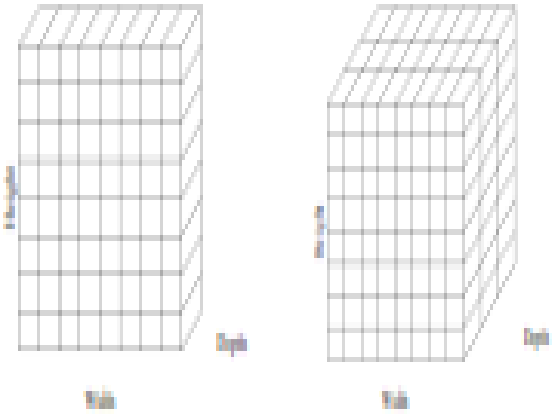
IMAGES AND GRAPHICS

•An image is a spatial representation of an object, a two-dimensional or three-dimensional scene or another image. Often the images reflect the intensity of lights.
•Most photographs are called continuous-tone images because the method used to develop the photograph creates the illusion of perfect continuous tone throughout the image.
•Images stored and processed by computers, displayed on computer screens, are called digital images although they often look like continuous-tone. This is because they are represented by a matrix of numeric values each represents a quantised intensity values.

Basic Concepts

•The smallest element on a digital image is known as a pixel — a picture element. A digital image consists of a (usually rectangular) matrix of pixels.



Depth.

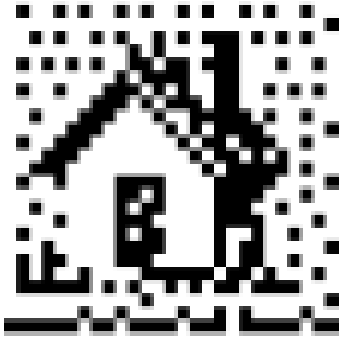
The depth of an image is the number of bits used to represent each pixel.

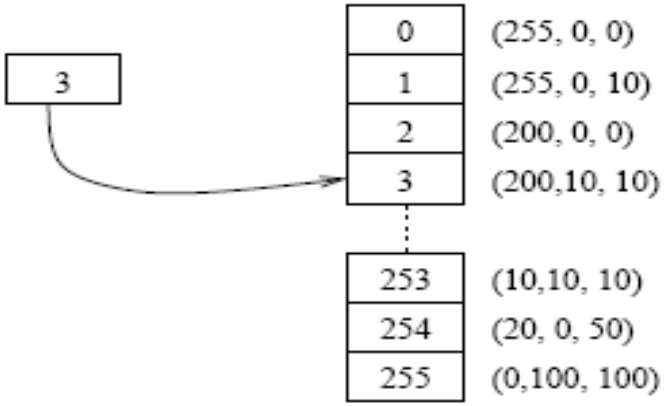
•1-bit black-and-white image, also called bitmap image.

•4-bit can represent 16 colours, used in low resolution screens(EGA/VGA)

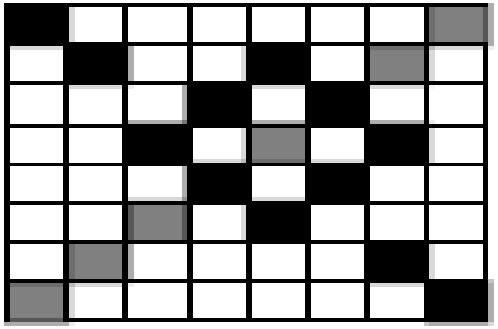
•8-bit can have 256 colours. The 256 colour images are often known as indexed colour images. The values are actually indexes to a table of many more different colours. For example, Colour 3 is mapped to (200, 10, 10).

•8-bit grey 256 grey-levels. The image contains only brightness/intensity data without colour information.





255	0	0	0	0	0	0	128
0	255	0	0	255	0	128	0
0	0	0	255	0	255	0	0
0	0	255	0	128	0	255	0
0	0	0	255	0	255	0	0
0	0	128	0	255	0	0	0
0	128	0	0	0	0	255	0
128	0	0	0	0	0	0	255



16-bit can have 65536 colours, also known as hi-colour in Windows systems. The 16 bits are divided into 5 bits for RED, 6 bits for GREEN and 5 bits for BLUE.

24-bit $2^{24} = 16,777,216$ colours, true colour. Each byte is used to represent the intensity of a primary colour, RED, GREEN and BLUE. Each colour can have 256 different levels.

RED	GREEN	BLUE	Colour
255	0	0	Red
0	255	0	Green
0	0	255	Blue
255	255	0	Yellow
255	0	255	Magenta
0	255	255	Cyan
127	127	127	Light gray
255	255	255	White
0	0	0	Black

32-bit $2^{32} = 4,294,967,296$ (4G). Usually, 3 bytes are used to represent the three primary colours and the fourth byte is used as the *alpha channel*.

1.3 Resolution

Resolution measures how much detail an image can have. There are several resolutions relating to images.

Image resolution is the number of pixels in an image.

$$320 \times 240 = 76800 \text{ pixels}, 700 \times 400 = 280000 \text{ pixels}$$

Display (Monitor) resolution — refers to number of dots per inch (dpi) on a monitor.

Windows systems usually have 96dpi resolution. Some high resolution video adapters/monitors support 120dpi. For example, a 288×216 image displayed on a monitor with 96dpi will be $3'' \times 2\frac{1}{4}''$.

Output resolution — refers to number of dots per inch (dpi) on a (hard copy) output device.

Many printers have 300dpi or 600 dpi resolution. High-quality imagesetters can print at a range between 1200dpi and 2400dpi, or higher. The above image printed on a 300dpi printer will be 0.96×0.72 inch.

1.4 Acquiring Digital Images

There are many ways to create or get digital images. We list asome of the most common ways:

- Make an image from scratch with a paint program. A good program will allow you to choose the depth, resolution and size.
- Grab an image of a screen. The depth, resolution and size is determined by the screen.
- Capture an image from a digital camera or a camcorder. The depth, resolution and size is determined by the camera or the camcorder. The popular depth is 24-bit. The commonly used resolution is 320×240, 640×480 and 800×600.

- Scan a photograph or a print using a scanner. You can select from a range of different depths and resolution. The choice should be determined by the type of original and the final output form.
- Convert from existing digital media — e.g., photoCD. The attribute is determined by the original image.
- Synthesize an image from numerical data.

2 Vector Graphics

Instead of using pixels, objects can be represented by their attributes, such as size, colour, location, and so on. This type of graphics is known as *vector graphics*, or *vector drawing*. This is an abstract representation of a 2-dimensional or 3-dimensional scene.

A vector graphics file contains graphics primitives, for example, rectangles, circles, lines.

There are many languages for describing vector grphics.
Three of them are very popular. They are:

PostScript was developed by Adobe as a page description language. The next page shows a graphic with its PostScript program source. (Example on next page.)

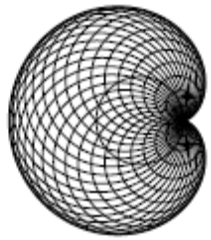
VRML stands for Virtual Reality Markup Language. It is for descripting a scene in a virtual world. An simple examle is shown on the right.

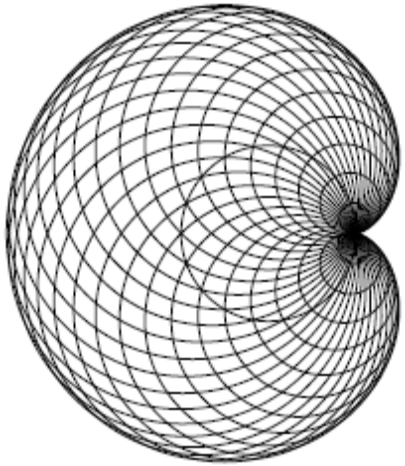
SVG stands for Scalable Vector Graphic. It is a language for describing two-dimensional graphics in XML. It allows three types of grahic objects: vector graphic shapes, images and text.

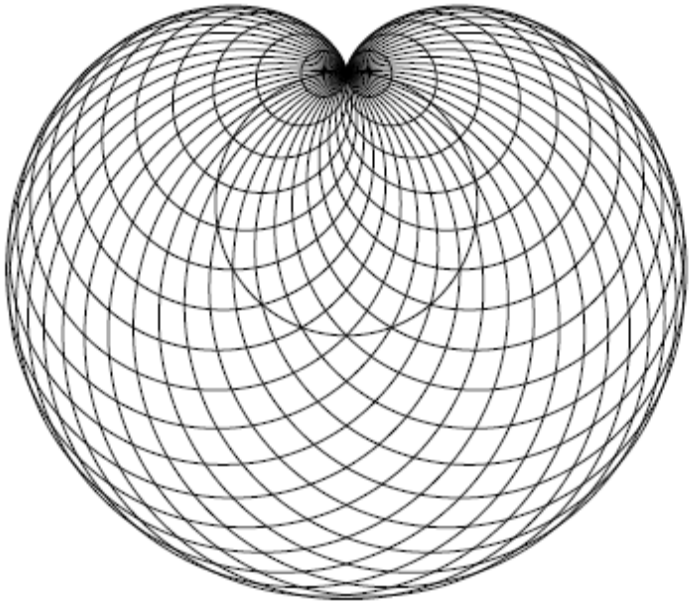
VRML sample

```
Cube {
   Width 30 Depth 30 Height 30}
Material {
   ambientColor 0.2 0.2 0.2
   diffuseColor 0.8 0.8 0.8
   specularColor 0 0 0
   emissiveColor 0 0 0
   shininess 0.2
   transparency 0
   }
```

```
%!PS-Adobe-1.0
%%BoundingBox: 36 90 360 432
% This file contains a program to draw a cardioid as an envolop of circles
% whose centres are on the circumference of a fixed circle and
% whose radius are the distance to a fixed point on the fixed circle

/inch {72 mul} def
/unitcircle{ newpath 1 0 moveto 0 0 1 0 360 arc stroke} def
/distance{ /y1 exch def /x1 exch def /y0 exch def
    x1 sub dup mul y0 y1 sub dup mul add sqrt} def

/cardioid{ /lnwid exch def
    /nsteps exch def /baserad exch def

    gsave translate baserad baserad scale

    360 nsteps div dup 359 {
        /theta exch def
        gsave
        theta cos dup theta sin dup 3 1 roll 1 0 distance
        dup /r exch def
        3 1 roll translate dup scale
        lnwid r div baserad div setlinewidth unitcircle
        grestore} for

    lnwid 2.2 mul baserad div setlinewidth unitcircle
    grestore} def

3.5 inch 4 inch 1 inch 36 0.5 cardioid
```







B. Okuku

2.1 Vector versus Bitmap

Bitmap

- A bitmap contains an exact pixel-by-pixel value of an image
- A bitmap file is fixed in resolution
- The file size of a bitmap is completely determined by the image resolution and its depth
- A bitmap image is easier to render

Vector graphic

- a vector graphic contains mathematical description of objects
- a vector graphic is resolution independent
- the file size of a vector graphic depends on the number of graphic elements it contains
- displaying a vector graphic usually involves a large amount of processing

3 Colour Systems

Colour is a vital component of multimedia. Colour management is both a subjective and a technical exercise, because:

- Colour is a physical property of light, but
- Colour perception is a human physiological activity.
- Choosing a right colour or colour combination involves many trials and aesthetic judgement.
- Colour is the frequency/wave-length of a light wave within the narrow band of the electromagnetic spectrum (380 – 760nm) to which the human eye responds.

Wavelength	Intensity	Spectral Purity
Hue	Brightness	Saturation

Our sensations of colour are within us and colour connot exist unless there is an observer to perceive them. Colour does not exist even in the chain of events between the retinal receptors and the visual cortex, but only when the information is finally interpreted in the consciousness of the observer.

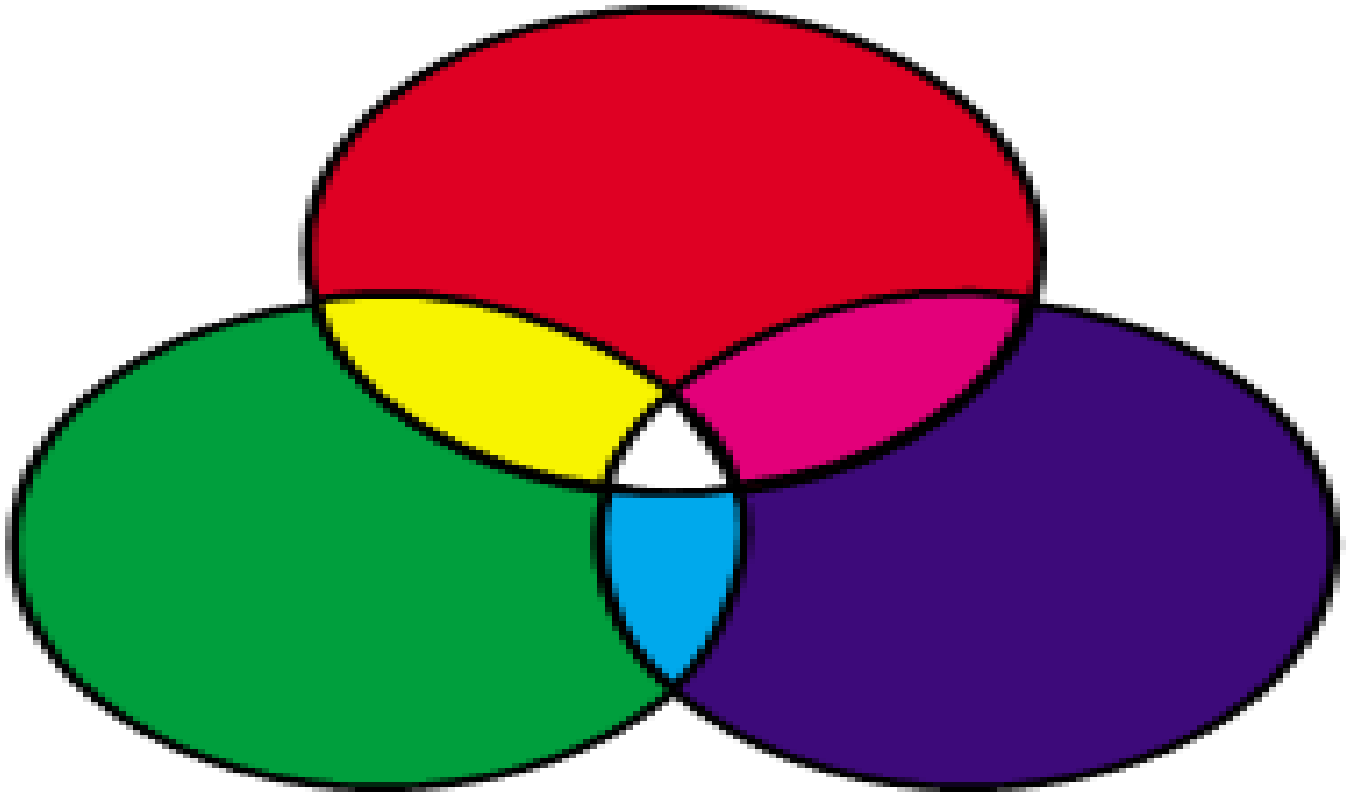
3.1 RGB Colour Model

- This is probably the most popular colour model used in computer graphics.
- It is an additive system in which varying amount of the three primary colours, red, green and blue, are added to black to produce new colours.
- You can imagine three light sources of the primary colours shine on a black surface. By varying the intensity of the lights, you will produce different colours.

R — Red

G — Green

B — Blue



3.2 CMY Colour Model

•This model is based on the light absorbing quality of inks printed on paper. Combining three primary colour pigments, Cyan, Magenta and Yellow, should absorb all light, thus resulting in black.

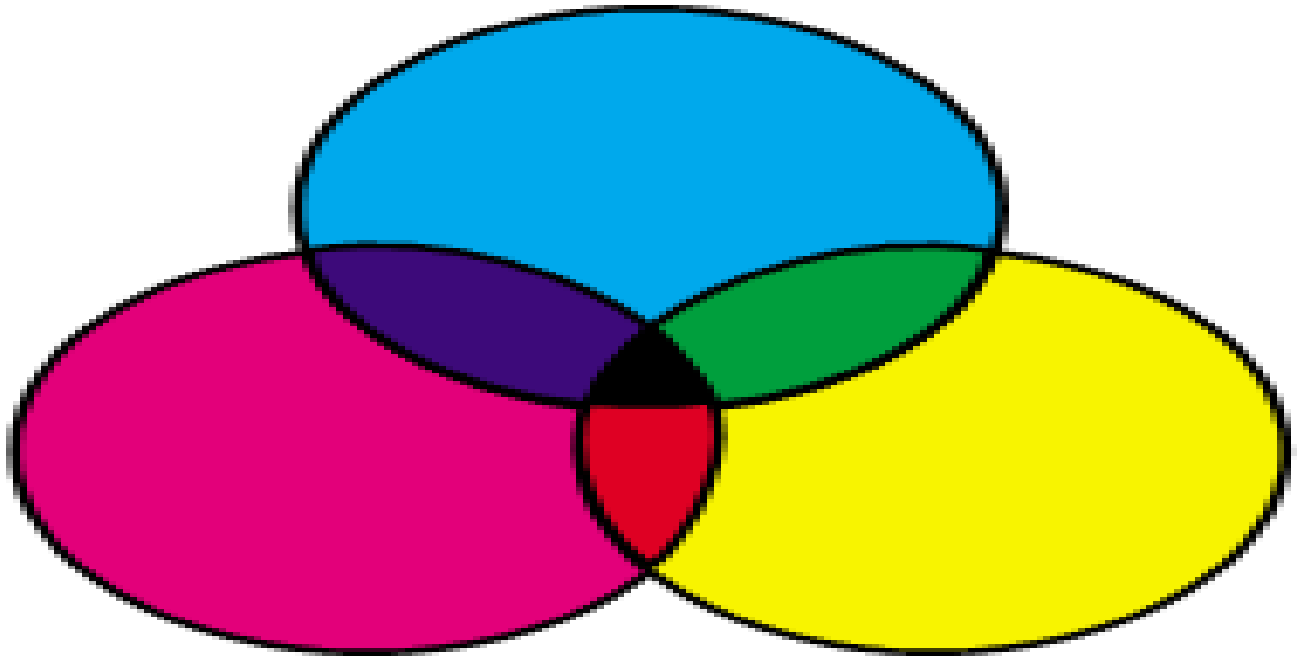
•It is a subtractive model.

•The value of each primary colour is assigned a percentage from the lightest (0%) to the darkest (100%).

•Because all inks contain some impurities, three inks actually produce a muddy brown, a black colour is added in printing process, thus CMYK model.

•Note: the primary colours in RGB and CMY models are complementary colours.

C — Cyan
M — Magenta
Y — Yellow



This model is based on the human perception of colour.

The three fundamental characteristics of colours are:

Hue — is the wavelength of the light. Hue is often identified by the name of the colour. It is measured as a location on the standard colour wheel as a degree between 0° to 360°.

Saturation — is the strength or purity of the colour. It represents the amount of gray in proportion to the hue and is measured as a percentage from 0%(gray) to 100%(fully saturated).

Brightness — is the relative lightness or darkness of the colour. It is measured as a percentage from 0%(black) to 100%(white).

3.4 YUV Colour Model

•This model is widely used in encoding colour for use in television and video.

•The theory behind this model is that human perception is more sensitive to brightness than any chrominance information, so a more suitable coding distinguishes between luminance and chrominance. This also produces a system that is compatible with black-and-white TV systems.

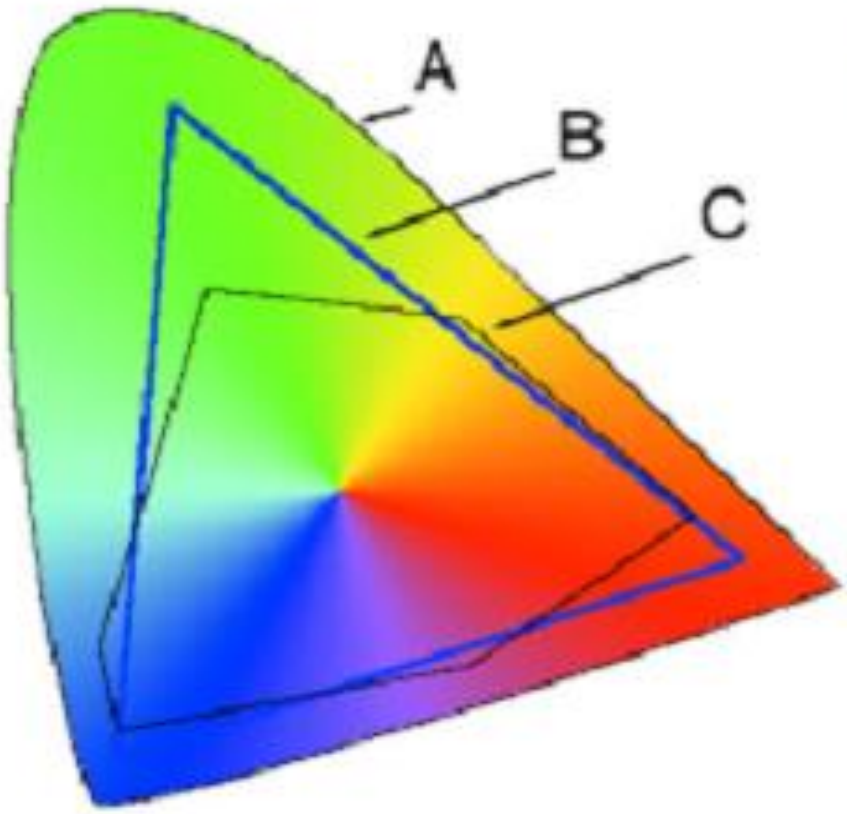
•The Y-signal encodes the brightness information. Black-and-white television system will use this channel only.

•The U and V channels encode the chromatic info. The resolution of the U and V channels is often less than the Y channel for the reason of reducing the size.

3.5 Gamut

•The gamut of a colour system is the range of colours that can be displayed or printed. The spectrum of colours that can be viewed by human eye is wider than any method of reproducing colour.

•Different colour models have different gamut. The CMYK model is smaller than RGB model. On the right is a Chromaticity Diagram which illustrates gumat of RGB and CMYK colour systems.

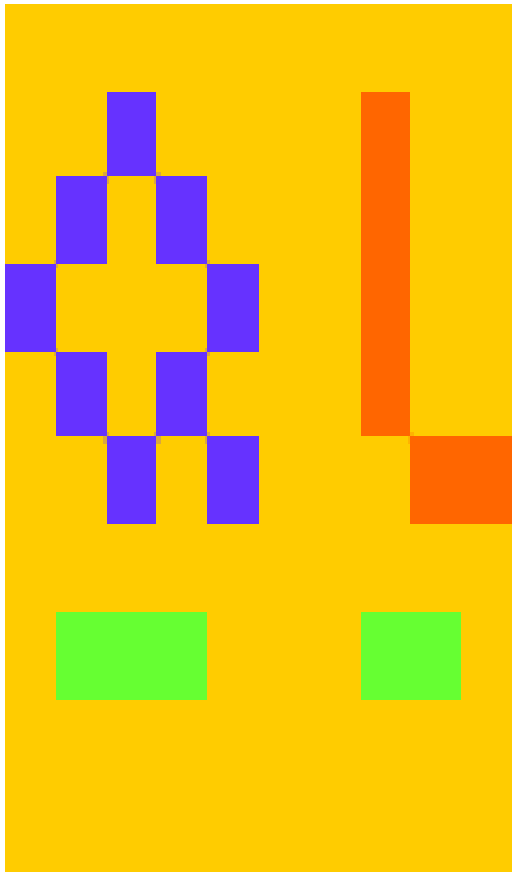


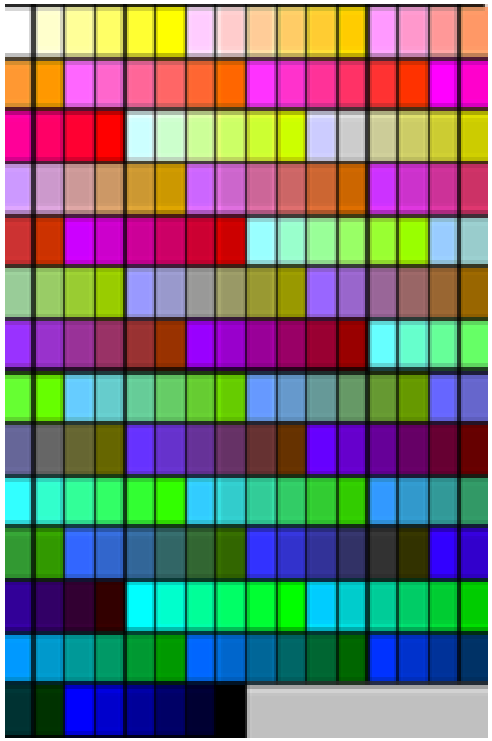
A Natural colour
B RGB gamut
C CMYK gamut

3.6 Colour Palette

•A colour palette is an index table to available colours in an indexed colour system. When working in 8-bit mode, a system can display only 256 colours out of a total of 16 million colours. The system keeps a default palette of available colours.

11	11	11	11	11	11	11	11	11	11
11	11	132	11	11	11	11	16	11	11
11	132	11	132	11	11	11	16	11	11
132	11	11	11	132	11	11	16	11	11
11	132	11	132	11	11	11	16	11	11
11	11	132	11	132	11	11	11	16	16
11	11	11	11	11	11	11	11	11	11
11	112	112	112	11	11	11	112	112	11
11	11	11	11	11	11	11	11	11	11
11	11	11	11	11	11	11	11	11	11





Palette flashing.

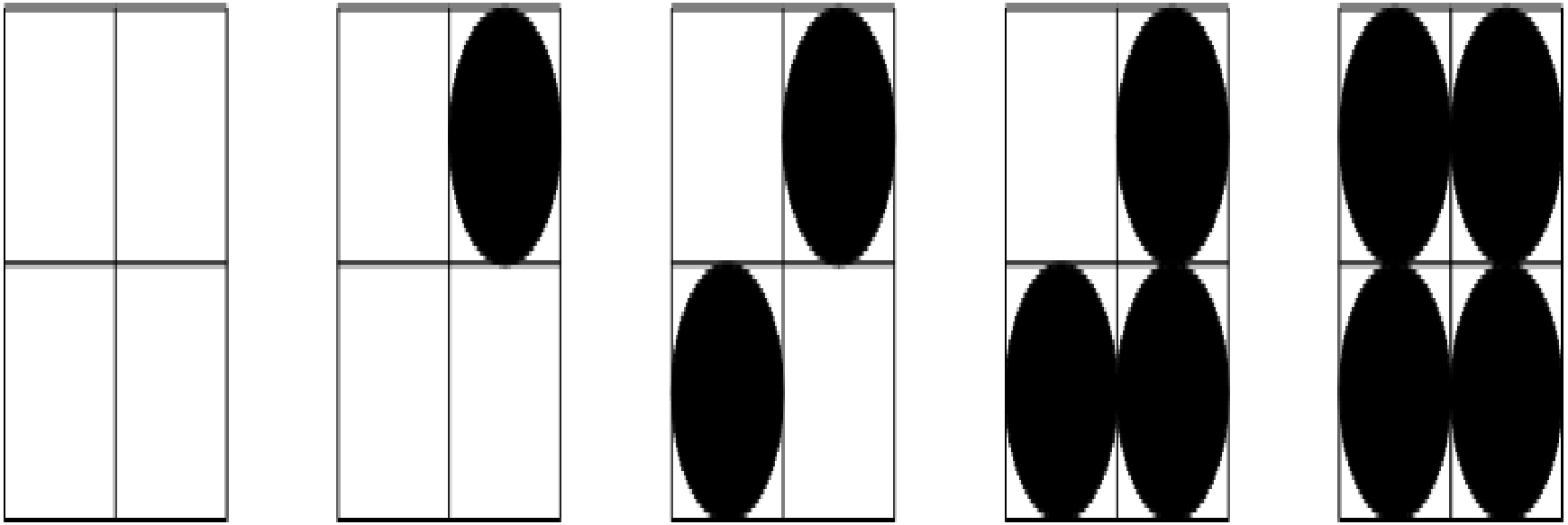
•Each program may have its own palette. It may replace the system palette with its own for the period it is active. This may cause an annoying flash of strange colours in your screen, known as palette flashing. This is a serious problem in multimedia applications.

4 Some Image Techniques

4.1 Dithering

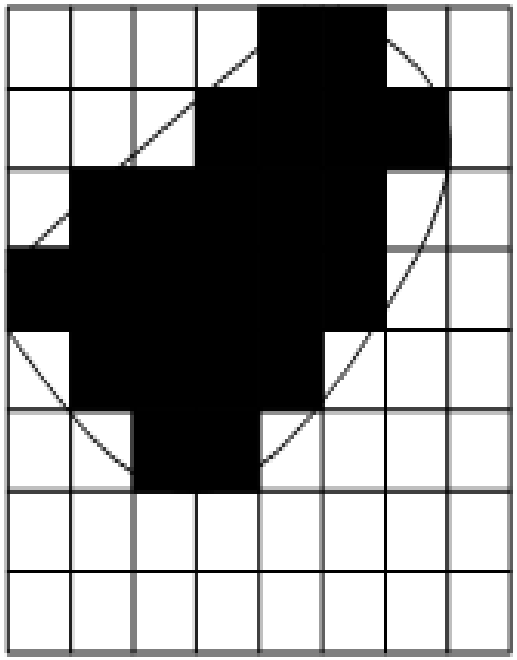
•Dithering is a technique to increase the number of colours to be perceived in an image. It is based on human eye's capability for spatial integration, that is, if you look at a number of closely placed small objects from a distance, they will look like merged together.

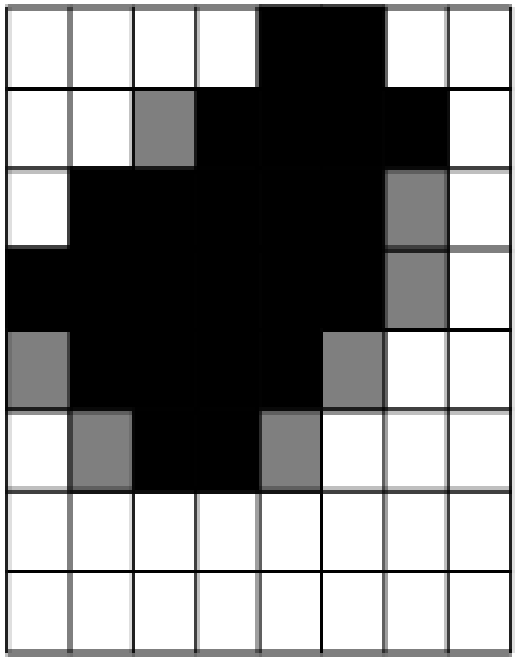
•Dithering technique groups a number of pixels together, say 4, to form a cluster. When viewed from sufficient distance, the individual pixel will not be distinguishable. The cluster will look like a single block of a colour different from the individual pixel.



4.2 Anti-aliasing

•Aliasing is caused by the limited resolution of an output device. Aliasing makes edges seen as staircases.
•Anti-aliasing is a technique to reduce the staircase effect. It works by filling in pixels which should be half filled with different levels of gray or matching colours. The result is sharper edges, not blurring or smoothing them.





5 Image And Graphics File Formats

A digital image is stored in a file conforming to certain format. In addition to the pixel data, the file contains information to identify and decode the data:

- The format
- The image size
- Depth
- Colour and palette
- Compression

•Some formats are defined to work only in certain platform while other can be used for all platforms. Some formats are specific for an application. Some formats are for images, others are for vector graphics. Some formats allow compression, others contain only raw data.

•Note: Formats using compression will make the file size smaller. Some compression algorithms will lose some image information.

Some popular file formats

Format	Type	Ext	Description
Adobe Photoshop	bitmap	psd	specific for the application
Apple Macintosh PICT	bitmap	pict	platform dependent format
AutoCAD DXF	vector	dxf	specific for the application
CompuServ GIF	bitmap	gif	cross platform, indexed colour, new standard allows animation, popular on WWW
Jpeg	bitmap	jpg	using lossy compression, file size is very small, popular on WWW
Portable Bitmap	bitmap	pbm, pgm, ppm	platform independent
PC Paintbrush	bitmap	pcx	specific for the application
Portable Network Graphic	bitmap	png	very new format, platform independent

PostScript	vector	ps, eps	page description language
TIFF	bitmap	tif	allows compression, and different depth, popular in many applications
Windows bitmap	bitmap	bmp	no compression, platform dependent
Windows Metafile	metafile	wmf	may contain bitmap and graphics elements

6 Digital Image Processing

This is a very large area containing the following sub-areas:

•Image analysis is concerned with techniques for extracting descriptions from images that are necessary for higher-level scene analysis methods.

•Image recognition is concerned with the techniques for recovering information about objects in the image. A sub-area is character recognition.

•Image enhancement is concerned with the technique to improve the image and to correct some defects, such as, colour and tonal adjustment, Transformations, e.g., scale, rotate, Special effects, e.g., texture, stylize, blur, sharpen.

7. Image And Graphics Software

- Image editing and processing tools, such as
- Windows Paint— simple
- Adobe Photoshop
- Macromedia Firework
- MetaCreation Painter
- Corel PhotoPaint
- Paint Shop Pro— a low cost shareware
- The GIMP— an open source program with excellent functions

Vector graphics tools, such as

- Adobe Illustrator
- Macromedia Freehand
- Corel Draw
- Format conversion tools— Many applications can open/import files in various formats and save/export to another format. Paint Shop Pro can understand files in a very large number of formats.

8 Exercises

1. A bitmap image has resolution 640*480 pixels. Each pixel is 24-bit deep. What is the size of the bitmap in bytes.

2. A photograph of 3*2 inches is to be scanned. It will be used in a multimedia application in which the image will be displayed on screen. Hardcopy may be printed on a 300dpi laser printer if the user wants. The size of the hardcopy should be 4*2 2/3 inches. What is the best resolution to be used in scanning?

3. A photograph of 3*4 inches is scanning in 300dpi resolution and 8-bit colour. The image is then saved in a jpeg file with 1:20 compression ratio. It is used on a web page. If a viewer connecting to the Internet using a modem with typical transfer rate of 800 bytes/sec, how long will it take to download the image to his/her computer?

4. The table on the left below represents an indexed image. The table on the right is the colour index table. What is the colour of the following pixels: (0,2), (1,1), (1,3), (2,1), (2,2), (3,0).

	0	1	2	3
0	2	3	0	3
1	7	2	1	5
2	5	6	4	4
3	2	7	5	0

	R	G	B
0	255	0	0
1	0	255	0
2	0	0	255
3	0	0	0

	R	G	B
4	0	255	255
5	128	128	128
6	255	255	0
7	255	255	255