Digital Image Processing

lecture 2

Digitization

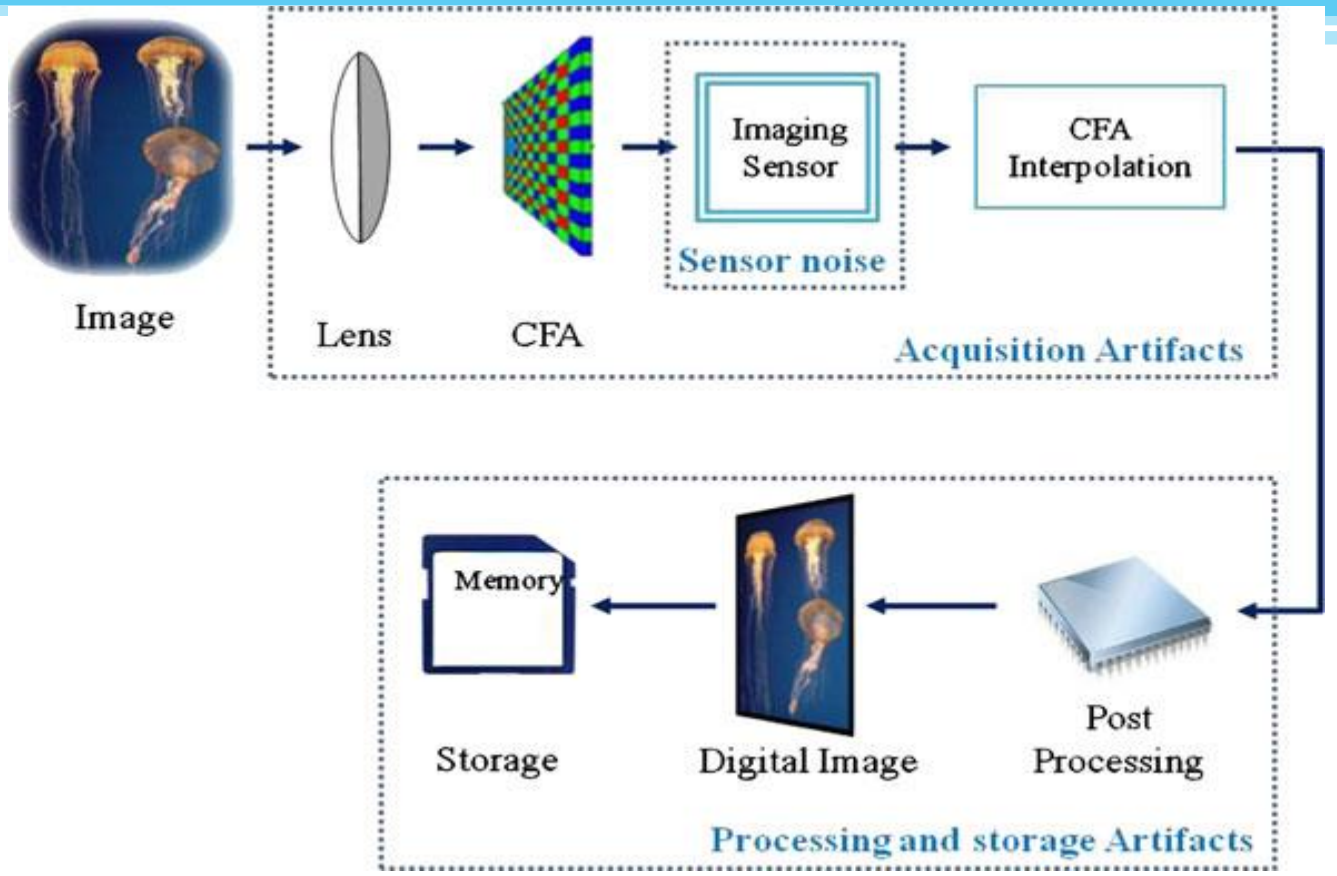
Image Representation

Digital Image File Format

Digitization

- Digitization is the process of converting information into a digital format .
- Information is organized into discrete units of data (called bit s) .
- This is the binary data that computers and many devices with computing capacity (such as digital camera s and digital hearing aid s) can process.

- The first step towards designing an image analysis system is digital image *acquisition* using sensors in optical or thermal wavelengths.



- **A** two dimensional image that is recorded by these sensors is the mapping of the three-dimensional visual world.
- The captured two dimensional signals are *sampled* and *quantized* to yield digital images.

Digitization

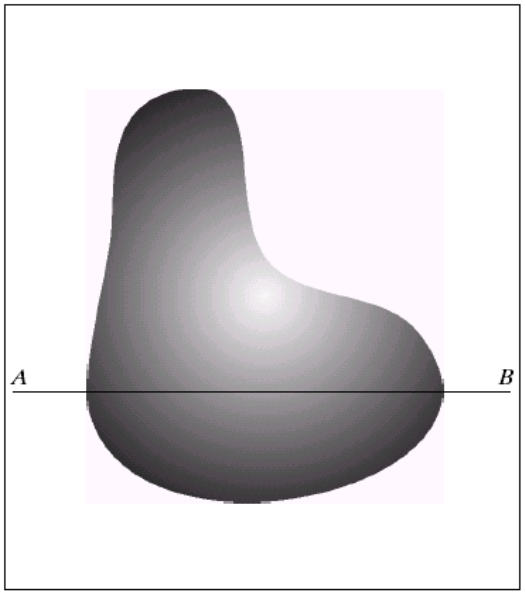
Sampling : related to coordinates values

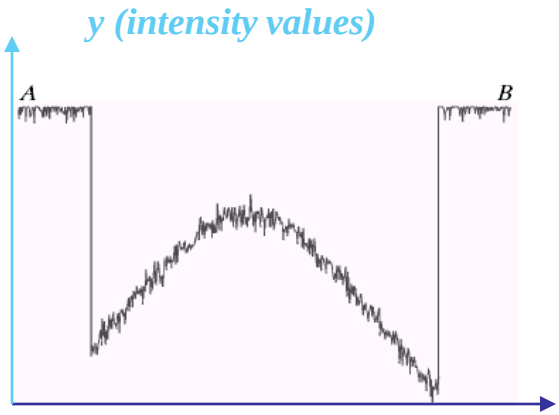
Sample = the 2D space on a regular grid

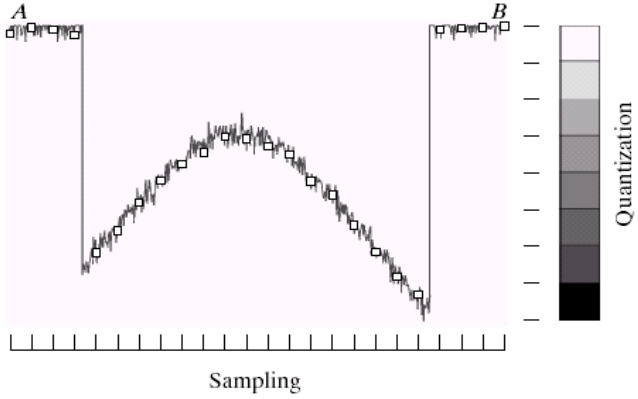
Digitizing the coordinate values is called sampling

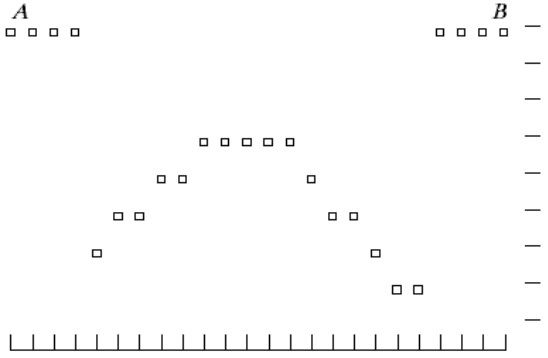
Quantization : related to intensity values.

Digitizing the amplitude values is called Quantization



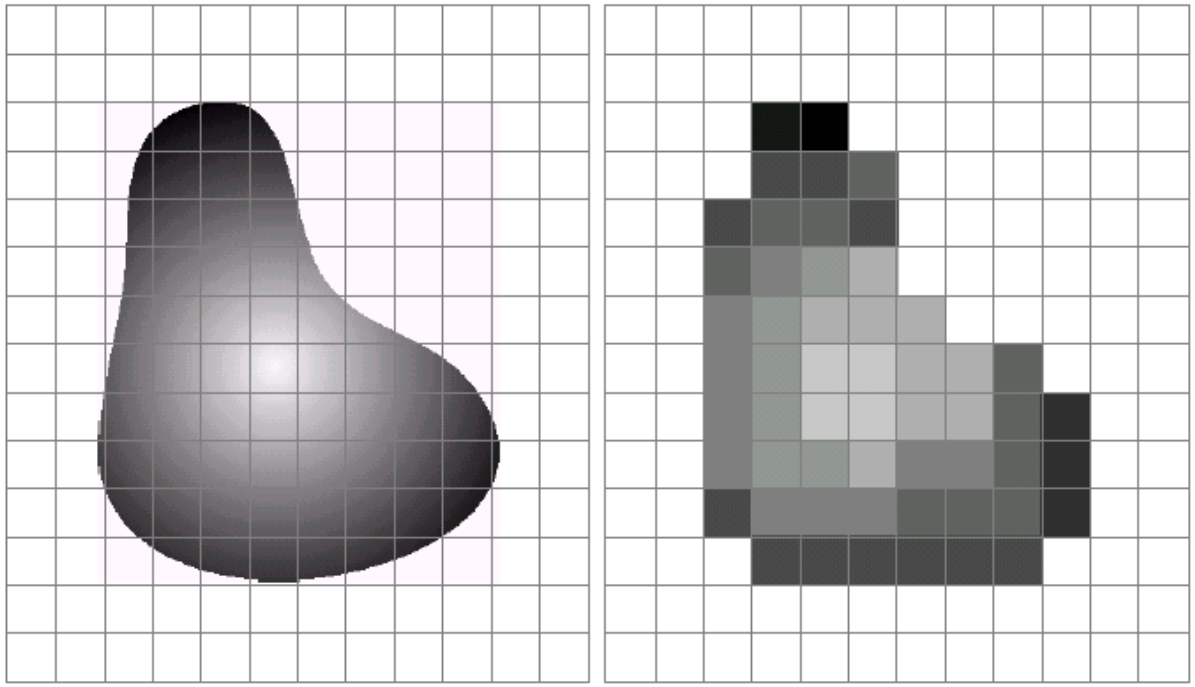






a b
c d

Generating a digital image. (a) Continuous image. (b) A scaling line from A to B in the continuous image, used to illustrate the concepts of sampling and quantization. (c) sampling and quantization. (d) Digital scan line.

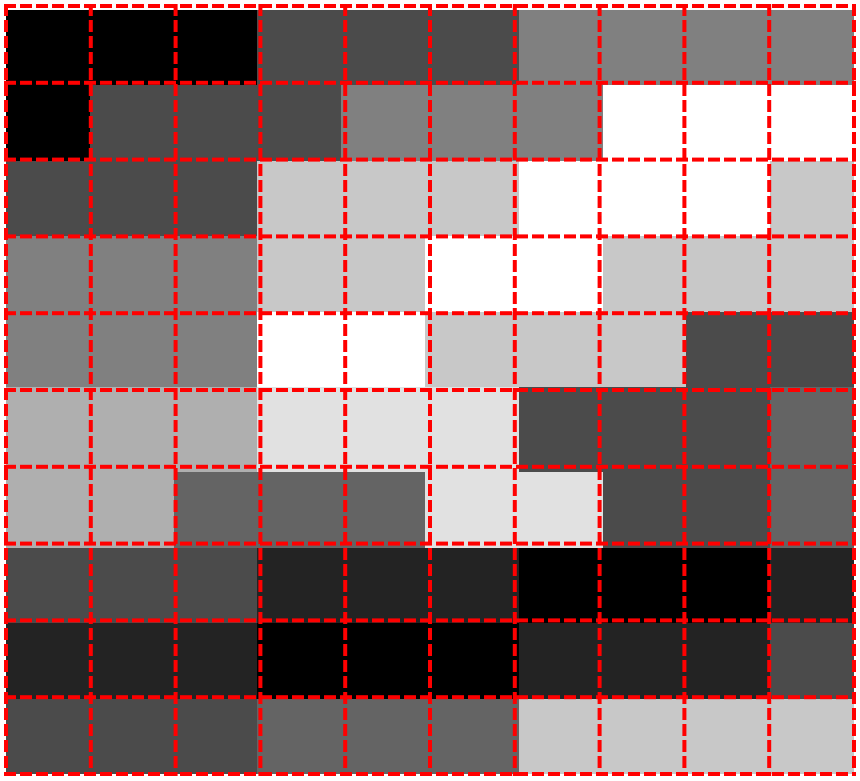


a b

FIGURE 2.17 (a) Continuos image projected onto a sensor array. (b) Result of image sampling and quantization.

a b

(a) Continuous image projected onto a sensor array. (b) Result of image sampling and quantization.



0	0	0	75	75	75	128	128	128	128
0	75	75	75	128	128	128	255	255	255
75	75	75	200	200	200	255	255	255	200
128	128	128	200	200	255	255	200	200	200
128	128	128	255	255	200	200	200	75	75
175	175	175	225	225	225	75	75	75	100
175	175	100	100	100	225	225	75	75	100
75	75	75	35	35	35	0	0	0	35
35	35	35	0	0	0	35	35	35	75
75	75	75	100	100	100	200	200	200	200

Sampling

1024

512

256

128

64

32

Sampling

1024

512

256

128

64

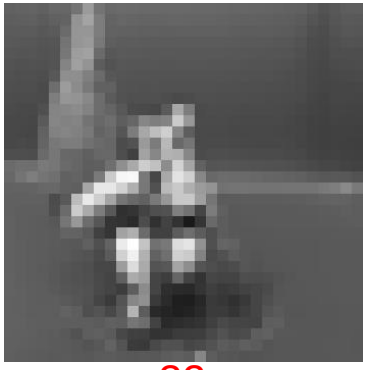


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Image Quantization

Conversion of the sampled analog pixel intensities to discrete valued integer numbers is the process of *quantization.* Quantization involves assigning a single value to each sample in such a way that the image reconstructed from the quantized sample values are of good quality and the error introduced because of quantization is small.

Digital Image Definitions

A digital image $a[m,n]$ described in a 2D discrete space is derived from an analog image $a(x,y)$ in a 2D continuous space through a *sampling* process that is frequently referred to as digitization.

Image Representation

- We have seen that the human visual system (HVS) receives an input image as a collection of spatially distributed light energy; this is form is called an optical image.
- Optical images are the type we deal with every day –cameras captures 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 I(r , c).
- The digital image I (r, c) is represented as a two- dimensional array of data, where each pixel value corresponds to the brightness of the image at the point (r, c). in linear algebra terms , a two-dimensional array like our image model I(r, c) is referred to as a matrix , and one row (or column)is called a vector.
- The image types we will consider are:

1) Binary Images

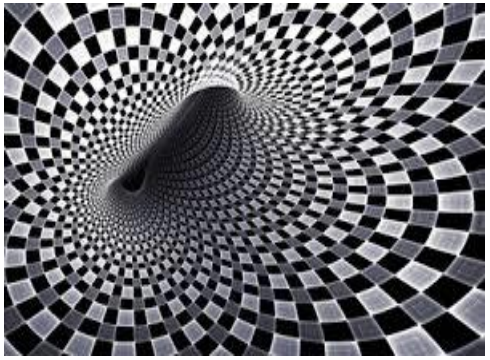
The simplest type of images it's can take two values ,typically black and white or 0 and 1 ,it’s referred to 1 bit/pixel because it takes only 1 binary digit(bit) to represent each pixel. Each image pixel is determined to be above or below a pre-determined brightness threshold value. In case of gray image if the pixel brightness is darker than the threshold the resulting pixel brightness is set to zero.

2) Gray scale images

- They contain brightness information only no the color information.
- The number of bits used for each pixel determines the no. of different brightness level available.
- The typical image contains 8 bit/pixel which allow us to have 256(0-255) different brightness (gray) levels.

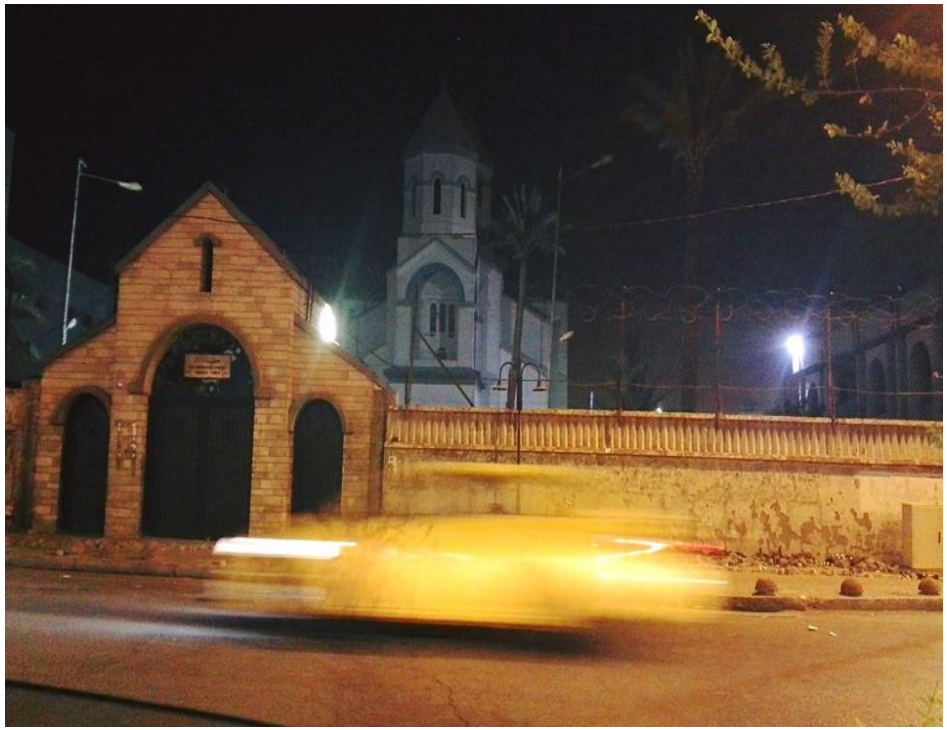
- The Gray Scale effect removes the colors from an image and replaces them with grays matching their luminance values.

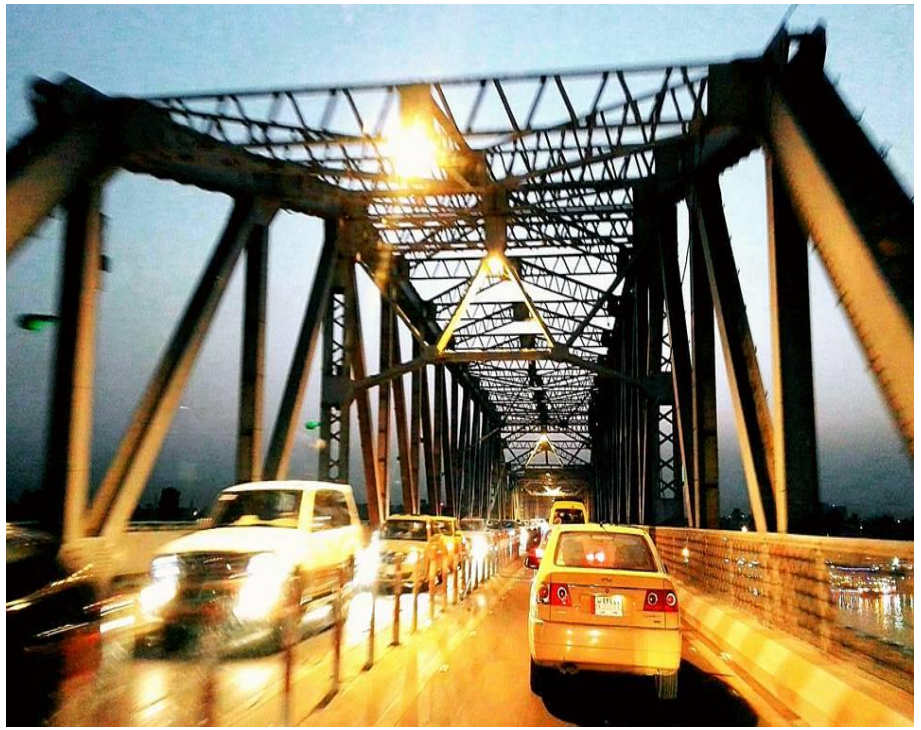


3.) Color images

- Color image can be modeled as three band monochrome image data,
- The actual information stored in the digital image data is 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. where each band of the data corresponds to a different color.

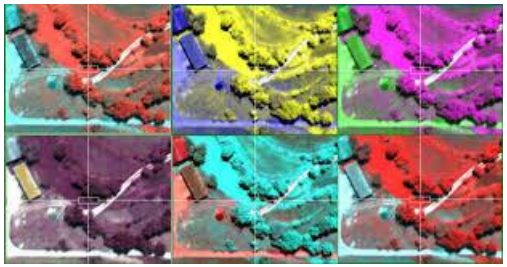


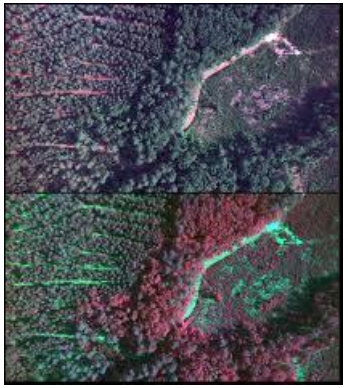


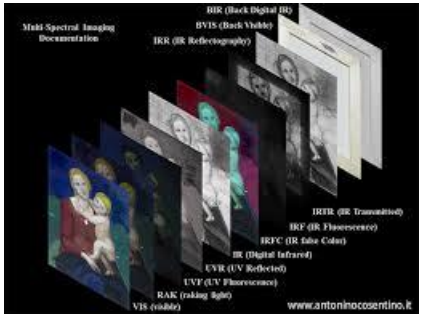
- Typical color images are represented as red, green ,and blue or RGB images .
- using the 8-bit monochrome standard as a model , the corresponding color image would have 24 bit/pixel – 8 bit for each color bands (red, green and blue).
- The following figure we see a representation of a typical RGB color image.

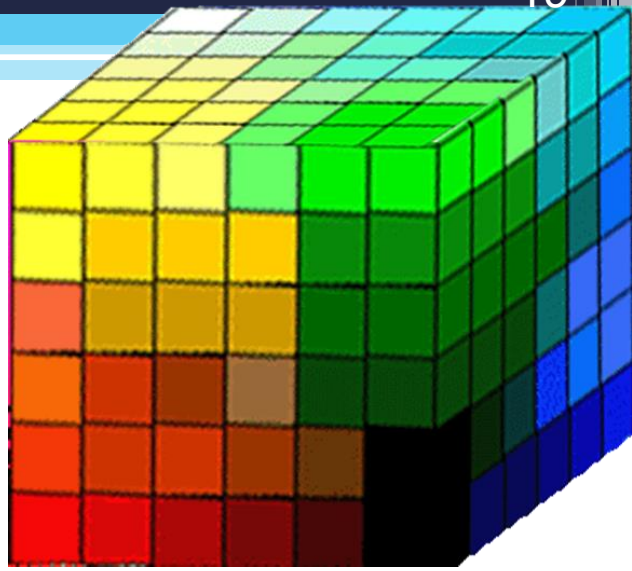
4.)Multispectral Images

- Multispectral Images typically contain of information outside the normal human perceptual range.
- This may include infrared, ultraviolet, X-rays, acoustic radar data.
- These are not images in the usual sense because the information represented is not directly visible by 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 images, the dimensionality is reduced by applying principle component transform.
- Source of this types of image are Satellite system, under water sonar system, Infrared imaging system, medical diagnostic imaging system.






Multi-Spectral Imaging
Documentation
BIR (Back Digital IR)
BVIS (Back Visible)
IRR (IR Reflectography)
IRTR (IR Transmitted)
IRF (IR Fluorescence)
IRFC (IR false Color)
IR (Digital Infrared)
UVR (UV Reflected)
UVF (UV Fluorescence)
RAK (raking light)
VIS (visible)
www.antoninocosentino.it



The process of generating colors with three basic components is based on the RGB Color cube as shown in the below figure.

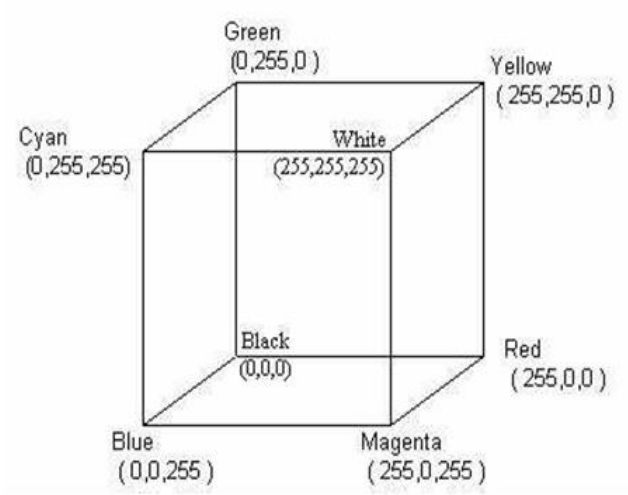
The three dimensions of the color cube correspond to the three basic colors.

The cube's corners are assigned each of the three primary colors, their complements, and the colors black and white.

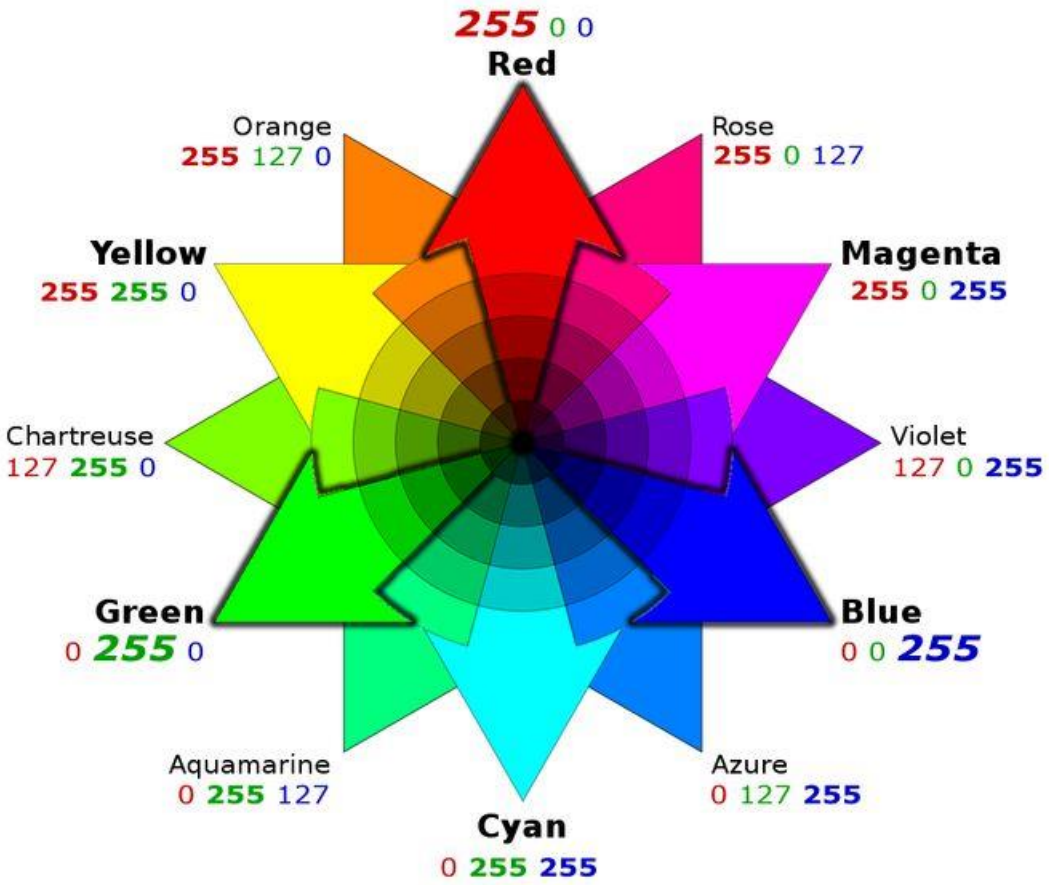
Complementary colors are easily calculated by subtracting the Color values from 255.

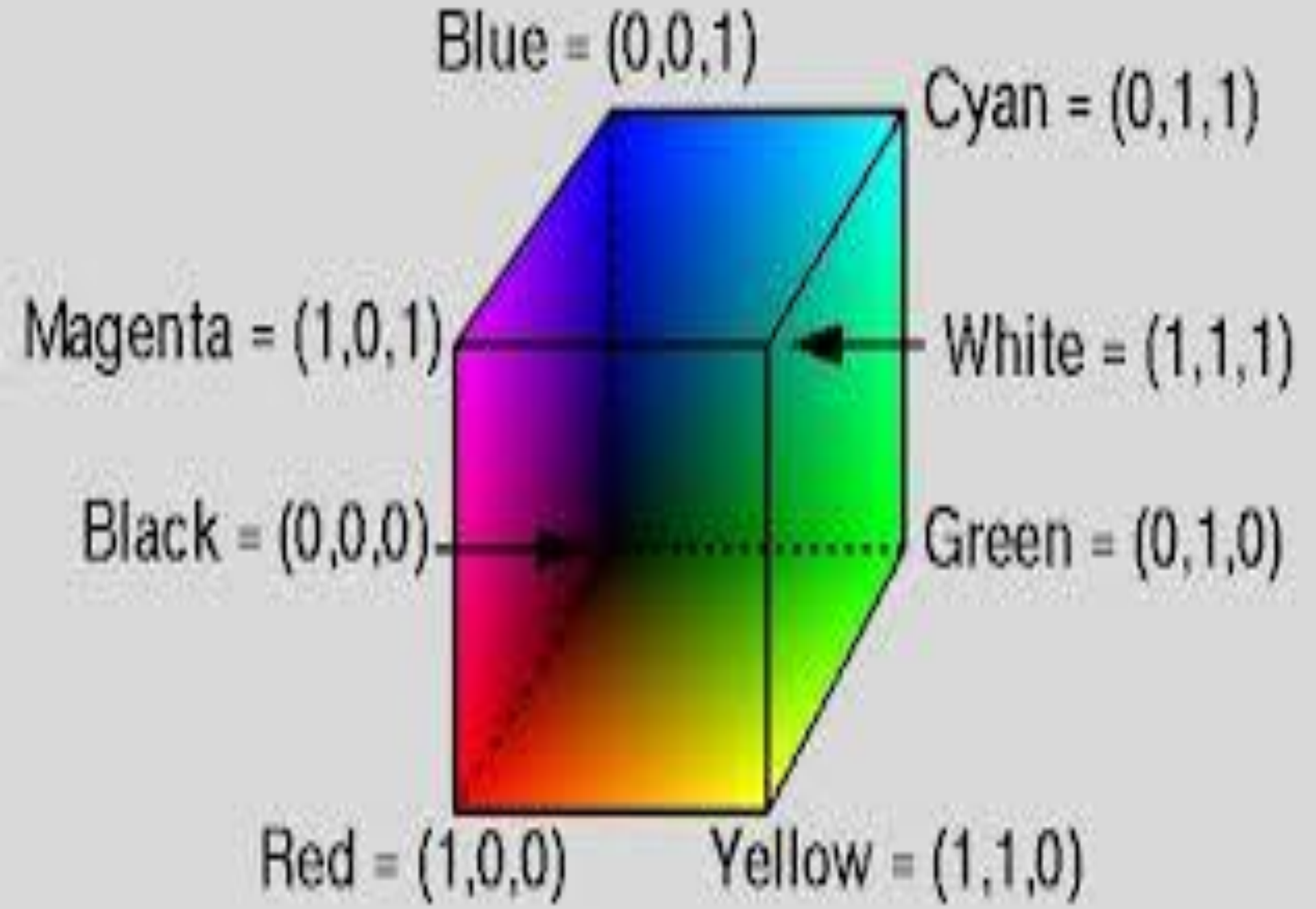
For example, the color (0,0,255) is a pure blue tone. Its complementary color is (255-0,255-0,255-255),

or (255,255,0), which is a pure yellow tone. Blue and Yellow are complementary colors, and they are mapped to opposite corners of the cube. The same is true for red and cyan, green and magenta, and black and white. Adding a color to its complement gives white.



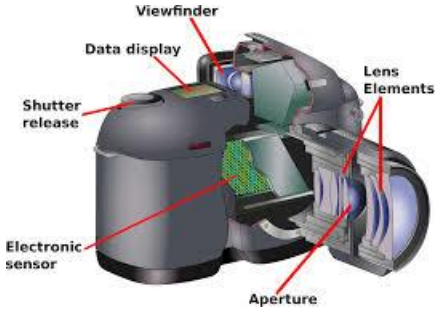
For many applications, RGB color information is transformed into mathematical space that that decouples the brightness information from the color information.




Blue = (0,0,1)
Cyan = (0,1,1)
Magenta = (1,0,1)
White = (1,1,1)
Black = (0,0,0)
Green = (0,1,0)
Red = (1,0,0)
Yellow = (1,1,0)

COLOR INTERPOLATION OR DEMOSAICING

Due to the cost and packaging consideration, in digital imaging devices such as a digital camera, only a single electronic sensor is used and the need for color interpolation or demosaicing will remain critical until other technologies such as multi-channel color free sensor is mature. the image color is captured in a subsampled pattern.



Typically each pixel in the captured raw image contains only one of the three primary color components, *R* (Red), G (Green), or *B* (Blue). This subsampled color image is generated using certain pattern of a ***Color Filter Array (CFA)***.

This CFA is realized by coating the surface of the electronic sensor array using some optical material that acts as a band-pass filter. This coating allows the photons corresponding to only one color component to be transmitted to the sensor. A typical and widely used CFA pattern is called Bayer Pattern [S]. In Figure 3.3, we have shown a Bayer pattern image of dimension 8 x 8. Each cell in Figure 3.3 represents a pixel with only one color component as indicated by either *R* or G or *B.*

	1	2	3	4	5	6	7	8
1	G	R	G	R	G	R	G	R
2	B	G	B	G	B	G	B	G
3	G	R	G	R	G	R	G	R
4	B	G	B	G	B	G	B	G
5	G	R	G	R	G	R	G	R
6	B	G	B	G	B	G	B	G
7	G	R	G	R	G	R	G	R
8	B	G	B	G	B	G	B	G

Fig. 3.3 Bayer pattern.

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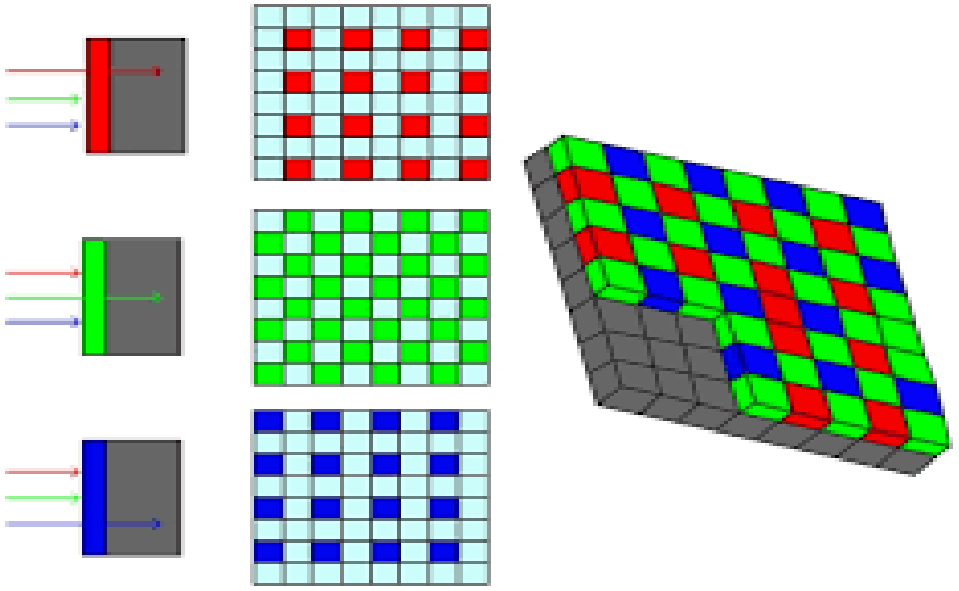

Digital Image File Format

Many image types can be converted to one of other type by easily available image conversion software. Field related to computer imaging is that computer graphics.

Computer Graphics :

Computer graphics is a specialized field within that refers to the computer science realm that refers to the reproduction of visual data through the use of computer.

In computer graphics, types of image data are divided into two primarily categories:

1. **Bitmap image (or raster image):** can represented by our image model I(r, c), where we have pixel data and corresponding brightness values stored in file format.
2. **Vector images**: refer to the methods of representing lines, curves shapes by storing only the key points. These key points are sufficient to define the shapes, and the process of turing theses into an image is called rending after the image has been rendered, it can be thought of as being in bit map format where each pixel has specific values associated with it.

Image File Format :

1. BMP format:

It is the format used by the windows, it's uncompressed format and the data of image are located in the field of data while there are two fields , one for header (54 byte) that contains the image information such as (height ,width , no. of bits per pixel, no of bands , the file type). The second field is the color map or color palette for gray level image, where its length is 0-255).

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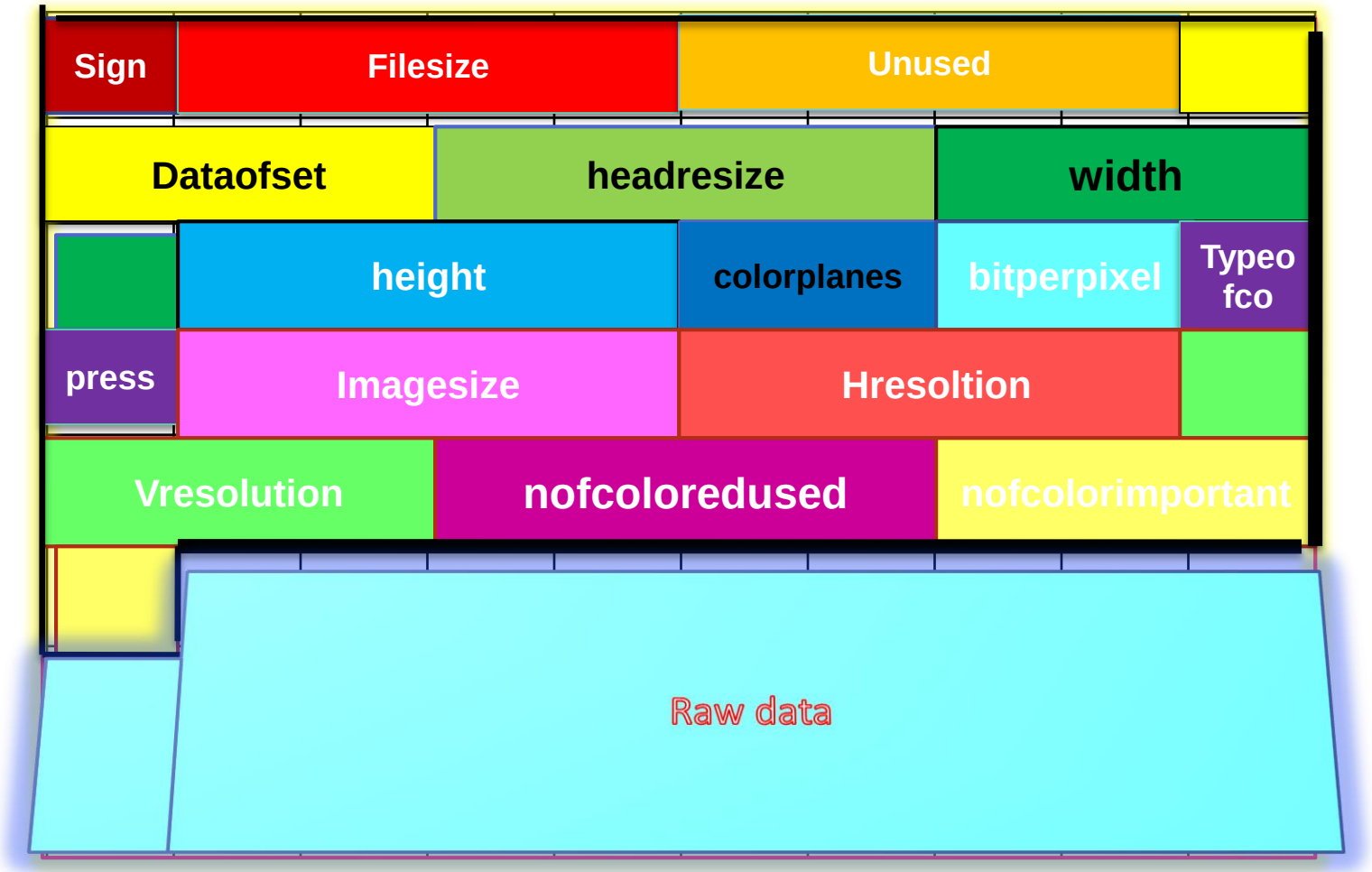
. Homework

Most the type of file format fall into category of bitmap images. In general, these types of images contain both header information and the raw pixel data. The header information contain information regarding

1. The number of rows(height)
2. The number of columns(Width)
3. The number of bands.
4. The number of bit per pixel.
5. the file type
6. Additionally, with some of the more complex file formats, the header may contain information about the type of compression used and other necessary parameters to create the image, I(r,c).

Image file


Sign
Filesize
Unused
Dataofset
headresize
width
height
colorplanes
bitperpixel
Typeo fco
press
Imagesize
Hresoltion
Vresolution
nofcoloredused
nofcolorimportant
Raw data

BMP Header

1) Sign As Byte
2) Filesize As Long
3) Unused As Long
4) Dataofset As Long
5) headresize As Long
6) width As Long
7) height As Long
8) colorplanes As Integer
9) bitperpixel As Integer
10) Typeofcopress As Integer
11) Imagesize As Long
12) Hresoltion As Long
13) Vresolution As Long
14) nofcoloredused As Long
15) nofcolorimportant As Long

In visual basic

General

```
Private Type header_bmp
➢Sign      (1 To 2) As Byte
➢Filesize          As Long
➢Unused1           As Long
➢Dataofset         As Long
➢headresize        As Long
➢width             As Long
➢height            As Long
➢colorplanes       As Integer
➢bitperpixel       As Integer
➢Typeofcopress     As Integer
➢Imagesize         As Long
➢Hresoltion        As Long
➢Vresolution       As Long
➢nofcoloredused    As Long
➢nofcolorimportant     As Long
End Type
Dim imh As header_bmp
```

```
Private Type Pixel
    R     as byte
    G     as byte
    B     as byte
End type
Dim pix ( ) as pixel
```

private

```
cd1.ShowOpen

Picture1.Picture = LoadPicture(cd1.FileName)

Open   cd1.FileName  For Binary As #1

 Get #1, , imh

 Close #1
```

```
cd1.ShowOpen

Picture1.Picture = LoadPicture(cd1.FileName)

Open   cd1.FileName  For Binary As #1

 Get #1, , imh

Redim pix(imh.Width, imh. height)

Get  #1,,pix()

 Close #1
```

Redimإيعاز لإعادة تحجيم المصفوفات اعتمادا على حجم الصورة