- Can usually only edit individual or groups of pixels in an image editing application, e.g. photoshop.

4) Audio

- Audio signals are continuous analog signals.
- Input: microphones and then digitised and stored.
- CD Quality Audio requires 16-bit sampling at 44.1 KHz.
- Usually compressed (E.g. MP3, AAC, Flac, Ogg Vorbis).

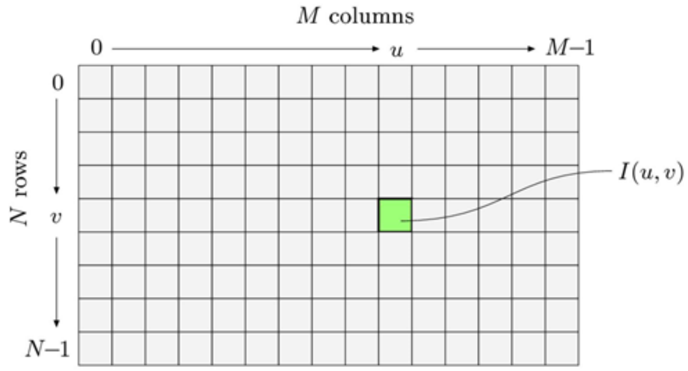
5) Video

- Input: Analog Video is usually captured by a video camera and then digitised, although digital video cameras now essentially perform both tasks.
- There are a variety of video (analog and digital) formats.
- Raw video can be regarded as being a series of single images. There are typically 25, 30 or 50 frames per second.

المحور الثاني

8 & 9 : Graphics and Image Data Representation

The image data structure is a 2D array of pixel values as shown in Figure below.



Digital Images

An image must be converted to numerical form before processing. This conversion process is called digitization, and a common form is illustrated in Figure (1). The image is divided into small regions called ***picture elements***, or ***pixel*** for short. The most common subdivision scheme is the rectangular sampling grid shown in Figure (1). The image is divided into horizontal lines made up of adjacent pixels.

At each pixel location, the image brightness are sampled and quantized. This step generates an integer at each pixel representing the brightness or darkness of the image at that point. When this has been done for all pixels, the image is represented by a rectangular array of integer. Each pixel has a location or address (Line or row number and sample or column number) and an integer value called gray level. This array of digital data is now a candidate for computer processing.

A digital image is a numeric representation of a two-dimensional image. Depending on whether the image resolution is fixed. The term "digital image" usually refers to **raster images or bitmapped images**.

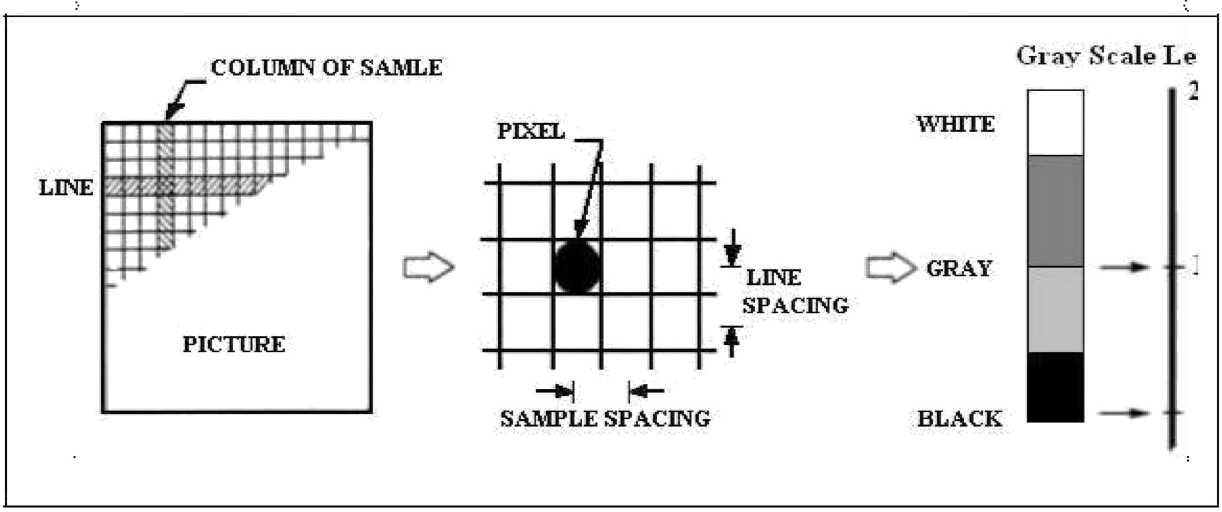


Figure Digitizing an Image

Thus a digital image is now a two-dimensional rectangular array of quantized sample value.

A digital image consists of many picture elements, termed pixels. The number of pixels determine the quality of the image (resolution).

Image Representation (Data Structures bitmap representation)

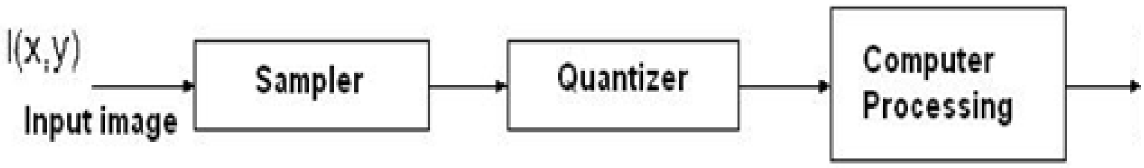
As we know, the human visual system receives an input image as a collection of spatially distributed light energy; this form is called an optical image. Optical images are the types we deal with every day - cameras capture them, monitors display them, and we see them. We know that these optical images are represented as video information in the form of analog electrical signals and have seen how these are sampled to generate the digital image *f(x,y)*.

The digital image *f(x,y)* is represented as a two-dimensional array of data, where each pixel value corresponds to the brightness of the image at the point *(x,y)*. In linear algebra terms, a two-dimensional array like our image model *f(x,y)* is referred to as a matrix, and one row (or column) is called a vector. This image model is for monochrome (one-color, this is what we normally refer to as black and white) image data, we also have other types of image data that require extensions or modifications to this model.

10. Image Digitalization

Typical image processing scenario

- The image is represented by a function of two continuous variables, spatial coordinates (x, y).
- The first function is ***sampling***: we sample the continuous image signal (discretization of the spatial coordinates).
- The result is then injected into the ***Quantization*** function: for a monochrome image, we often choose 256 luminance levels.
- The image is now digitalized, so we can apply the required image processing, which could be binarization, contrast enhancement, etc.

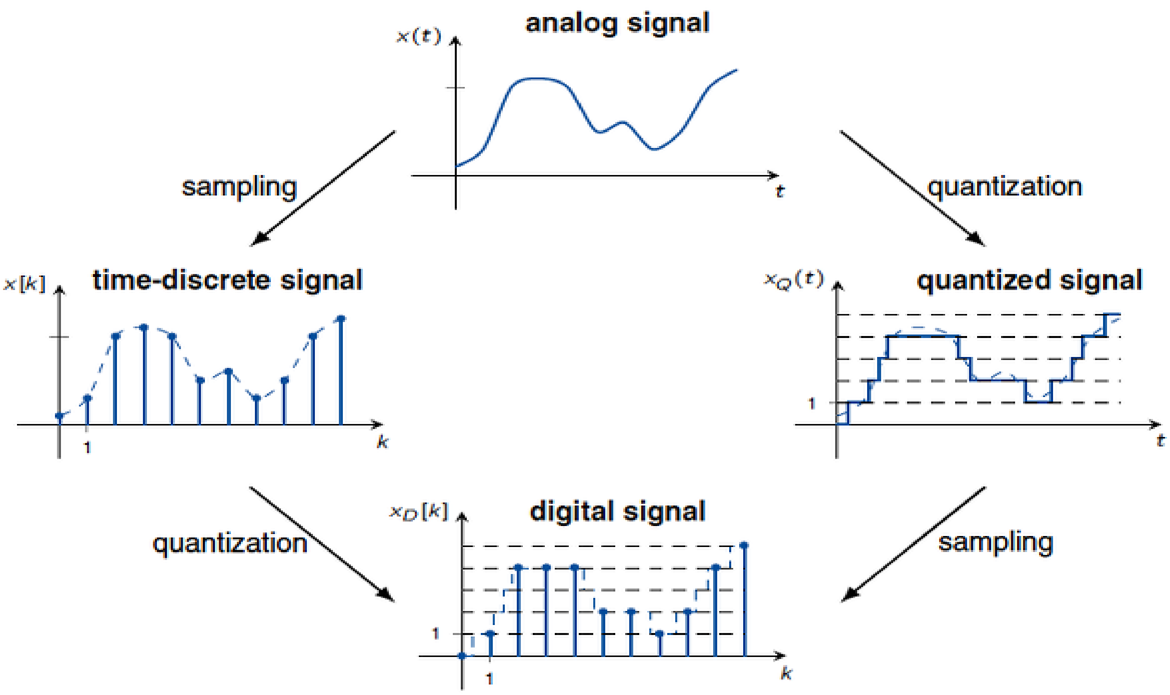


Hence, in order to create an image which is digital, we need to covert continuous data into digital form. There are two steps in which it is done:

1- Sampling

2- Quantization

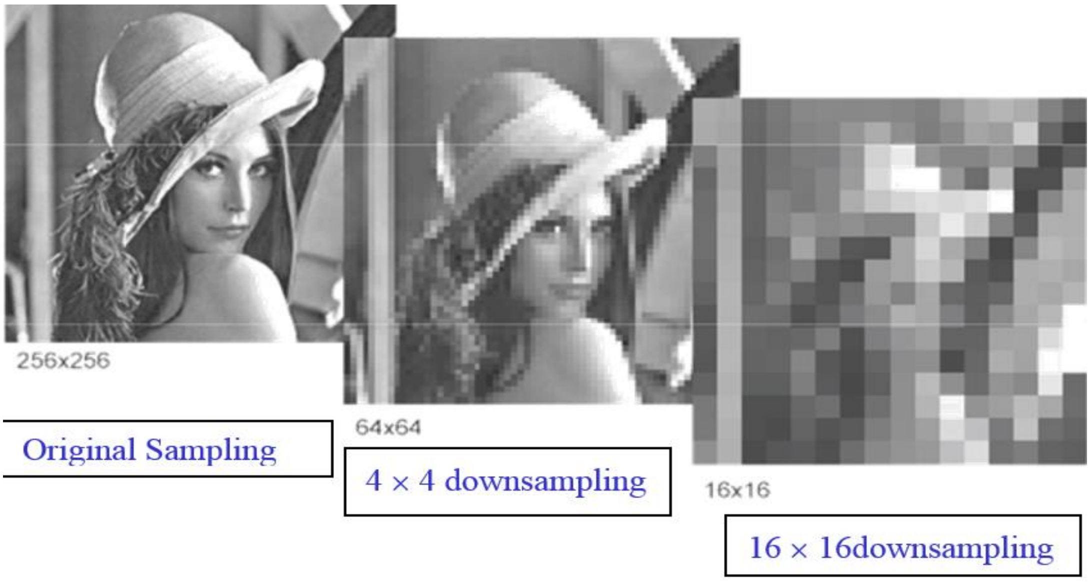
The sampling rate determines the spatial resolution of the digitized image, while the quantization level determines the number of gray levels in the digitized image. A magnitude of the sampled image is expressed as a digital value in image processing. The transition between continuous values of the image function and its digital equivalent is called quantization.



The number of quantization levels should be high enough for human perception of fine shading details in the image. The occurrence of false contours is the main problem in an image which has been quantized with insufficient brightness levels.

1. Sampling (represents => resolution)

Sampling: is a process of measuring the value of the image function *f (x, y)* at discrete ***intervals in space***. Each sample corresponds to a small square area of the image, known as a pixel. two-dimensional pattern to represent the measurements (light intensity or color) that are made in the form of an image numerically.



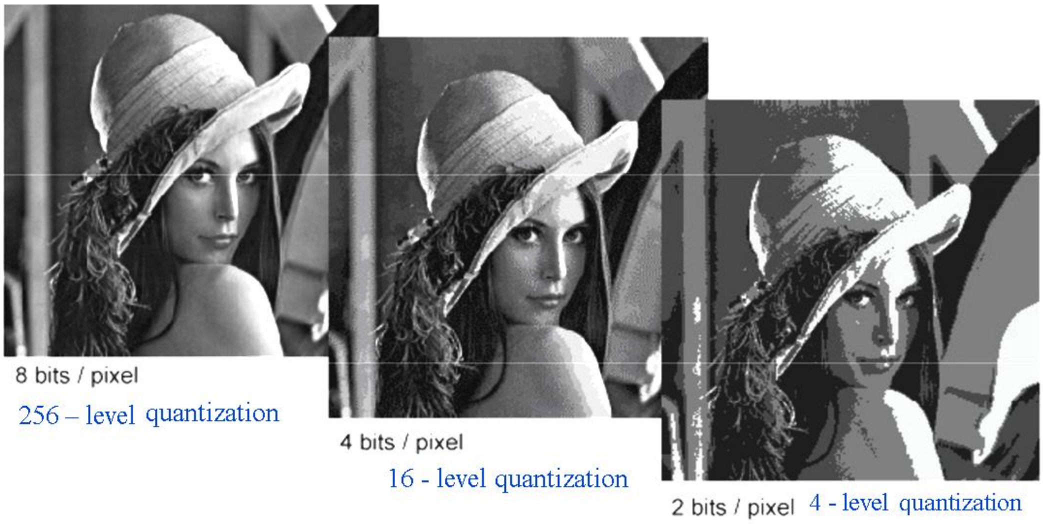
Examples: Image Sampling

In this figure, we have represented the image "Lena" sampled with two different sampling structures. The image on the left is the reference image (spatial dimensions: (256*256) pixels). The second image is sampled with a sampling frequency four times lower for each of the two spatial dimensions. This means it is (64*64) pixels. For display purposes, it has been brought to the same size as the original using a zoom. This is in fact an interpolation of zero- order (each pixel is duplicated 4*4 times, so that on the screen it displays a square of (4*4) identical pixels).

2. Quantization

Quantization: is the process of converting a continuous range of values into a finite range of discreet values. The accuracy with which variations in *f (x, y)* are represented is determined by The number of quantization levels that we use: the more levels we use, the better the approximation.

As number of bits to represent a pixel intensity is quantized. Suppose 8 bit is used for a pixel, it’s equivalent value ranges from 0 to 255 (discrete values). 0 is assigned to pure Black, and 255 is assigned to pure White. Intermediate values are assigned to gray scales as shown in this image.



Quantization of an image

This illustration shows examples of a quantization carried out on the image :

For the image on the left: quantization is followed by a natural binary coding with 8 bits per pixel. There are $2^8 = 256$ reconstruction levels to represent the magnitude of each pixel. It is the typical case of a monochrome image (only in gray scales).

For the middle image: quantization is carried out with a 4 bits per pixel coding, giving $2^4 = 16$ reconstruction levels. Contours are well rendered but textures are imprecise in some cases. These are areas in the signal with a weak spatial variation, which suffer more visually due to the appearance of false contours (loss on the face and the shoulder).

For the image on the right: quantization is carried out with a 2 bits per pixel coding, so we have $2^2 = 4$ reconstruction levels. The deterioration seen on the previous image is even more flagrant here.

11. Spatial resolution and quantization

What is size of the image? And what is a resolution?

Resolution = width x height
Image Size = width x height x No. of bit per pixel

Quantization = Number of bits per pixel (***Quantization***)

Spatial resolution can be defined as the smallest discernible detail in an image. In short, what spatial resolution refers to is that we cannot compare two different types of images to see that which one is clear or which one is not. If we have to compare the two images, to see which one is more clear or which has a more spatial resolution, we have to compare two images of the ***same size***.

Spatial resolution is determined by the ***sampling process***. The spatial resolution of a digital image reflects the amount of details that one can see in the image (i.e. the ratio of pixel "area" to the area of the image display). If an image is spatially sampled at *X* pixels, then the larger *X* the finer the observed details. Or in other way we can define spatial resolution as the number of independent pixels per inch (PPI).

Effect of reducing the spatial resolution

Decreasing spatial resolution of a digital image, within the same area, may result in what is known as *checkerboard pattern*. Also image details are lost when the spatial resolution is reduced.

To demonstrate the checkerboard pattern effect, we subsample the 1024×1024 image shown in Figure (1) to obtain the image of size 512×512 pixels. The 512×512 is then subsampled to 256×256 image, and so on until 32×32 image. The subsampling process means deleting the appropriate number of rows and columns from the original image. The number of allowed gray levels ***was kept*** at 256 in all the images.

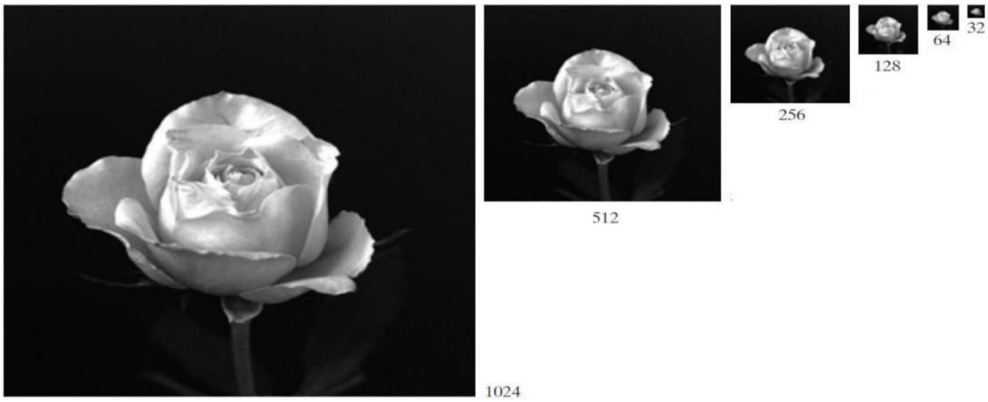


Figure : A 1024×1024, 8-bit image Sub sampled down to size 32×32 pixels.

To see the effects resulting from the reduction in the number of samples, we bring all the subsampled images up to size 1024×1024 by row and column pixel replication. The resulted images are shown in Figure.

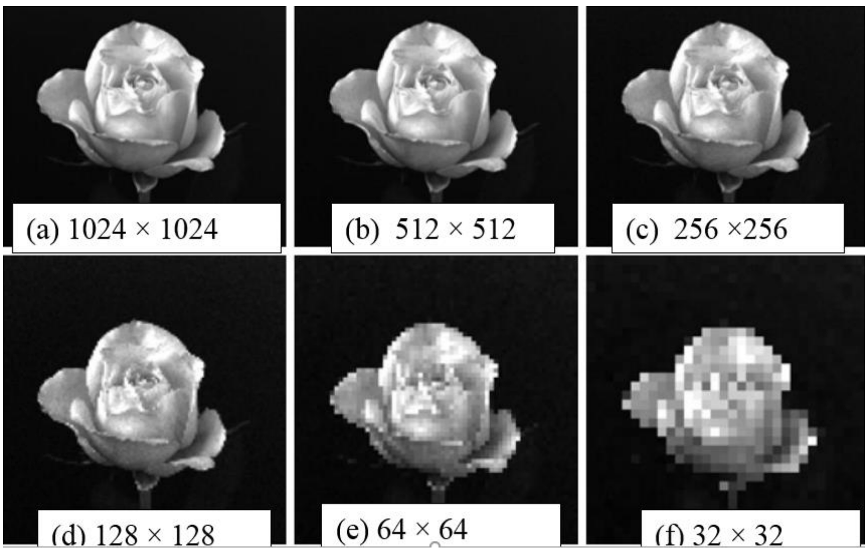


Figure 2. the effects of resulting from the reduction in the number of samples. All images have 8 – bits.

Compare Figure 2(a) with the 512×512 image in Figure 2(b), we find that the level of detail lost is simply too fine to be seen on the printed page at the scale in which these images are shown. Next, the 256×256 image in Figure 2(c) shows a very slight fine checkerboard pattern in the borders between flower petals and the black background. A slightly more pronounced graininess throughout the image also is beginning to appear. These effects are much more visible in the 128×128 image in Figure 2(d), and they become pronounced in the 64×64 and 32×32 images in Figures 2(e) and (f), respectively.

12. Type of image

The image types we will consider are :

1) Binary **2) grayscale** **3) color** **4) multispectral.**

The more general term pixmap refers to a map of pixels, where each one may store more than two colors, thus using more than one bit per pixel. Often bitmap is used for this as well

1. Binary Images (Black and White Images) (monochrome image)

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 most frequently used in computer vision applications where the only information required for the task is general shape or outline, information.

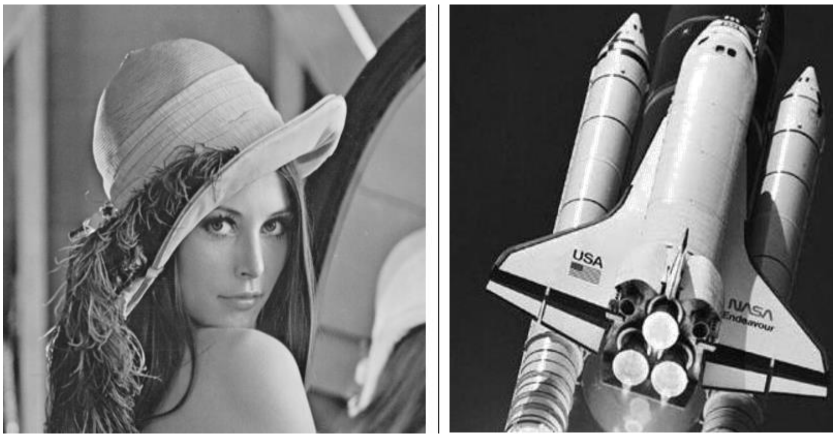
Binary images are often created from gray-scale images via a threshold operation where every pixel above the threshold value is turned white ('1'), and those below it are turned black ('0').

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

2. Gray-Scale Images

Gray-scale images are referred to as monochrome, or one-color, images. They contain brightness information only, no color information. The number of bits used for each pixel determines the number of different brightness levels Available. The typical image contains 8 bits/pixel data, which allows us to have 256 (0-255) different brightness (gray) levels.

This representation provides more than adequate brightness resolution, in terms of the human visual system's requirements and provides a "noise margin" by allowing for approximately twice as many gray levels as required. Additionally, the 8 bit representation is typical due to the fact that the byte which corresponds to 8 bit of data, is the standard small unit in the world of digital computers.



Each pixel is usually stored as a byte (value between 0 to 255). A dark pixel may have a value of 10; a bright one may be 240 (**dark=0; white=255**)

Example: find image size with 640*480 pixles

Total no. of bits = 640*480* 8 bit=2457600 bit Or 640*480*1 Byte=307200Bytes

Convert to Byte: 2457600/8=307200 Byte

Convert to KByte: 307200 Byte/1024 = 300 KB

3. Color Images

Color images can be modeled as three-band monochrome image data, where each band of data corresponds to a different color. The actual information stored in the digital image data is the brightness information in each spectral band. When the image is displayed, the corresponding brightness information is displayed on the screen by picture elements that emit light energy corresponding to that particular color. Typical color images are represented as Red, Green, and Blue, or RGB images. Using the 8-bit monochrome standard as a model, the corresponding color image would have 24 bits/pixel 8-bits for each of the three color bands (Red, Green, and Blue). In Figure (2-a) we see a representation of a typical RGB color image. Figure (2-a) illustrates that, in addition to referring to a row or column as a vector, we can refer to a single pixel's Red, Green, and Blue values as a color pixel vector (R, G, B).

For many applications, RGB color information is transformed into a mathematical space that decouples the brightness information from the color information. After this is done, the image information consists of a one-dimensional brightness, or luminance, space and a two-dimensional color space. Now the two-dimensional color space does not contain any brightness information; but it typically contains information regarding the relative amounts of the different colors. An additional benefit of modeling the color information in this manner is that it creates a more people-oriented way of describing the colors.

24-Bit Color Images

How many colors in RGB model?

In a color 24-bit image, each pixel is represented by three bytes, usually representing RGB. Since each value is in the range 0–255, this format supports 256 × 256 × 256, or a total of 16,777,216, possible combined colors. However, such flexibility does result in a storage penalty: a 640 × 480 24-bit color image would require 921.6 kB of storage without any compression. Color images are actually stored as 32-bit images, with the extra byte of data for each pixel used to store an alpha value representing special effect information (e.g., transparency).

Examples: Color Image uses 32 bits with high = 200 and width = 200 pixels?

Size= 200*200*4 Bytes=160000B/1024=156.25KB.

4. Multispectral Images

Multispectral images typically contain information outside the normal human perceptual range. This may **include** infrared, ultraviolet, X-ray, acoustic, radar data. These are not images in the usual sense because the information represented is not directly visible by the human system. However, the information is often represented in visual form by mapping the different spectral bands to RGB components. If more than three bands of information are in the multispectral image, the dimensionality is reduced by applying a principal component's transform.

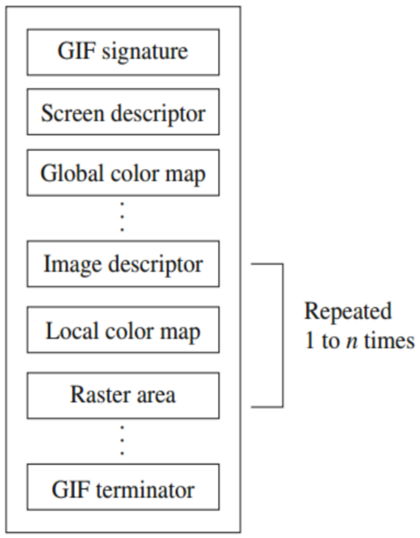
13. Image file formats

Some popular file formats are listed in the table below with their respective extensions:

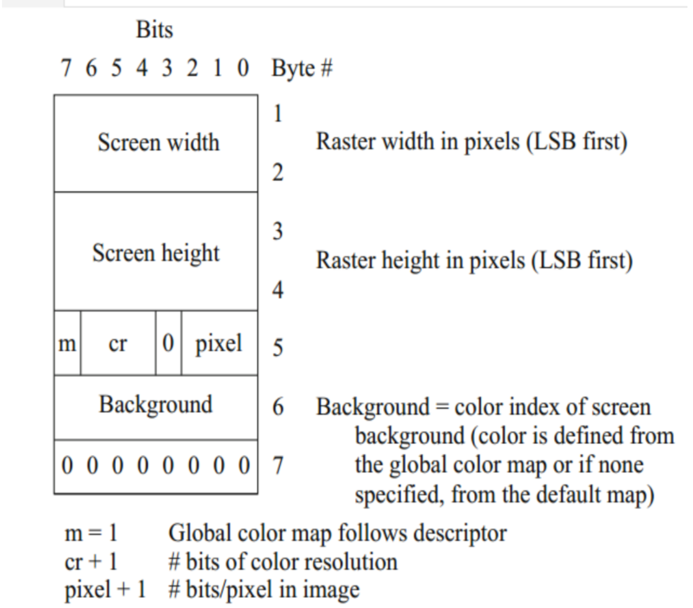
Format Name	Description	Recognized Extensions
GIF	Graphics Interchange Format	.gif
JPEG	Joint Photographic Experts Group	.jpg, .jpeg
TIFF	Tagged Image File Format	.tif, .tiff
BMP	Windows Bitmap	.bmp
PNG	Portable Network Graphics	.png

1- GIF

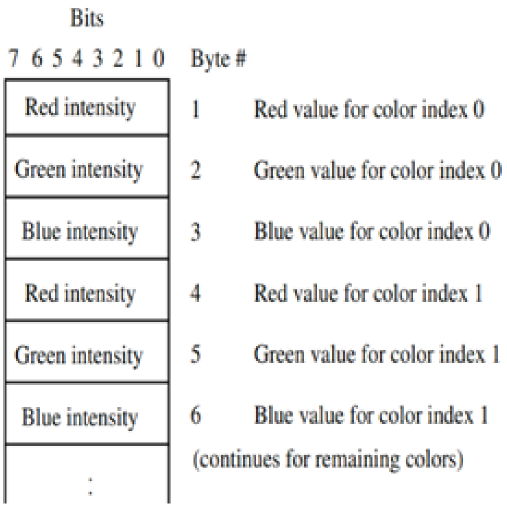
- Graphics Interchange Format (GIF) devised by the UNISYS Corp. and CompuServe, initially for transmitting graphical images over phone lines via modems.
- One of the simplest is the 8-bit GIF format, and we study it because it is easily understood, and also because of its historical connection to the WWW and HTML markup language as the first image
- type recognized by net browsers.
- Limited to only 8-bit (256) colour images, suitable for images with few distinctive colours (e.g., graphics, drawing)
- GIF89a: supports simple animation, transparency index etc.



GIF file format



Screen descriptor



Color map

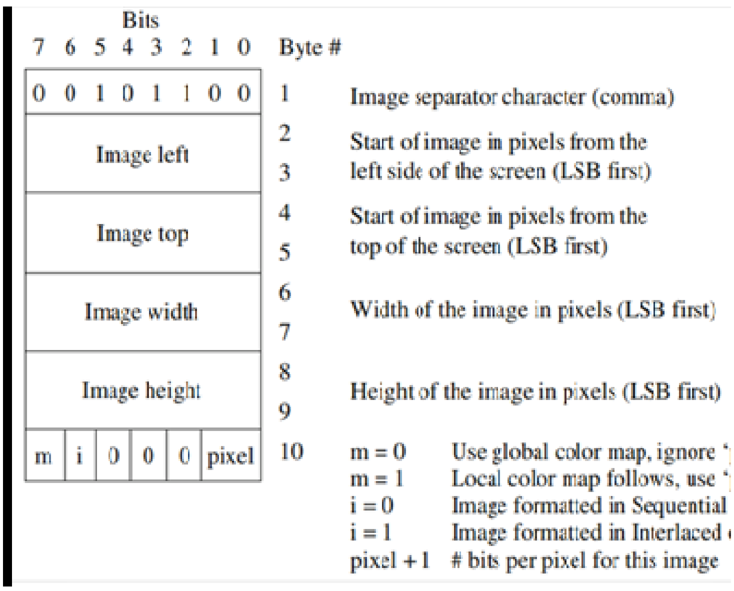


Image descriptor

2- JPEG Standard

- A standard for photographic image compression created by the Joint Photographic Experts Group
- Takes advantage of limitations in the human vision system to achieve high rates of compression.
- Lossy compression which allows user to set the desired level of quality/compression.

3- TIFF

- Tagged Image File Format stores many dierent types of images (e.g., bit-map, greyscale, 8-bit & 24-bit RGB, etc.).
- Developed by the Aldus Corp. in the 1980's and later supported by the Microsoft
- TIFF is a typically lossless format.
- It does not provide any major advantages over JPEG and is not as user-controllable it appears to be declining in popularity

4- BMP

- BitMap (BMP) is the major system standard graphics file format for Microsoft Windows.
- used in Microsoft Paint and other programs. It makes use of run-length encoding compression and can fairly efficiently store 24-bit bitmap images.
- Note, however, that BMP has many different modes, including uncompressed 24-bit images.

5- PNG

PNG meant to supersede GIF standard

Features of PNG:

- Support up to 48 bits per pixel - more accurate colors
- Support description of gamma-correction and
- alpha-channel for controls such as transparency
- Support progress display through 8×8 blocks.