جامعة المستقبل
AL MUSTAQBAL UNIVERSITY

قسم الامن السيبراني
Department of Cyber Security

Subject:

Image Processing

Class:

Third

Lecturer:

Asst. Prof. Dr. Ali Kadhum Al-Quraby

Lecture: (1)

Introduction to Computer Vision and Image Processing

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.

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.

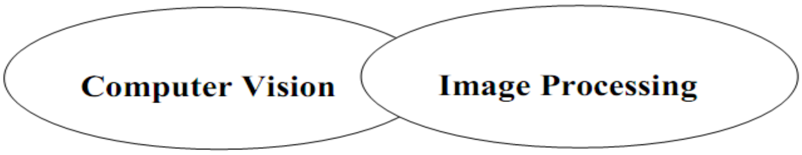


Fig.(1.1) computer imaging

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 –

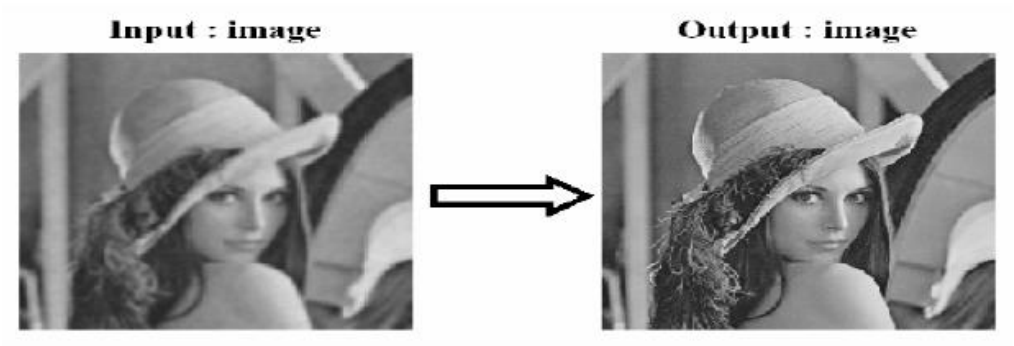
(1) Methods whose **outputs are input** are **images**.
(2) Methods whose outputs are attributes extracted from those images.

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

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

1. Image restoration.

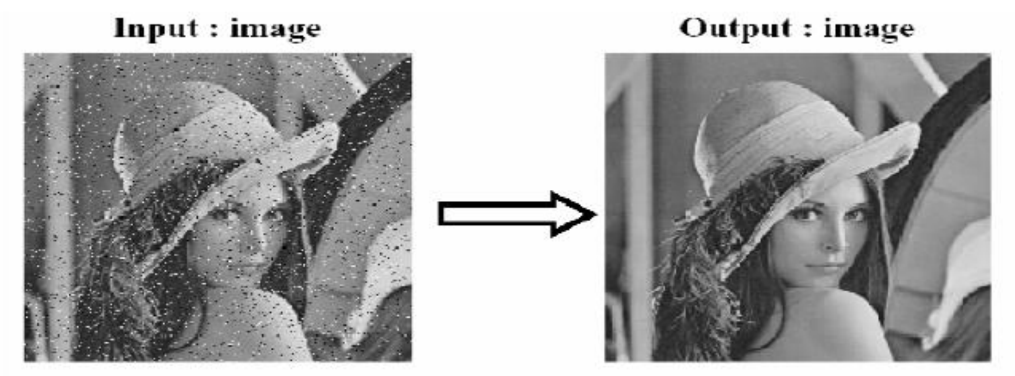
Is the process of taking an image with some known, or estimated degradation, and restoring it to its original appearance. Image restoration is often used in the field of **photography or publishing** where an image was somehow degraded but needs to be improved before it can be printed.



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

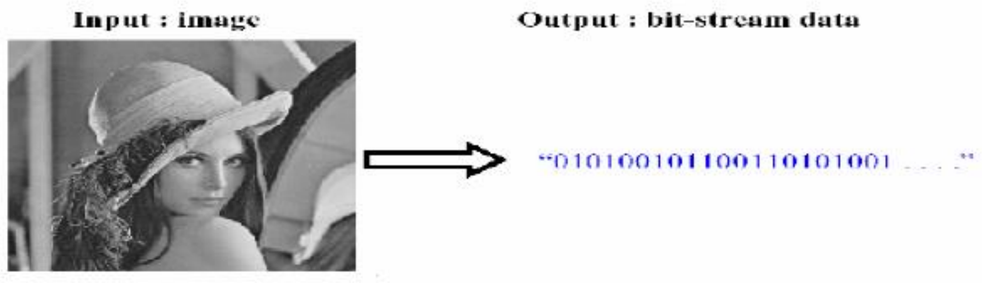
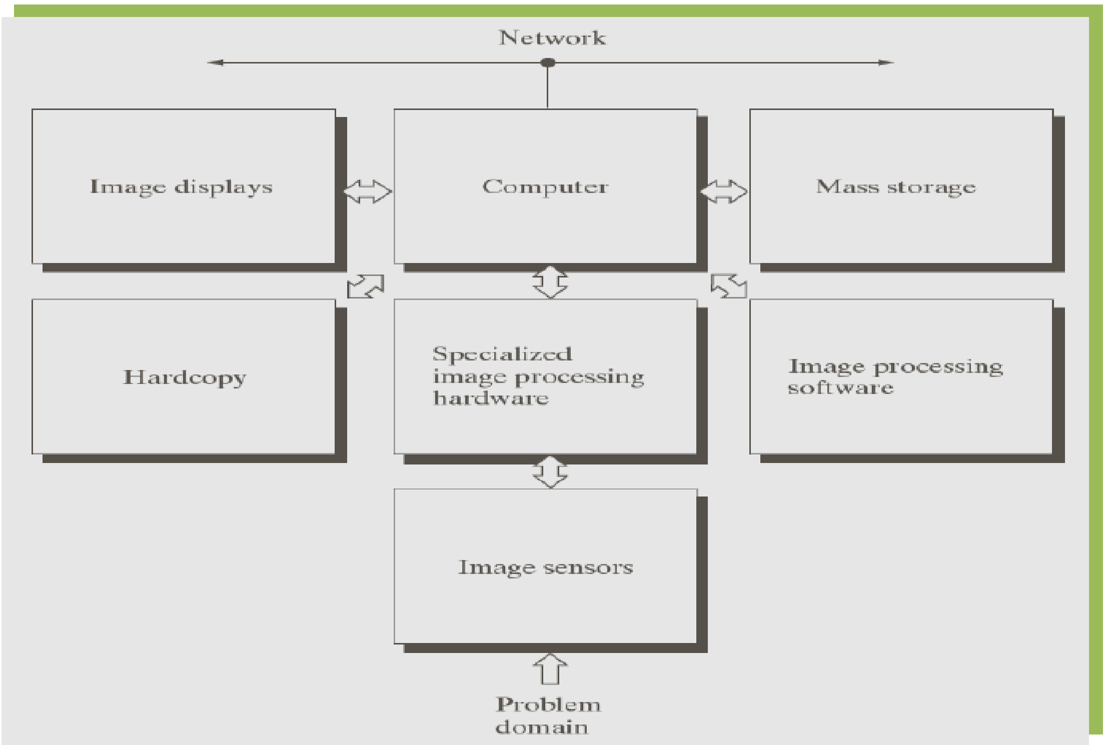


Image processing systems are used in many and various types of environments, such as:

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)

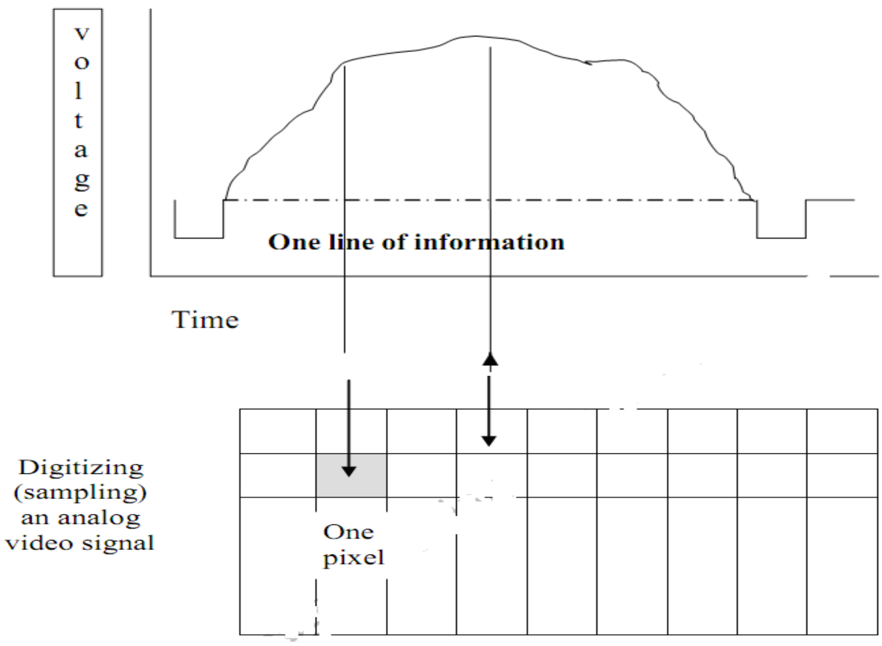
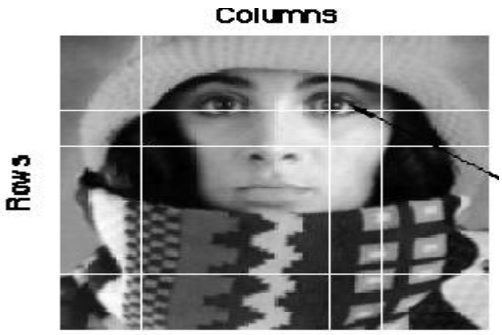


Figure (3) Digitizing (Sampling) an Analog Video Signal

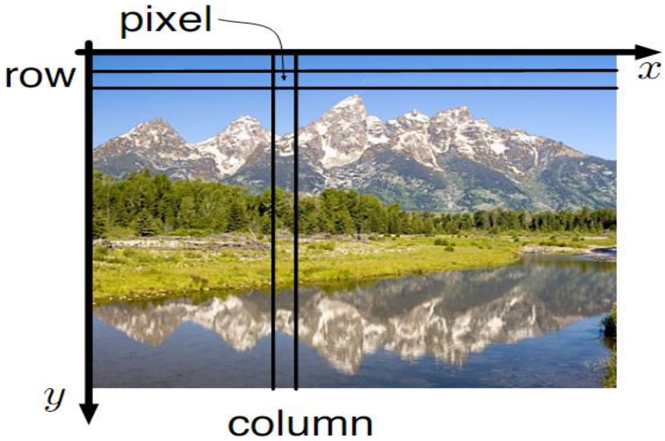
6 Digital Image Definition

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”($256=2^8$)

Image Types

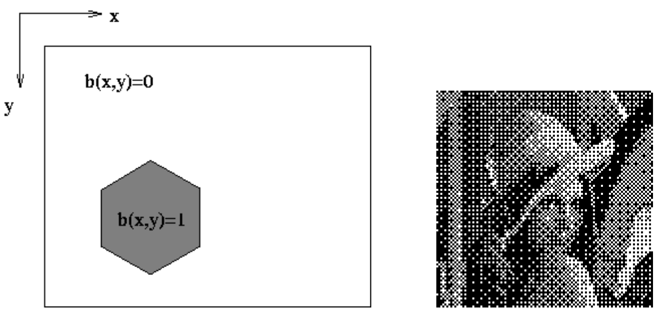
The image types we will consider are:

1. Binary Images

Binary images are the simplest type of images and can take on two values, typically black and white, or ‘0’ and ‘1’. A binary image is referred to as a 1 bit/pixel image because it takes only 1 binary digit to represent each pixel. These types of images are frequently used in computer vision application where the only information required for the task is general shapes, or outlines information. For example, to position a robotics gripper (ذراع الروبوت)to grasp an object or in optical character recognition (OCR).

Binary images are often created from gray-scale images via a threshold value is turned white (‘1’), and those below it are turned black (‘0’). We define the characteristic function of an object in an image to be

$$b(x,y)\begin{cases} =1 & \text{for points on the object} \\ =0 & \text{for background points.} \end{cases}$$



(a) (b)

Figure(1) (a) binary image representation (b) binary Lenna image

- Each pixel is stored as a single bit (0 or 1)
- A 640 x 480 monochrome image (صورة احادية اللون) requires 37.5 KB of storage.

2-Gray Scale Images

They contain brightness information only, no color information. The number of different brightness level available. The typical image contains 8 bit/pixel , which allows us to have (0-255) different brightness (gray) levels. The 8 bit representation is typically due to the fact that the byte, which corresponds to 8-bit of data, is the standard small unit in the world of digital computer.

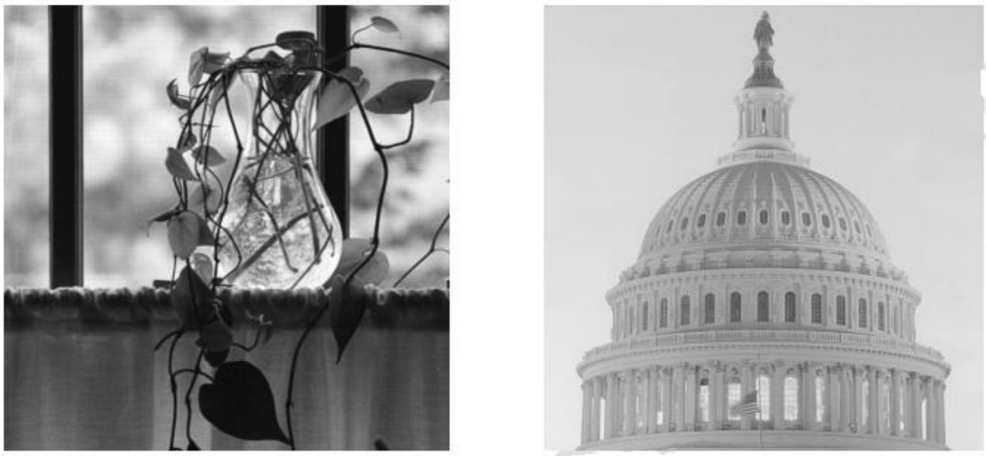


Figure Examples of gray-scale images

- Each pixel is usually stored as a byte (value between 0 to 255)
- A 640 x 480 greyscale image requires over 300 KB of storage.

Figure 3 shows a grayscale image and a 6 × 6 detailed region, where brighter pixels correspond to larger values.

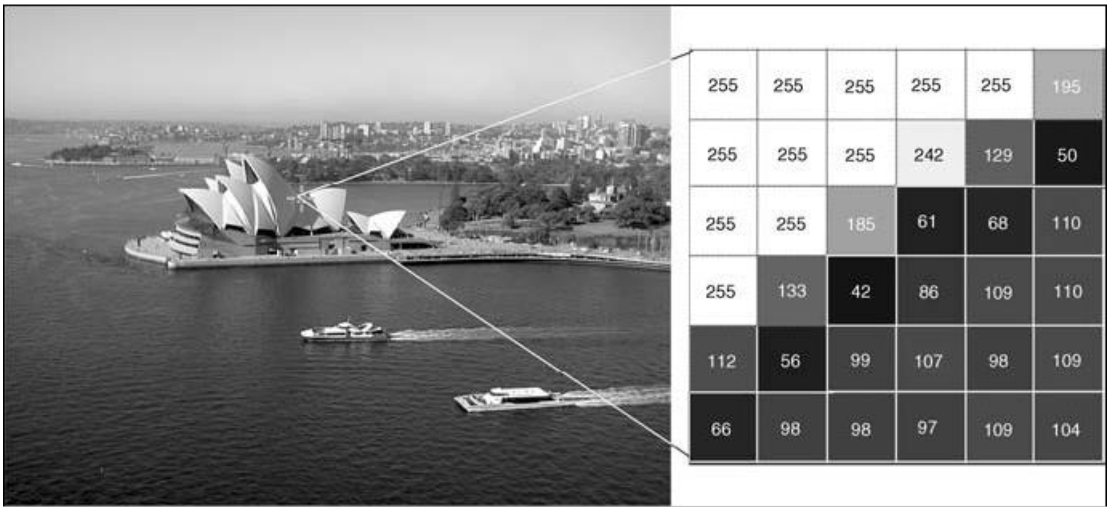


FIGURE 3 A grayscale image and the pixel values in a 6 × 6 neighborhood.

3. Color Images

Representation of color images is more complex and varied. The two most common ways of storing color image contents are:

1)RGB representation—in which each pixel is usually represented by a 24-bit number containing the amount of its red (R), green (G), and blue (B) components.

2) **Indexed representation**—where a 2D array contains indices to a color palette (or lookup table - (LUT)).

24-Bit (RGB) Color Images Color images can be represented using three 2D arrays of same size, one for each color channel: red (R), green (G), and blue (B) (Figure 4). Each array element contains an 8-bit value, indicating the amount of red, green, or blue at that point in a [0, 255] scale. The combination of the three 8-bit values into a 24-bit number allows 2^{24} (16,777,216 usually referred to as 16 million or 16 M) color combinations. An alternative representation uses 32 bits per pixel and includes a fourth channel, called the alpha channel, that provides a measure of transparency (الشفافية) for each pixel and is widely used in image editing effects. In the figure 4 we see a representation of a typical RGB color image.

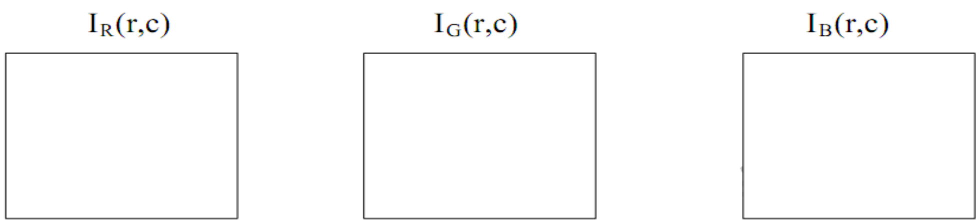


Figure ( ) Typical RGB color image can be thought as three separate images $I_R(r,c)$,$I_G(r,c)$,$I_B(r,c)$ [1]

Figure 5 illustrate that in addition to referring to arrow or column as a vector, we can refer to a single pixel red ,green, and blue values as a color pixel vector –(R,G,B).

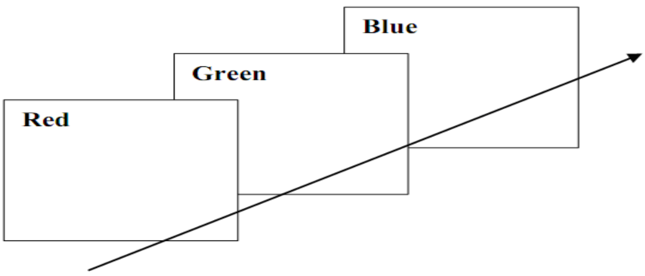


Figure ( ) A color pixel vector consists of the red, green and blue pixel values (R, G, B) at one given row/column pixel

Example of 24-Bit Colors Image

- Each pixel is represented by three bytes (e.g., RGB)

- Supports 256 x 256 x 256 possible combined colors (16,777,216)
- A 640 x 480 24-bit color image would require 921.6 KB of storage

Indexed Color Images: A problem with 24-bit color representations is backward compatibility(انسجام) with older hardware that may not be able to display the 16 million colors simultaneously(معا). A solution devised before 24-bit color displays and video cards were widely available consisted of an indexed representation, in which a 2D array of the same size as the image contains indices (pointers) to a *color palette* (or *color map*) of fixed maximum size (usually 256 colors). The color map is simply a list of colors used in that image. Figure 6 shows an indexed color image and a 4 × 4 detailed region, where each pixel shows the index and the values of R, G, and B at the color palette entry that the index points to.

- One byte for each pixel
- Supports 256 out of the millions s possible, acceptable color quality
- Requires Color Look-Up Tables (LUTs)
- A 640 x 480 8-bit color image requires 307.2 KB of storage (the same as 8-bit grayscale)

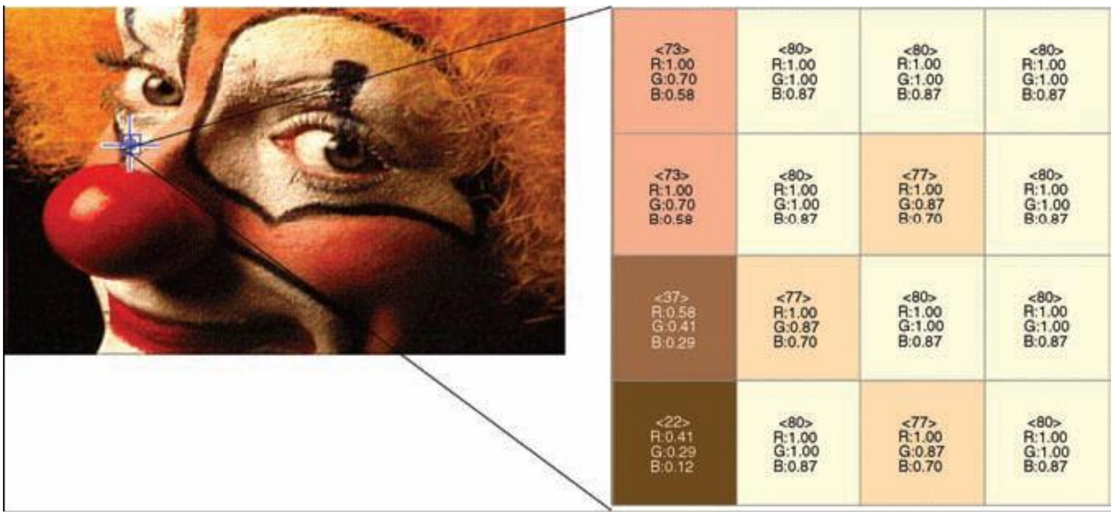


FIGURE 2.5 An indexed color image and the indices in a 4 × 4 neighborhood. Original imag

MCQs for Digital Image Processing - Lecture 1

1. What is the primary input and output of a digital image processing system?
2. The field of Computer Vision historically grew from which discipline?
3. In the context of computer imaging, which category involves a human being in the visual loop?
4. Which of the following is a major topic within the field of Image Processing?
5. What is the key difference between Image Restoration and Image Enhancement?
6. The process of reducing data by eliminating visually unnecessary information is called:
7. Which type of compression eliminates data, potentially leading to a loss of quality?
8. What are the two main processes involved in digitizing an image?
9. Digitalizing the coordinate values of an image is known as:
10. A digital image is essentially a:
11. If an image has 128 possible gray levels, how many bits per pixel (k) is it?
12. The number of bits required to store an N x N image with 2^k gray levels is:
13. A Binary Image is also referred to as a:
14. How is a binary image typically created from a grayscale image?
15. How much storage is required for a 640 x 480 binary image?
16. In an 8-bit grayscale image, the brightness values range from:
17. In the RGB color model, how many bits are used to represent one pixel in a 24-bit image?
18. How many total color combinations are possible in a 24-bit RGB image?
19. What is the primary purpose of the alpha channel in a 32-bit image representation?
20. In Indexed Color representation, what does each pixel store?
21. What is a major advantage of using Indexed Color images?
22. Which component of a computer imaging system is described as an "information processing unit" analogous to a computer?
23. The two components that characterize the simple image model f(x, y) are:
24. The intersection of a row and a column in a digital image is called a:
25. Which hardware component performs primitive operations like addition and subtraction on images in parallel?