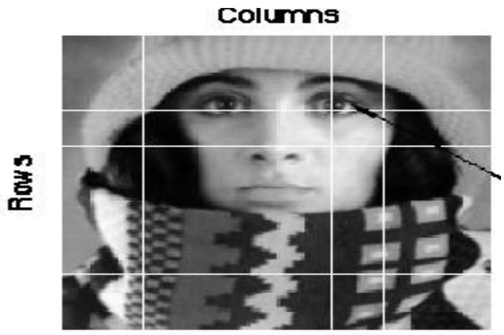


Figure (3) Digitizing (Sampling) an Analog Video Signal

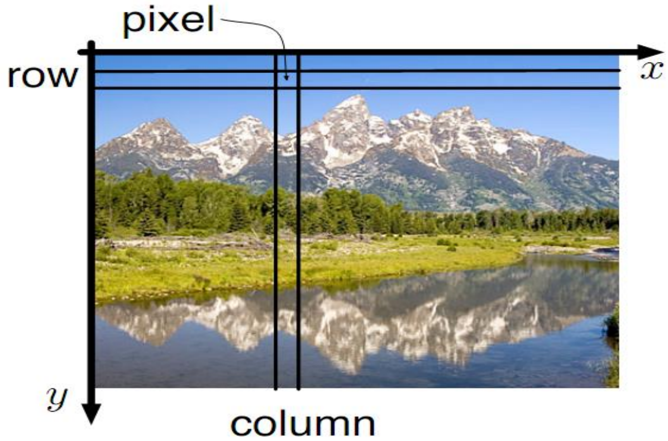
6 Digital Image Definition

A digital image described in a 2D discrete space is derived from an analog image in a 2D continuous space through a sampling process that is frequently referred to as digitization.

The effect of digitization is shown in figure 4. The 2D continuous image is divided into ***N*** rows and ***M*** columns. The intersection of a row and a column is termed a pixel. The value assigned to the integer coordinates [m, n] with (m=0,1,…..,M) and (n=0,1,….,N-1) is f[m,n].



A digital image is composed of a finite number of elements, each of which has a particular location and values of these elements are referred to as picture elements, image elements, **pels and pixels**.



7 Representing Digital Images

The result of sampling and quantization is matrix of real numbers. Assume that an image f(x,y) is sampled so that the resulting digital image has M rows and N columns. The values of the coordinates (x,y) now become discrete quantities thus the value of the coordinates at origin become (x,y) =(0,0). The next coordinates value along the first signify the image along the first row.

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

Due to processing storage and hardware consideration, the number gray levels typically is an integer power of 2.

$L=2^K$

Then, the number, B, of bites required to store a digital image is

B=M *N* k

When M=N

The equation become $B = N^2 * k$

When an image can have 2^k gray levels, it is referred to as “k- bit” . An image with 256 possible gray levels is called an “8- bit image”($256=2^8$)