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SCHOOL OF COMPUTING

DEPARTMENT OF COMPUTER SCIENCE

UNIT – I – Computer Graphics and Multimedia – SBS1303

Introduction to computer Graphics - Video display devices- Raster scan Systems - Random Scan Systems - Interactive input devices - Hard copy devices - Graphics software - Output primitives - line drawing algorithms - initializing lines - line function - circle Generating algorithms.

INTRODUCTION TO COMPUTER GRAPHICS

Computer Graphics involves creation, display, manipulation and storage of pictures and experimental data/models or images for proper visualization using a computer. Computers are becoming a powerful tool for the rapid and economic production of pictures.

Computer graphics are used in diverse areas such as :

Science
Business
Art
Education
Engineering
Industry
Entertainment
Training
Medicine
Government
Advertising

APPLICATIONS OF COMPUTER GRAPHICS

1. Computer Aided Design (CAD) :

- It is used in the design of Buildings, Automobiles, Aircraft, Watercraft, Spacecraft, Computers, Textiles and many more products
- For some design applications, objects are first displayed in a wireframe outline which shows the overall shape and internal features of objects
- Circuits and Networks for communications, water supply or other utilities are constructed

- The shapes used in a design represent the different network or circuit components
- Real time animations using wireframe displays on a video monitor are useful for testing performance of a vehicle or system
- Realistic displays are generated for advertising of automobiles and other vehicles using special lighting effects and background scenes
- Architects use interactive graphics methods to layout floor plans such as positioning of rooms, windows, stairs, shelves and other building features

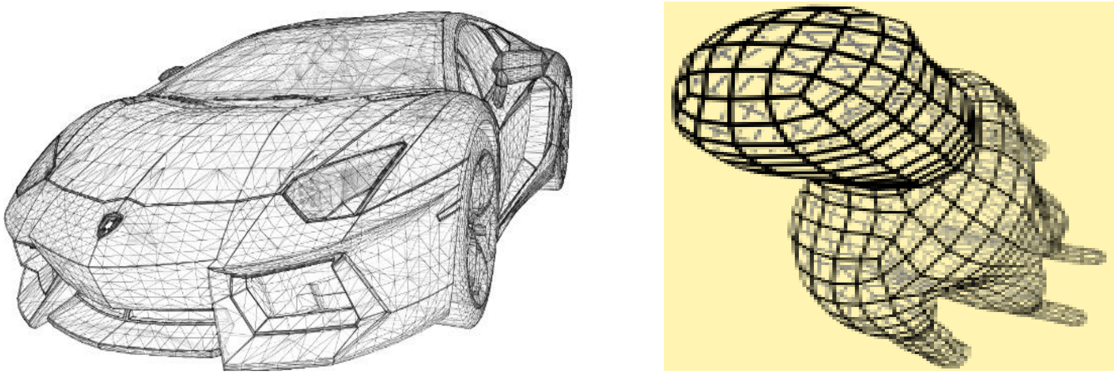
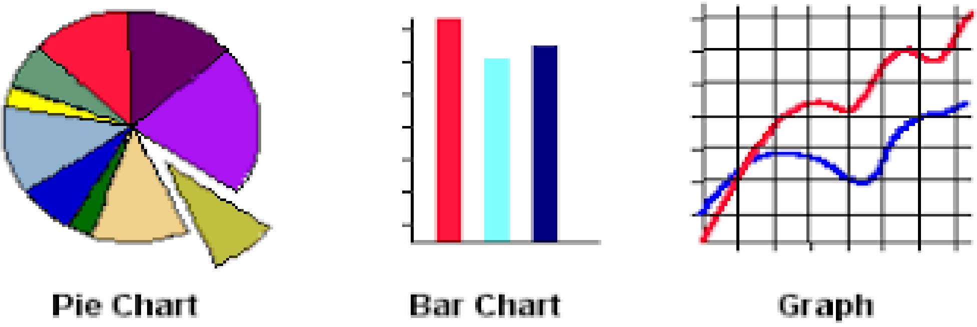


Fig 1.1 Example for Wireframe drawing

2. Presentation Graphics

Presentation Graphics is used to produce illustrations for reports, Slides or transparencies for use with projectors. It is used to summarize Financial, Statistical, Mathematical, Scientific as well as Economic Data. For example,Bar charts, Line Graphs, Surface Graphs, Pie charts and other displays shows relationships between multiple parameters.



Pie Chart Bar Chart Graph

Fig 1.2 Example for Presentation Graphics

3. Computer Art

Computer Graphics are used in both fine art and commercial art applications. Artists use a variety of computer methods including special purpose hardware, artists paint brush programs, specially developed software,symbolic mathematical packages, CAD software, Desktop publishing software and Animation packages that provide facilities for designing object shapes and specifying object motions

Eg) LOGOs , TV advertising, Combining Text and Graphics, Morphing, etc.

Fig 1.3 Example for Computer Art

4. Entertainment

Graphics objects are combined with actors and live scenes.Eg) Motion pictures, Music Videos, Television shows.

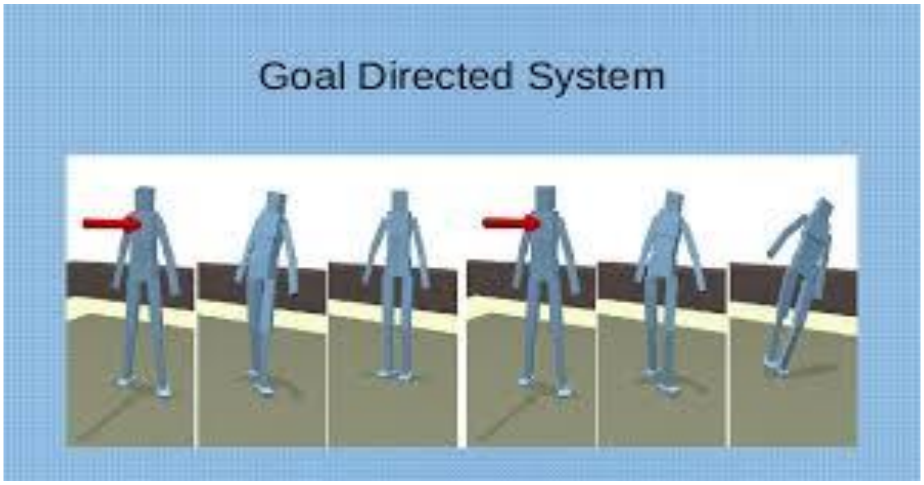


Fig 1.4 Example for animation

5. Education and Training

Computer generated models of physical, financial and economic systems are often used as educational aids. Eg) Simulators for practice sessions, Training of ship captions, Training of pilots, Air traffic control personnel, etc.

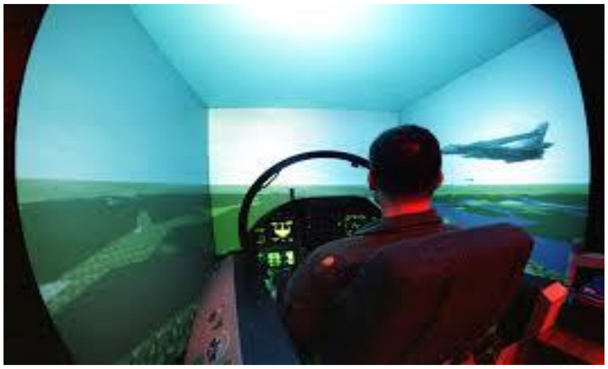


Fig 1.5 Example for aircraft simulator

6. Visualization

Scientists, Engineers, Medical Personnel, Business Analysts need to analyze large amount of data. Numerical simulations carried out on super computers frequently produce data files containing thousands and millions of data values. Satellite cameras and other sources can process amassing large data files faster than they can be interpreted .

Visualization can be of two types :

1. Scientific : Graphical representation for scientific, engineering and Medical datasets
2. Business : Datasets related to commerce,industry and other non-scientific areas

Fig 1.5 Example for Data Analysis

7. Image Processing

Image processing is applied to modify / interpret existing pictures such as photographs and TV scans.

Applications of Image Processing:

1. Improving picture quality
2. M/C perception of visual information as used in robotics

In order to apply image-processing methods:

Digitize a photograph or picture into an image file

Apply techniques to enhance color separation or improve the quality of shading

e.g., Analyze satellite photos, Photos of earth, Galaxy, etc.

Medical Image processing uses Ultrasonics which converts High frequency sound waves to process data and Medical scanners

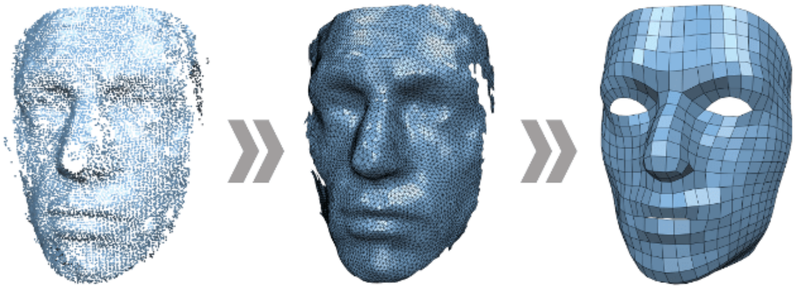


Fig 1.6 Example for Image Processing

8. Graphical User Interface

Uses Window manager which allows a user to display multiple window areas. It can be activated by an icon.

Fig 1.6 Example for Graphical User Interface

VISUAL DISPLAY DEVICES

The Primary output device is Video Monitor. The operation is based on the Standard **Cathode Ray Tube.**

A beam of electrons (cathode rays) emitted by the electron gun passes through focusing and deflection systems that direct the beam towards specified positions on the phosphor-coated screen.The phosphor emits a small spot of light at each position contacted by the electron beam. Because the light emitted by the phosphor fades rapidly, some means is needed for maintaining the picture.One way to keep the phosphor glowing is to redraw the picture repeatedly and quickly by directing the electron beam back over the same points. This type of display is Refresh CRT.

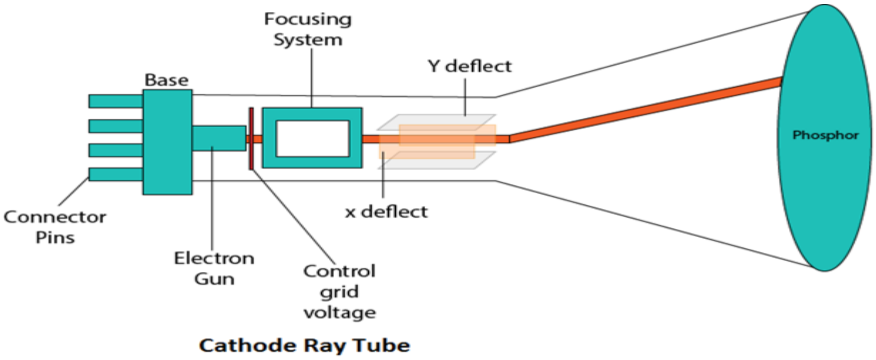


Fig 1.7 Structure of CRT

Main Components of CRT are:

1. Electron Gun: Electron gun consisting of a series of elements, primarily a heating filament (heater) and a cathode. The electron gun creates a source of electrons which are focused into a narrow beam directed at the face of the CRT.

2. Control Electrode: It is used to turn the electron beam on and off.

3. Focusing system: It is used to create a clear picture by focusing the electrons into a narrow beam.

4. Deflection Yoke: It is used to control the direction of the electron beam. It creates an electric or magnetic field which will bend the electron beam as it passes through the area. In a conventional CRT, the yoke is linked to a sweep or scan generator. The deflection yoke which is connected to the sweep generator creates a fluctuating electric or magnetic potential.

5. Phosphorus-coated screen: The inside front surface of every CRT is coated with phosphors. Phosphors glow when a high-energy electron beam hits them. Phosphorescence is the term used to characterize the light given off by a phosphor after it has been exposed to an electron beam.

Functions of Heated metal Cathode and a Control Grid

Heat is supplied to the cathode by directing current through a coil of wire called filament, inside a cylindrical cathode structure. This causes electrons to be “boiled off” the hot cathode surface. In the vacuum inside the CRT envelope, the free negatively charged electrons are then accelerated towards the phosphor coating by a high positive voltage or an accelerating anode or focusing anode.Intensity of the electron beam is controlled by setting voltage levels on the control grid will shut off the beam by repelling the electrons and stopping them from passing through the small grid at the end of the control grid.A small negative charge will decrease the electrons passing through.

The light emitted by the phosphor coating depends on the number of electrons striking the screen, so we can control the brightness of a display by varying voltage on the control grid.The focusing system in a CRT is needed to force the electron beam to converge into a small spot as it strikes the phosphor, otherwise the electrons would repel each other and the beam would spread out as it reaches the screen.

Focussing is done with electric / magnetic fields. Electrostatic focusing is done in television and computer graphics monitors. Additional focusing hardware is used in high-precision systems to keep the beam in focus at all screen positions. Electron beam will be focused at the centre properly and to other places it will be blurred. This can be compensated by adjusting focusing systems.

Deflection can be controlled by electric or magnetic fields. CRTs are constructed with magnetic deflection coils mounted on the outside of the CRT. Spots of light are produced on the screen by the transfer of CRT beam energy to the phosphor. When the electrons collide with phosphor coated screen, they are stopped and their kinetic energy is absorbed by the phosphor.Part of beam energy is converted by friction into heat energy and the remainder causes electrons in the phosphor atoms to move upto high-quantum levels.After a short time, the excited phosphor electrons begin dropping back to their stable ground state.

High resolution systems are called as High definition system

Aspect Ratio : Number of vertical points to horizontal points necessary to produce equal length lines in both directions on the screen.

E.g., Aspect Ratio ¾ : Vertical points 3 plotted with horizontal 4

Different kinds of phosphors are available for use in CRT. Major factor is **persistence (how long they continue to emit light).**

Persistence is defined as the time it takes the emitted light from the screen to decay to one-tenth of its original intensity.Lower persistence phosphor requires higher refresh rates. Lower persistence is used for animation. High persistence is used for highly complex and static pictures. Persistence varies between 10-60 microsec

RASTER SCAN DISPLAYS

The most common type of CRT is the Raster Scan display, based on television technology.In a raster-scan system,the electron beam is swept across the screen, one row at a time from top to bottom.As the electron beam moves across each row, the beam intensity is turned on and off to create a pattern of illuminated spots.Picture definition is stored in a memory area called refresh buffer or frame buffer.The memory area holds the set of intensity values for all screen points.Stored intensity values are then retrieved from the refresh buffer and “painted” on the screen one row at a time.

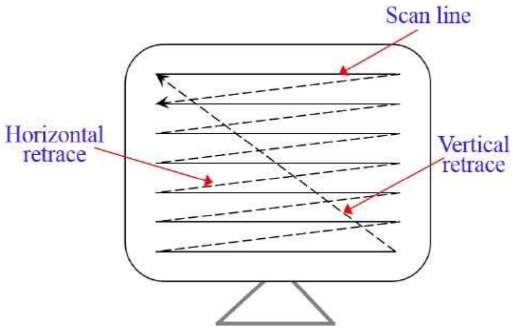


Fig 1.8 Raster Scan display

Each screen point is referred to as a Pixel or Pel (Picture element). Eg) Home television sets and printers are examples of systems using raster-scan methods.Intensity range for pixel positions depends on the capability of raster system.In a simple black and white system, each screen point is either on or off . (i.e.) only one pixel is needed to control the intensity of screen positions

In High Quality system upto 24 bits / pixel is required. 3MB of storage is required for Frame buffer. Black and White Frame buffer is called as Bitmap. Color monitor is called as Pixmap. Refreshing on a raster scan is carried out at a rate of 60-80 frames/second.

Scanning left to right is called as Horizontal retrace. At the end of each frame, the electron beam returns to the top left corner of the screen (vertical retrace) to begin the next frame.The CRT has the electron beam directed only to the parts of the screen where a picture is to be redrawn.

Random Scan (Vector Scan)

In this technique, the electron beam is directed only to the part of the screen where the picture is to be drawn rather than scanning from left to right and top to bottom as in raster scan. It is also called **vector display, stroke-writing display,** or **calligraphic display**.

Picture definition is stored as a set of line-drawing commands in an area of memory referred to as the **refresh display file**. To display a specified picture, the system cycles through the set of commands in the display file, drawing each component line in turn. After all the line-drawing commands are processed, the system cycles back to the first line command in the list. Random-scan displays are designed to draw all the component lines of a picture 30 to 60 times each second.

Refresh rates depends on the no. of lines to be drawn.Picture definition is stored as a set of line-drawing commands in an area of memory called refresh display file (refresh buffer).

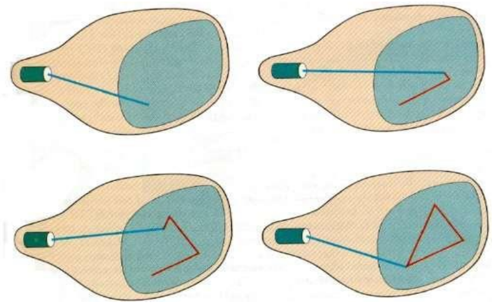


Fig 1.9 Structure of Random Scan display

Suppose we want to display a square ABCD on the screen. The commands will be:

- Draw a line from A to B
- Draw a line from B to C
- Draw a line from C to D
- Draw a line from D to A

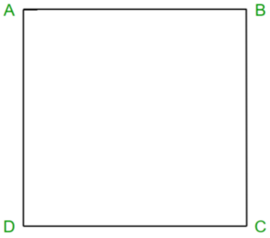


Fig 1.10 Example for construction of square with Random scan display

Drawbacks of random scan display

- It can be used for line drawing applications
- Cannot display realistic shaded scenes
- Not stored as a set of intensity

COLOR CRT MONITOR

A CRT monitor displays color pictures by using a combination of phosphors that emit different colored light. Techniques for color displays :

i) Beam penetration method

ii) Shadow mask method

i) Beam penetration method

Color pictures can be displayed with random scan monitors. Two layers of phosphors (Red and Green) are coated on the inside of CRT screen.A beam of slow electrons excites only the outer red color. A beam of very fast electrons penetrates through the red layer and excites the inner green color.

At intermediate beam speeds, combinations of red and green are emitted which gives additional two colors orange and yellow. Beam penetration is inexpensive way to produce color in random-scan monitors but only few colors are possible. Quality of picture is not as good as with other methods

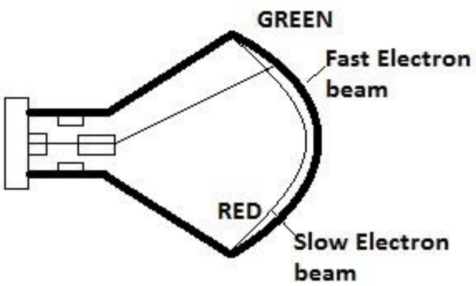


Fig 1.11 Working of CRT with Beam penetration method

ii) Shadow Mask method

They are used in Raster scan systems because they produce a wide range of colors than the beam penetration method. It contains three phosphor color dots at each pixel position. One phosphor dot emits a red light and another emits green light and the third emits a blue light

This type of CRT has three electron guns, one for each color dot and a shadow-mask grid just behind the phosphor coated screen. The three electron beams are deflected and focused as a group onto the shadow mask, which contains a series of holes aligned with the phosphor-dot patterns. When the three beams pass through a hole in the shadow mask, they activate a dot triangle which appears as a small color spot on the screen.The phosphor dots are arranged so that each electron beam can activate only its corresponding color dot when it passes through the shadow mask. We obtain color variations in a shadow-mask CRT by varying the intensity levels of the three electron beams.

R + G + B➔ Equal intensity ➔ White

G + R➔ Yellow

B + R➔ Magenta

B + G➔ Cyan

Color displays in Graphic systems are designed as RGB monitors.They use shadow-mask method and take the intensity level for each electron gun (Red,Green and Blue).

High Quality raster systems have 24 bits / pixel in the frame buffer. An RGB color system with 24 bits of storage/pixel is referred to as full-color system / true-color system.

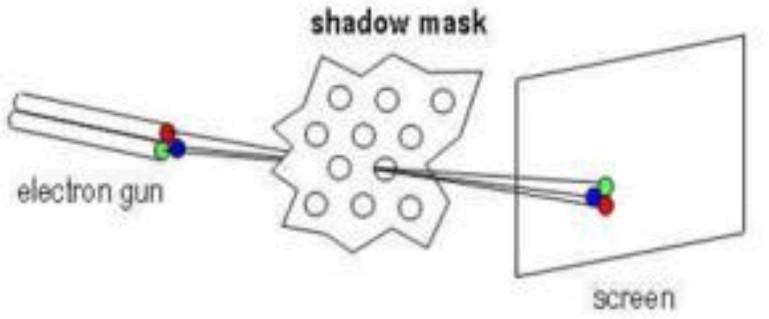


Fig 1.12 Working of CRT with Beam penetration method

Direct View Storage Tube

DVST terminals use random scan approach to generate the image on the CRT screen. The term "storage tube" refers to the ability of the screen to retain the image once it is projected.

Function of guns: Two guns are used in DVST

1. Primary guns: It is used to store the picture pattern.
2. Flood gun or Secondary gun: It is used to maintain picture display.

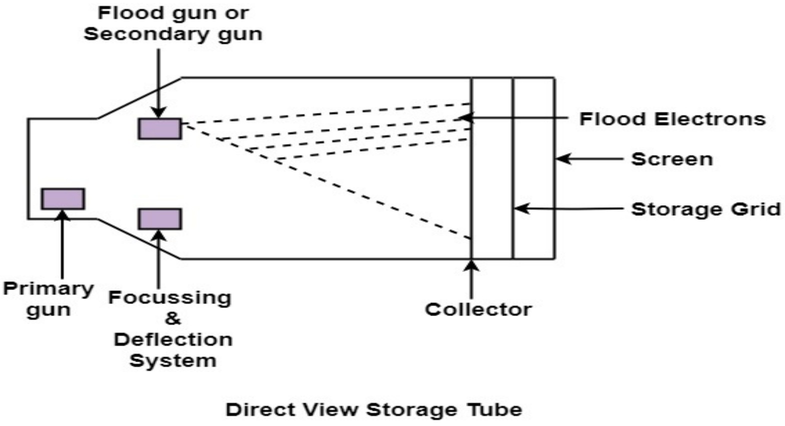


Fig 1.13 Structure of CRT with Direct View Storage Tube

Advantage:

- No refreshing is needed.
- High Resolution
- Cost is very less

Disadvantage:

- It is not possible to erase the selected part of a picture.
- It is not suitable for dynamic graphics applications.
- They do not display colors and are available with single level of line intensity
- If a part of picture is to modify, then time is consumed.
- Erasing of screen produces unpleasant flash over the entire screen surface which prevents its use of dynamic graphics applications.
- It has poor contrast as a result of the comparatively low accelerating potential applied to the flood electrons.

The performance of DVST is inferior to Refresh CRT.

FLAT PANEL DISPLAYS

Flat panel displays refer to a class of video devices that have reduced volume, weight and power requirements in comparison with CRT

e.g) TV monitors, Calculators, Laptop,Pocket video games, armrest viewing of movies on airlines, advertisement boards in elevators, etc.

Flat panel displays are divided into two categories:

1. Emissive display
2. Non-Emissive display

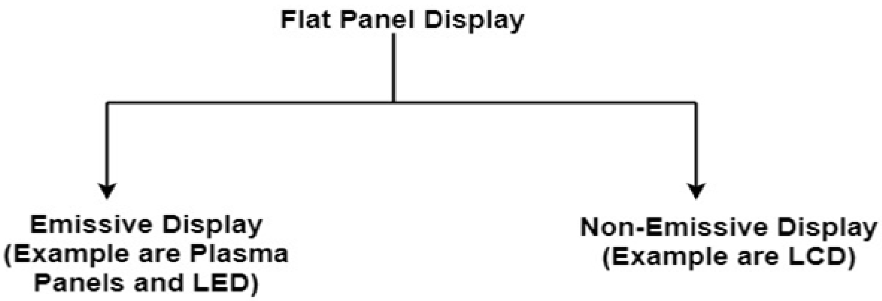

Flat Panel Display
Emissive Display (Example are Plasma Panels and LED)
Non-Emissive Display (Example are LCD)

Fig 1.14 Classification of Flat Panel Display

1. EMISSIVE DISPLAYS (E.G., PLASMA PANEL AND LED)

These displays convert electric energy into light

i) Plasma Panel

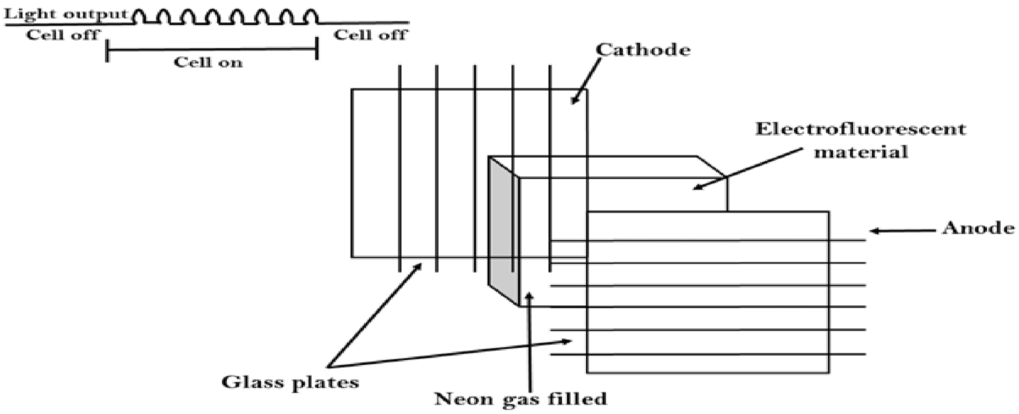


Fig 1.15 Structure of Plasma Panel

They are constructed by filling the region between two glass plates with a mixture of gases that usually includes neon. A series of vertical conducting ribbon is placed on one glass panel and a series of horizontal ribbon is built into the other glass panel.

Voltages applied to a pair of horizontal and vertical conductors cause the gas at the intersection of the two conductors to break down into glowing plasma of electrons and icons.Picture definition is stored in the refresh buffer and voltages are applied to refresh the pixel positions 60 times / sec.

Advantages:

1. High Resolution
2. Large screen size is also possible.
3. Less Volume
4. Less weight
5. Flicker Free Display

Disadvantage:

1. Poor Resolution
2. Its addressing is also complex.

ii) LED (Light Emitting Diode):

In an LED, a matrix of diodes is organized to form the pixel positions in the display and picture definition is stored in a refresh buffer. Data is read from the refresh buffer and converted to voltage levels that are applied to the diodes to produce the light pattern in the display.

2. NON-EMISSIVE DISPLAY (E.G., LCD)

Liquid Crystal Displays are the devices that produce a picture by passing polarized light through a liquid-crystal material that transmits the light.LCD uses the liquid-crystal material between two glass plates; each plate is the right angle to each other between plates liquid is filled. One glass plate consists of rows of conductors arranged in vertical direction. Another glass plate is consisting of a row of conductors arranged in horizontal direction. The pixel position is determined by the intersection of the vertical & horizontal conductor. This position is an active part of the screen.

Advantage:

1. Low power consumption.
2. Small Size
3. Low Cost

Disadvantage:

1. LCDs are temperature-dependent (0-70°C)
2. The resolution is not as good as that of a CRT.

INPUT DEVICES

The Input Devices are the hardware that is used to transfer input to the computer. The data can be in the form of text, graphics, sound, and text. Output device display data from the memory of the computer. Output can be text, numeric data, line, polygon, and other objects.

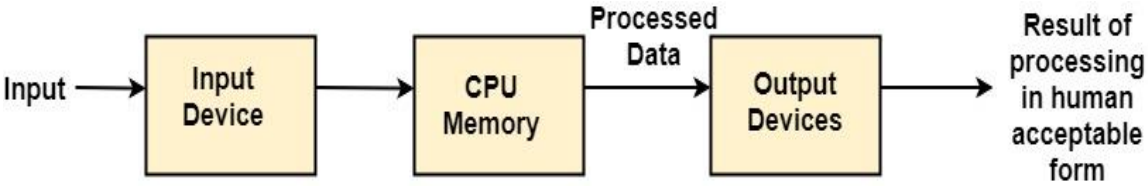


Fig 1.16 Processing of input to output

The following are some of the examples of Input Devices :

1. Keyboard
2. Mouse
3. Trackball
4. Spaceball
5. Joystick
6. Lightpen
7. Digitizer
8. Touch panels
9. Image Scanner

1. **Keyboard :**

   The most commonly used input device is a keyboard. The data is entered by pressing the set of keys. All keys are labeled. A keyboard with 101 keys is called a QWERTY keyboard. The keyboard has alphabetic as well as numeric keys. Some special keys are also available.

1. Numeric Keys: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9
2. Alphabetic keys: a to z (lower case), A to Z (upper case)
3. Special Control keys: Ctrl, Shift, Alt
4. Special Symbol Keys: ; , " ? @ ~ ? :
5. Cursor Control Keys: ↑ → ← ↓
6. Function Keys: F1 F2 F3....F9.
7. Numeric Keyboard: It is on the right-hand side of the keyboard and used for fast entry of numeric data.

Functions of Keyboard:

1. Alphanumeric Keyboards are used in CAD. (Computer Aided Drafting)
2. Keyboards are available with special features line screen co-ordinates entry, Menu selection or graphics functions, etc.
3. Special purpose keyboards are available having buttons, dials, and switches.

Advantage:

1. Suitable for entering numeric data.
2. Function keys are a fast and effective method of using commands, with fewer errors.

Disadvantage:

1. Keyboard is not suitable for graphics input.

2. Mouse

A Mouse is a pointing device and used to position the pointer on the screen. There are two or three depression switches on the top. The movement of the mouse along the x-axis helps in the horizontal movement of the cursor and the movement along the y-axis helps in the vertical movement of the cursor on the screen. The mouse cannot be used to enter text.

Advantage:

- **Easy to use**
- **Not very expensive**

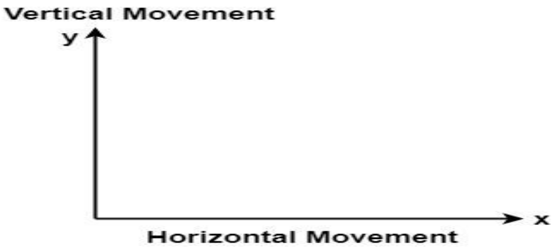


Fig 1.17 Movement of Mouse

3. Trackball

It is a pointing device. It is similar to a mouse. This is mainly used in notebook or laptop computer, instead of a mouse. This is a ball which is half inserted, and by changing fingers on the ball, the pointer can be moved.

Advantage:

1. Trackball is stationary, so it does not require much space to use it.
2. Compact Size

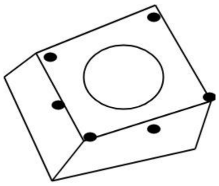


Fig 1.18 Trackball

4. Space ball

It is similar to trackball, but it can move in six directions where trackball can move in two directions only. The movement is recorded by the strain gauge. Strain gauge is applied with pressure. It can be pushed and pulled in various directions. The ball has a diameter around 7.5 cm. The ball is mounted in the base using rollers. One-third of the ball is an inside box, the rest is outside.

Applications:

- It is used for three-dimensional positioning of the object.
- It is used to select various functions in the field of virtual reality.
- It is applicable in CAD applications.
- Animation is also done using spaceball.
- It is used in the area of simulation and modeling.

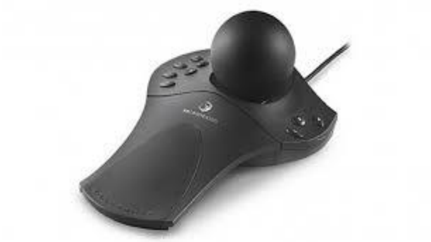


Fig 1.19 Space ball

5. Joystick

A Joystick is also a pointing device which is used to change cursor position on a monitor screen. Joystick is a stick having a spherical ball as its both lower and upper ends as shown in Fig. 1.20.
The lower spherical ball moves in a socket. The joystick can be changed in all four directions. The function of a joystick is similar to that of the mouse. It is mainly used in Computer Aided Designing (CAD) and playing computer games.

Fig 1.20 Joystick

6. Light Pen

Light Pen (similar to the pen) is a pointing device which is used to select a displayed menu item or draw pictures on the monitor screen. It consists of a photocell and an optical system placed in a small tube. When its tip is moved over the monitor screen, and pen button is pressed, its photocell sensing element detects the screen location and sends the corresponding signals to the CPU.

Uses:

1. Light Pens can be used as input coordinate positions
2. If background color or intensity, a light pen can be used as a locator.
3. It is used as a standard pick device with many graphics system.
4. It can be used as stroke input devices.
5. It can be used as valuators

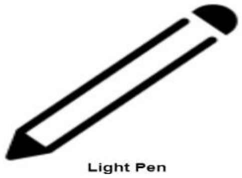


Fig 1.21 Joystick

7. Digitizers

The digitizer is an operator input device, which contains a large, smooth board (the appearance is similar to the mechanical drawing board) & an electronic tracking device

The electronic tracking device contains a switch for the user to record the desire x & y coordinate positions. The coordinates can be entered into the computer memory or stored or an off-line storage medium such as magnetic tape.

Advantages:

- Drawing can easily be changed.
- It provides the capability of interactive graphics.

Disadvantages:

- Costly
- Suitable only for applications which required high-resolution graphics.

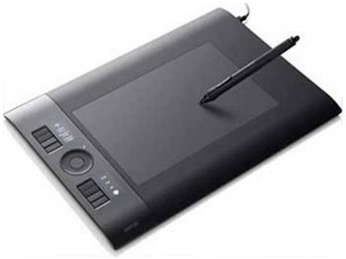


Fig 1.22 Digitizer

Fig 1.23 Digital Camera

8. Touch Panels

Touch Panels is a type of display screen that has a touch-sensitive transparent panel covering the screen. A touch screen registers input when a finger or other object comes in contact with the screen. When the wave signals are interrupted by some contact with the screen, that located is recorded. Touch screens have long been used in military applications.

9. Voice Recognition

Voice Recognition is one of the newest, most complex input techniques used to interact with the computer. The user inputs data by speaking into a microphone. The simplest form of voice recognition is a one-word command spoken by one person. Each command is isolated with pauses between the words. Voice Recognition is used in some graphics workstations as input devices to accept voice commands. The voice-system input can be used to initiate graphics operations or to enter data. These systems operate by matching an input against a predefined dictionary of words and phrases.

Advantage:

1. More efficient device.
2. Easy to use
3. Unauthorized speakers can be identified

Disadvantages:

1. Very limited vocabulary
2. Voice of different operators can't be distinguished.

10. Image Scanner

It is an input device. The data or text is written on paper. The paper is feeded to scanner. The paper written information is converted into electronic format; this format is stored in the computer. The input documents can contain text, handwritten material, picture extra.

By storing the document in a computer document became safe for longer period of time. The document will be permanently stored for the future. We can change the document when we need. The document can be printed when needed. Scanning can be of the black and white or colored picture. On stored picture 2D or 3D rotations, scaling and other operations can be applied.

Types of image Scanners:

1. Flat Bed Scanner:

It resembles a photocopy machine. It has a glass top on its top. Glass top in further covered using a lid. The document to be scanned is kept on glass plate. The light is passed underneath side of glass plate. The light is moved left to right. The scanning is done the line by line. The process is repeated until the complete line is scanned. Within 20-25 seconds a document of 4" * 6" can be scanned.

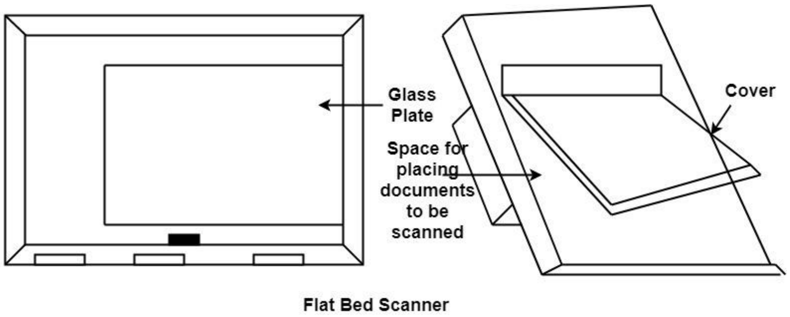


Fig 1.24 Flatbed Scanner

2. Hand Held Scanner:

It has a number of LED's (Light Emitting Diodes). The LED's are arranged in the small case. It is called a Hand held Scanner because it can be kept in hand which performs scanning. For scanning the scanner is moved over document from the top towards the bottom. Its light is on, while we move it on document. It is dragged very slowly over document. If dragging of the scanner over the document is not proper, the conversion will not correct.

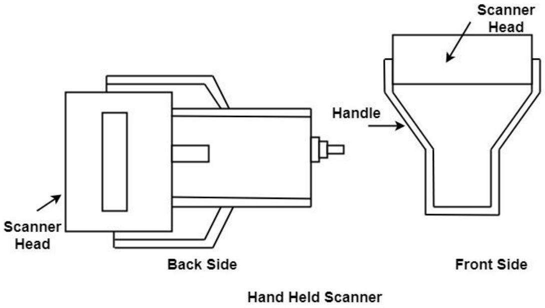


Fig 1.25 Handheld Scanner

HARDCOPY DEVICES

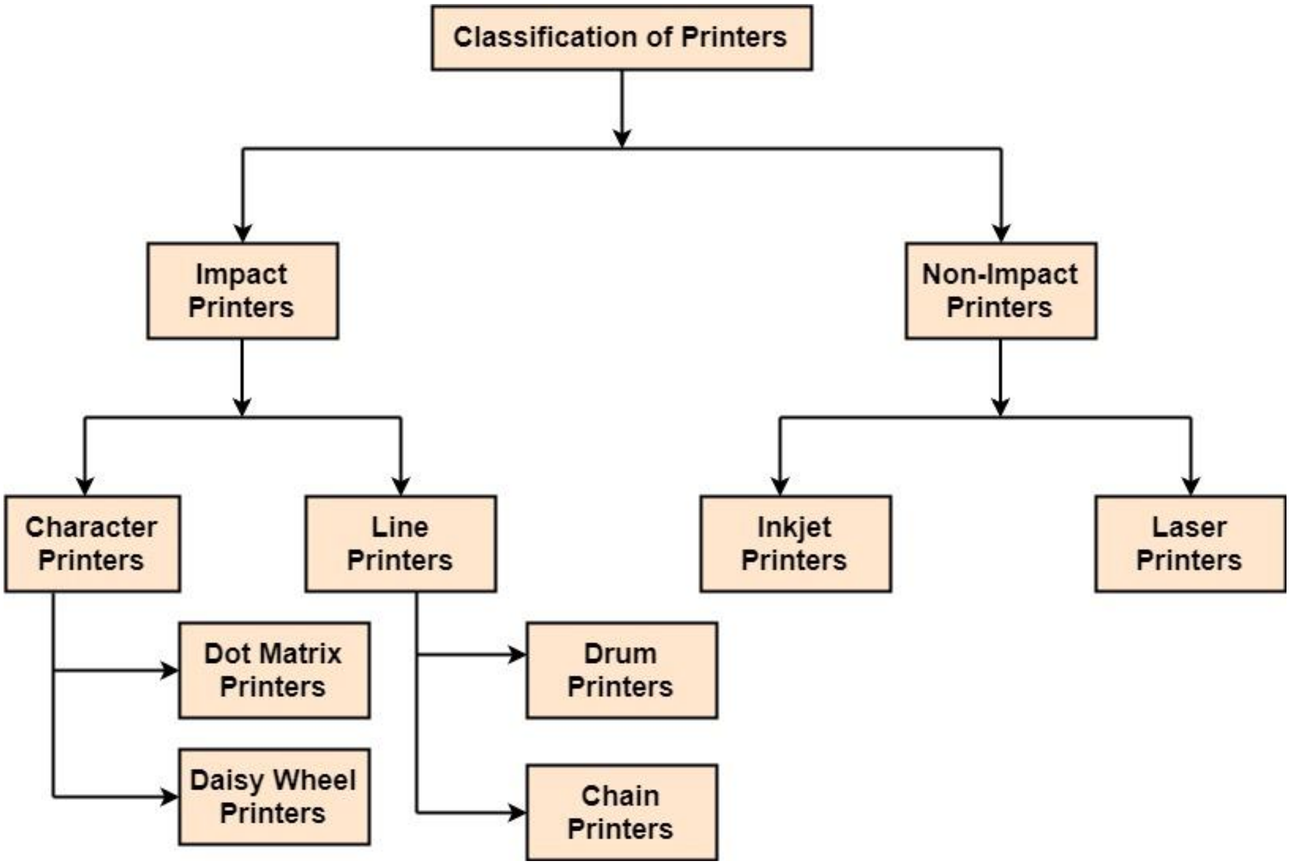


Fig 1.26 Classification of Printers

Types of printers

1. **Impact Printers:** The printers that print the characters by striking against the ribbon and onto the papers are known as Impact Printers.

These Printers are of two types:

1. Character Printers
2. Line Printers

2. Non-Impact Printers: The printers that print the characters without striking against the ribbon and onto the papers are called Non-Impact Printers. These printers print a complete page at a time, therefore, also known as Page Printers.

Page Printers are of two types:

1. Laser Printers
2. Inkjet Printers

Impact Printers

1. **Dotmatrix printers**

Dot matrix has printed in the form of dots. A printer has a head which contains nine pins. The nine pins are arranged one below other. Each pin can be activated independently.

All or only the same needles are activated at a time. When needless is not activated, and then the tip of needle stay in the head. When pin work, it comes out of the print head.

In nine pin printer, pins are arranged in 5 * 7 matrixes.

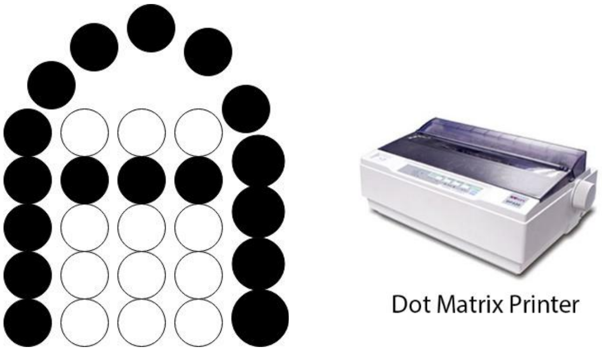


Fig 1.27 Dotmatrix printer

Advantages of Dotmatrix printers

1. Dot Matrix Printers prints output as dots, so it can print any shape of the character. This allows the printer to print special character, charts, graphs, etc.
2. Dot Matrix Printers come under the category of impact printers. The printing is done when the hammer pin strikes the inked ribbon. The impressions are printed on paper. By placing multiple copies of carbon, multiple copies of output can be produced.
3. It is suitable for printing of invoices of companies.

2. Daisy Wheel Printers

Head is lying on a wheel and Pins corresponding to characters are like petals of Daisy, that's why called Daisy wheel printer.

Advantage:

1. More reliable than Dot Matrix Printers
2. Better Quality

Disadvantage:

Slower than Dot Matrix Printers

Fig 1.28 Daisywheel Printer

3. Drum Printers

These are line printers, which prints one line at a time. It consists of a drum. The shape of the drum is cylindrical. The drum is solid and has characters embossed on it in the form of vertical bands. The characters are in circular form. Each band consists of some characters. Each line on drum consists of 132 characters. Because there are 96 lines so total characters are (132 * 95) = 12, 672.

Chain Printers:

These are called as line printers. These are used to print one line at a line. Basically, chain consists of links. Each link contains one character. Printers can follow any character set style, i.e., 48, 64 or 96 characters. Printer consists of a number of hammers also.

Advantages:

1. Chain or Band if damaged can be changed easily.
2. It allows printing of different form.
3. Different Scripts can be printed using this printer.

Disadvantages:

1. It cannot print charts and graphs.
2. It cannot print characters of any shape.
3. Chain Printers is impact printer, hammer strikes so it is noisy.

Non-Impact Printers – Inkjet printers

These printers use a special link called electrostatic ink. The printer head has a special nozzle. Nozzle drops ink on paper. Head contains up to 64 nozzles. The ink dropped is deflected by the electrostatic plate. The plate is fixed outside the nozzle. The deflected ink settles on paper.

Advantages:

1. These produce high quality of output as compared to the dot matrix.
2. A high-quality output can be produced using 64 nozzles printed.
3. Inkjet can print characters in a variety of shapes.
4. Inkjet can print special characters.
5. The printer can print graphs and charts.

Disadvantages:

1. Inkjet Printers are slower than dot matrix printers.
2. The cost of inkjet is more than a dot matrix printer.

Fig 1.29 Inkjet Printer

Non-Impact Printers – Laser printers

These printers uses laser lights to produces the dots needed to form the characters to be printed on a page & hence the name laser printers.

The output is generated in the following steps:

Step1: The bits of data sent by processing unit act as triggers to turn the laser beam on & off.

Step2: The output device has a drum which is cleared & is given a positive electric charge.

To print a page the laser beam passing from the laser scans back & forth the surface of the drum.

Step3: The laser exposed parts of the drum attract an ink powder known as toner.

Step4: The attracted ink powder is transferred to paper.

Step5: The ink particles are permanently fixed to the paper by using either heat or pressure technique.

Step6: The drum rotates back to the cleaner where a rubber blade cleans off the excess ink & prepares the drum to print the next page.

PLOTTERS

Plotters are a special type of output device. It is suitable for applications:

1. Architectural plan of the building.
2. CAD applications like the design of mechanical components of aircraft.
3. Many engineering applications.

Advantage:

- It can produce high-quality output on large sheets.
- It is used to provide the high precision drawing.
- It can produce graphics of various sizes.
- The speed of producing output is high.

Fig 1.30 Plotter

GRAPHICS SOFTWARE

There are two types of Graphics Software.

1. General Purpose Packages: Basic Functions in a general package include those for generating picture components (straight lines, polygons, circles and other figures), setting color and intensity values, selecting views, and applying transformations.Example of general-purpose package is the GL (Graphics Library), GKS, PHIGS, PHIGS+ etc.

2. Special Purpose Packages: These packages are designed for non programmers, so that these users can use the graphics packages, without knowing the inner details.

Example of special purpose package is :

- Painting programs
- Package used for business purpose
- Package used for medical systems.
- CAD packages

LINE DRAWING ALGORITHMS

A line connects two points. It is a basic element in graphics. To draw a line, you need two end points (x1,y1) and (x2,y2). The line segment is sampled at unit intervals in one coordinate and corresponding integer values nearer to the line path are determined for other coordinates.

Equation of a line is given by :

$$y = mx+b$$

where m is the slope of the line and b is the slope intercept.

$$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{\Delta Y}{\Delta X}$$

$b = y-mx$

Considering a line with positive slope, if the slope is less than or equal to 1, we sample at unit x intervals (dx=1) and compute successive y values as :

$$Y_{k+1} = Y_k + m$$

Subscript k takes integer values starting from 0, for the 1st point and increases along x axis in unit intervals until the endpoint is reached. Y is rounded off to a nearest integer to correspond to a screen pixel.

Similarly, if the slope is greater than or equal to 1, we sample at unit y intervals (dy=1) and compute x in successive manner as :

$$X_{k+1} = X_k + 1/m$$

Digital Differential Analyzer (DDA) line drawing algorithm

Digital Differential Analyzer (DDA) algorithm is the simple line generation algorithm which is explained step by step here

- Get the inputs of two end points (X1,Y1) and (X2, Y2)
- Calculate the difference between two endpoints (dx and dy)
- Based on the calculated difference, you need to identify the number of steps to put pixel. If

dx > dy, then you need more steps in x coordinate; otherwise in y coordinate.

- Calculate the increment in x coordinate and y coordinate.
- Put the pixel by successfully incrementing x and y coordinates accordingly and complete the drawing of the line.

Algorithm for DDA

```
Procedure lineDDA (x1,y1,x2,y2 : integer)
        {
        var
        dx,dy,steps,k : integer;
        xinc, yinc, x,y : real;
        dx = x2-x1;
        dy = y2-y1;
        if  abs(dx) > abs(dy) then
        steps = abs (dx)
        else steps = abs(dy);
        xinc = dx/steps;
        yinc = dy/steps;
        x = x1;
        y = y1;
        Setpixel (round(x),round(y),1);
        for (i=1; i<=steps; i++)
         {
          x = x + xinc;
           y =   y +  yinc;
        Setpixel (round(x),round(y),1);
          }
        }
```

Eg 1) Draw a line between (5,5) – (10,10)

$x_1 = 5$, $y_1 = 5$, $x_2 = 10$, $y_2 = 10$

$$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{\Delta Y}{\Delta X}$$

$$m = \frac{y2-y1}{x2-x1} = \frac{10-5}{10-5} = 1$$

```
if dx >dy
    steps = abs (dx)
else
    steps = abs(dy)
```

From this example , both dx and dy are equal.

steps = abs(dy)

Xinc = dx / steps = 5/5 = 1

Yinc = dy /steps = 5/5 = 1

Increment both x and y using xinc and yinc for steps number of times and the points generated are given in table below and it is also plotted in Fig. 1.31.

K	**X_k**	**Y_k**
0	5	5
1	6	6
2	7	7
3	8	8
4	9	9
5	10	10

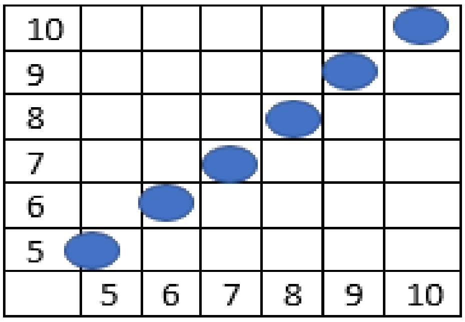


Fig 1.31 Line generated using DDA algorithm

Eg 2) Draw a line between (5,5) – (10,8)

$x_1 = 5$, $y_1 = 5$, $x_2 = 10$, $y_2 = 8$

$$m = \frac{y2-y1}{x2-x1} = \frac{8-5}{10-5} = .6$$

From the above equation dy > dx : **Hence yinc = .6 and xinc = 1** and the points generated are shown in table below and it is plotted in Fig. 1.32.

K	X_k	Y_k
0	5	5
1	6	5.6
2	7	6.2
3	8	6.8
4	9	7.4
5	10	8

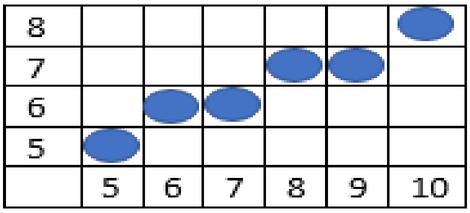


Fig 1.32 Line generated using DDA algorithm

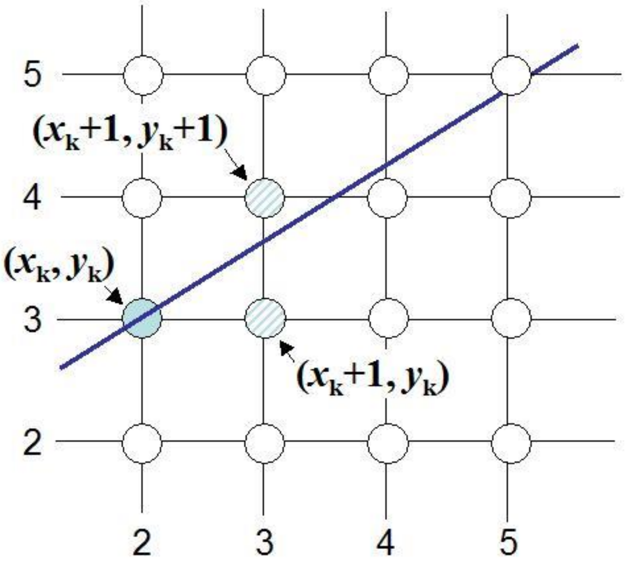
Advantages :

1. It is the simplest algorithm and does not require special skills for implementation
2. Fastest method for calculating pixel positions
3. Involves floating point arithmetic

Bresenham line drawing algorithm

The big advantage of this algorithm is that it uses only integer calculations.

The main idea of the Bresenham's line drawing algorithm: Move across the x-axis in unit intervals and at each step choose between two different y coordinates. For example from position (2,3) we have to choose between (3,3) and (3,4), we would like the point that is closer to the original line.



Deriving TheBresenham Line Algorithm

To illustrate Bresenham's approach, we first consider the scan conversion process for lines with positive slope less than 1 **(m<1)**.

Pixel positions along a line path are determined by sampling at unit **x** intervals. Starting from the left endpoint **(x_0, y_0)** of a given line, we step to each successive column (**x** position) and demonstrate the kth step in this process.

Assuming we have determined that the pixel at **(x_k, y_k)** is to be displayed, we next need to decide which pixel to plot in column x_k+1. Our choices are the pixels at positions (x_k+1, y_k) and (x_k+1, y_k+1).

Bresenham line drawing algorithm

1. Input the two-line end-points, storing the left end-point in **(x_0,y_0)**
2. Plot the point **(x_0, y_0)**

3. Calculate the constants dx, dy, 2dy, and (2dy – 2dx) and get the first value for the decision parameter as:

   $\mathbf{P_0 = 2dy - dx}$

4. At each $\mathbf{x_k}$ along the line, starting at **k=0**, perform the following test:

   If $\mathbf{p_k < 0}$, the next point to plot is

   $\mathbf{(x_k+1,\ y_k)}$ and

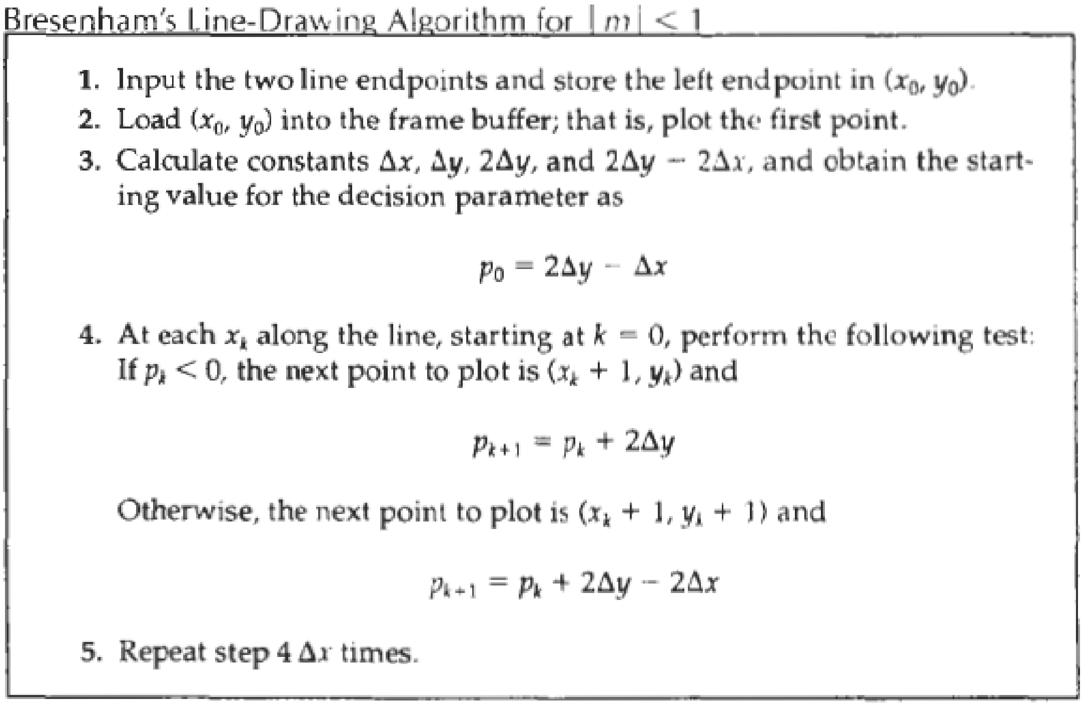
   $\mathbf{p_{k+1} = p_k + 2dy}$

   Otherwise, the next point to plot is

   $\mathbf{(x_k+1,\ y_k+1)}$ and

   $\mathbf{p_{k+1} = p_k + 2dy - 2dx}$

   Repeat step 4 (dx) times



Bresenham's Line-Drawing Algorithm for $|m| < 1$

1. Input the two line endpoints and store the left endpoint in (x_0, y_0).
2. Load (x_0, y_0) into the frame buffer; that is, plot the first point.
3. Calculate constants Δx, Δy, $2\Delta y$, and $2\Delta y - 2\Delta x$, and obtain the starting value for the decision parameter as

$$p_0 = 2\Delta y - \Delta x$$

4. At each x_k along the line, starting at $k = 0$, perform the following test: If $p_k < 0$, the next point to plot is $(x_k + 1, y_k)$ and

$$p_{k+1} = p_k + 2\Delta y$$

   Otherwise, the next point to plot is $(x_k + 1, y_k + 1)$ and

$$p_{k+1} = p_k + 2\Delta y - 2\Delta x$$

5. Repeat step 4 Δx times.

Detailed algorithm

```
Procedure lineBresenham (x1, y1, x2, y2 : integer)
var
dx,dy,x, y, xend, p : integer;
{
 dx=abs(x1-x2);
dy=abs(y1-y2);
 p=2*dy-dx;
   if(x1>x2) then
{
                x=x2;
                y=y2;
xend=x1;
}
else
  {
x=x1;
y=y1;
xend=x2;
 }

putpixel(x,y,4);
while(x<=xend)
{
x=x+1;
   if (p<0) then
          p=p+2*dy;
  else
        {
           y=y+1;
          p=p+2*(dy-dx);
        }
putpixel(x,y,4);
  }
}
```

Eg., Draw a line between **(20,10)** and **(30, 18)**

dx =10, **dy = 8**

The initial decision parameter has the value **P_0 = 2dy – dx = 6**

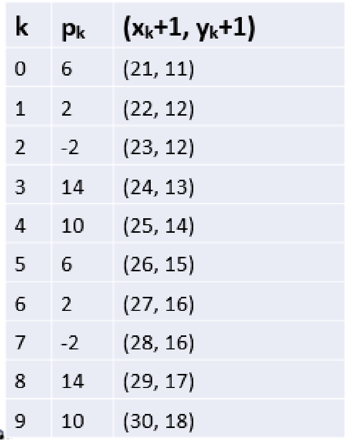
The increments for calculation successive decision parameters are:

2dy = 16

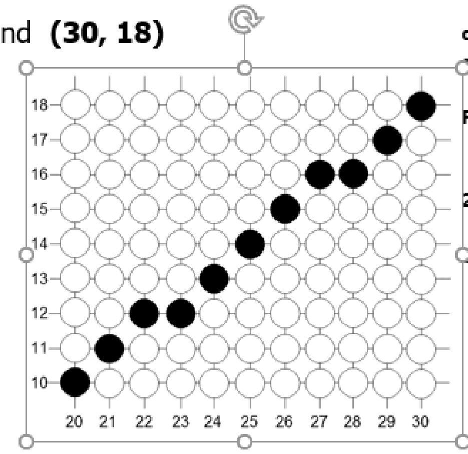
2dy – 2dx = – 4

We plot the initial point **(20, 10)** , and determine successive pixel positions along the line path from the decision parameters as:

Draw a line between **(20,10)** and **(30, 18)**



k	p_k	(x_k+1, y_k+1)
0	6	(21, 11)
1	2	(22, 12)
2	-2	(23, 12)
3	14	(24, 13)
4	10	(25, 14)
5	6	(26, 15)
6	2	(27, 16)
7	-2	(28, 16)
8	14	(29, 17)
9	10	(30, 18)



dx =10
dy =8

P_0 = 2dy-dx
= 2*8-10 = 16-10 =6

2dy = 2*8=16

2dy – 2dx = 16-20 = -4

Difference between DDA Line Drawing Algorithm and Bresenhams Line Drawing Algorithm

Features	**Digital Differential Analyzer Line Drawing Algorithm**	**Bresenham’s Line Drawing Algorithm**
Arithmetic	DDA algorithm uses floating points i.e. Real Arithmetic.	Bresenham’s algorithm uses fixed points i.e. Integer Arithmetic
Operations	DDA algorithm uses multiplication and division in its operations.	Bresenham’s algorithm uses only subtraction and addition in its operations.
Speed	DDA algorithm is rather slowly than Bresenham’s algorithm in line drawing because it uses real arithmetic (floating point operations)	Bresenham’s algorithm is faster than DDA algorithm in line drawing because it performs only addition and subtraction in its calculation and uses only integer arithmetic so it runs significantly faster.
Accuracy & Efficiency	DDA algorithm is not as accurate and efficient as Bresenham’s algorithm	Bresenham’s algorithm is more efficient and much accurate than DDA algorithm.
Drawing	DDA algorithm can draw circles and curves but that are not as accurate as Bresenham’salgorithm	Bresenham’s algorithm can draw circles and curves with much more accuracy than DDA algorithm.
Round off	DDA algorithm round off the coordinates to integer that is nearest to the line	Bresenham’s algorithm does not round but takes the incremental value in its operation.
Expensive	DDA algorithm uses an enormous number of floating-point multiplications so it is expensive	Bresenham’s algorithm is less expensive than DDA algorithm as it uses only addition and subtraction.

Mid Point Subdivision algorithm for Circle

The **mid-point** circle drawing algorithm is an algorithm used to determine the points needed for generating a circle. We use the **mid-point** algorithm to calculate all the perimeter points of the circle in the **first octant** and then print them along with their mirror points in the other octants. This will work because a circle is symmetric about it'scentre.

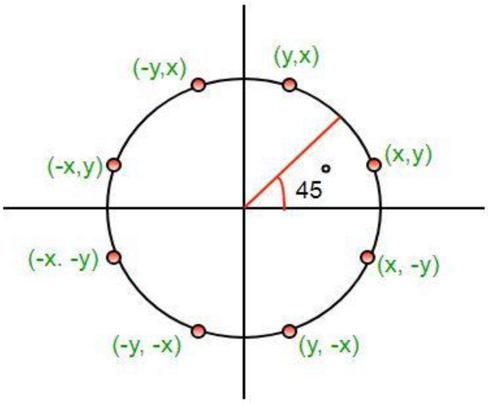


Fig 1.33 8 way symmetry for drawing circle

The equation for a circle is:

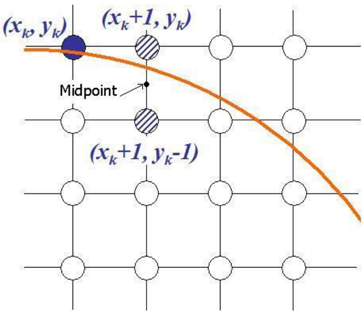
$$x^2 + y^2 = r^2$$

Where **r** is the **radius** of the circle. So, we can write a direct circle drawing algorithm by solving the equation for **y** at unit **x** intervals using:

$$y = \pm(r^2 - x^2)^{1/2}$$

For a given radius **r** and screen center position (x_c, y_c), we can first set up our algorithm to calculate pixel positions around a circle path centered at the coordinate (0, 0). Then each calculated position (x, y) is moved to its proper screen position by adding x_c to **x** and y_c to **y**.

Assuming we have just plotted point (x_k, y_k), we next need to determine whether the pixel at position (x_k+1, y_k) or the one at position (x_k+1, y_k-1) is closer to the circle path. Our decision parameter is The circle function evaluated at the midpoint between these two pixels:



The relative position of any point (x, y) can be determined by checking the sign of the on the boundary of the circle function:

< 0 If (x, y) is inside the circle boundary

$\mathbf{f_{circle}(x, y) = 0}$ If (x, y) is on the circle boundary

> 0 If (x, y) is outside the circle boundary

The circle function tests are performed for the midpoints positions between pixels near the circle path at each sampling step. Thus, circle function is decision parameter in the midpoint algorithm, and we can set up incremental calculations for this function as we did in the line algorithm.

1. Input radius *r* and circle centre **(xc, yc),** and obtain the first point on the circumference of a circle centred on the origin as:

   $$(x_0, y_0) = (0, r)$$

2. Calculate the initial value of the decision parameter as:

   $$P_0 = 5/4 - r \quad \text{(or)} \quad p=1-r$$

3. At each position x_k Starting with **k=0**, perform the following test.

   If pk < 0, the next point along the circle centred on (0, 0) is

   (x_{k+1}, y_k) and $p_{k+1} = p_k + 2x_{k+1} + 1$

   Otherwise the next point along the circle is

   (x_{k+1}, y_{k-1}) and $p_{k+1} = p_k + 2x_{k+1} + 1 - 2y_{k+1}$

   where $2x_{k+1} = 2x_{k+1} + 2$ and $2y_{k+1} = 2y_{k+1} - 2$

4. Determine symmetry points in the other seven octants

5. Move each calculated pixel position (x, y) onto the circular path centred at **(xc, yc)** and plot the coordinate values:

   x= x+ **xc** and y = y+ **yc**

6. Repeat steps 3 to 5 until **x >= y**

eg.,) Given a circle with **radius=10**, we demonstrate the midpoint circle algorithm by determining positions along the circle octant in the first quadrant from x = 0 to x = y. the initial value of the decision parameter is **$P_0 = 1 – r = – 9$**

For the circle centred on the origin, the initial point is **$(x_0, y_0) = (0, 10)$**, and the initial increment term for calculating the decision parameters are

$2x_0 = 0$ and **$2y_0 = 20$**

Successive decision parameters values and positions along the circle path are calculated using midpoint algorithm as:

k	P_k	x_{k+1}, y_{k-1}	$2x_{k+1}$	$2y_{k+1}$
0	-9	(1, 10)	2	20
1	-6	(2, 10)	4	20
2	-1	(3, 10)	6	20
3	6	(4, 9)	8	18
4	-3	(5, 9)	10	18
5	8	(6, 8)	12	16
6	5	(7, 7)	14	14

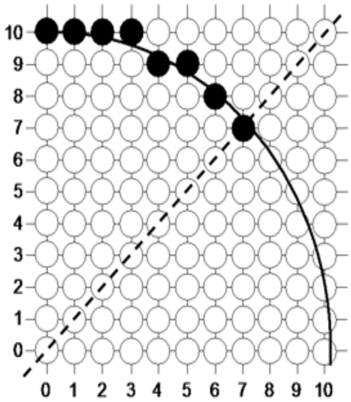
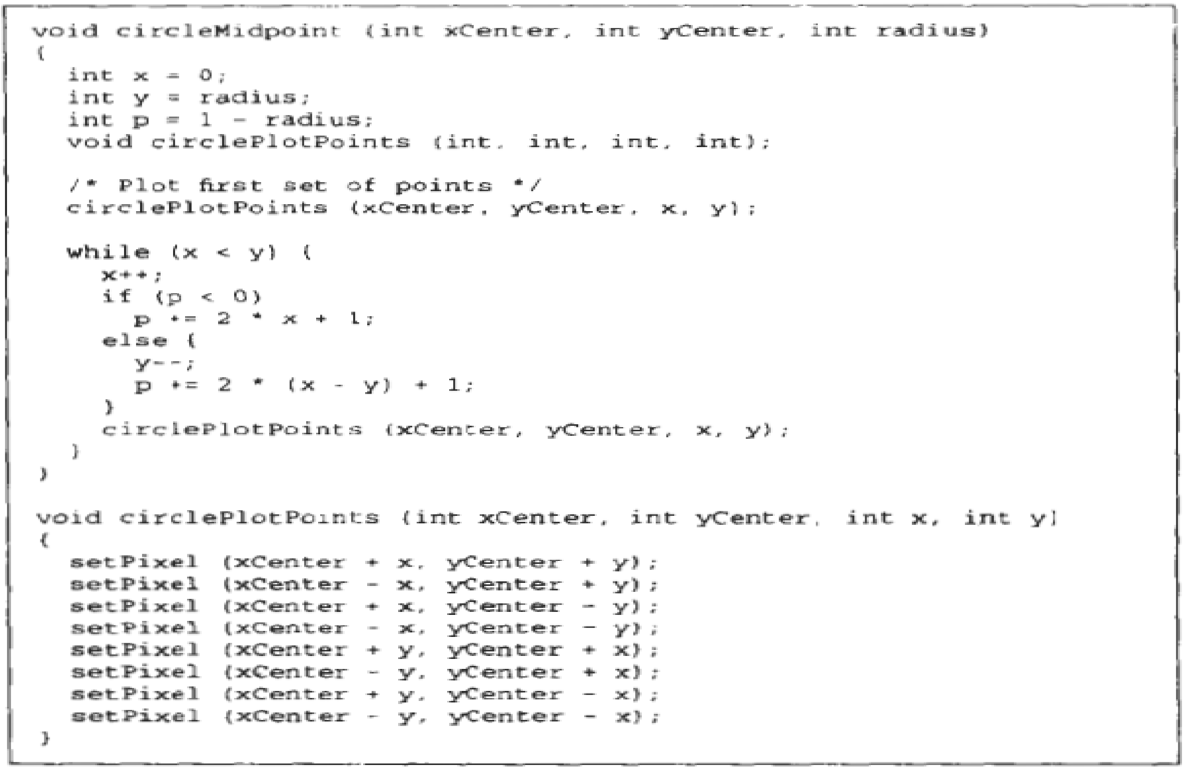


Fig 1.34 A plot of the generated pixel positions in the first quadrant

DETAILED ALGORITHM



```
void circleMidpoint (int xCenter, int yCenter, int radius)
{
  int x = 0;
  int y = radius;
  int p = 1 - radius;
  void circlePlotPoints (int, int, int, int);

  /* Plot first set of points */
  circlePlotPoints (xCenter, yCenter, x, y);

  while (x < y) {
    x++;
    if (p < 0)
      p += 2 * x + 1;
    else {
      y--;
      p += 2 * (x - y) + 1;
    }
    circlePlotPoints (xCenter, yCenter, x, y);
  }
}

void circlePlotPoints (int xCenter, int yCenter, int x, int y)
{
  setPixel (xCenter + x, yCenter + y);
  setPixel (xCenter - x, yCenter + y);
  setPixel (xCenter + x, yCenter - y);
  setPixel (xCenter - x, yCenter - y);
  setPixel (xCenter + y, yCenter + x);
  setPixel (xCenter - y, yCenter + x);
  setPixel (xCenter + y, yCenter - x);
  setPixel (xCenter - y, yCenter - x);
}
```

The advantages of Mid Point Circle Drawing Algorithm are-

- It is a powerful and efficient algorithm.
- The entire algorithm is based on the simple equation of circle $X^2 + Y^2 = R^2$.
- It is easy to implement from the programmer's perspective.
- This algorithm is used to generate curves on raster displays.

The disadvantages of Mid Point Circle Drawing Algorithm are-

- Accuracy of the generating points is an issue in this algorithm.
- The circle generated by this algorithm is not smooth.
- This algorithm is time consuming.

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SCHOOL OF COMPUTING

DEPARTMENT OF COMPUTER SCIENCE

UNIT – II – Computer Graphics and Multimedia – SBS1303

2D Geometric Transformations: Basic Transformations – Matrix Representations – Composite Transformations – Other Transformations. 2D Viewing: The Viewing Pipeline – Viewing Co-ordinate Reference Frame – Window-to-Viewport Co-ordinate Transformation - 2D Viewing Functions – Clipping Operations- Point Clipping-Line Clipping-Polygon Clipping-Curve Clipping-Text Clipping-Exterior Clipping.

2-Dimensional Transformations

The Basic Transformations:

1. Translation
2. Scaling
3. Rotation

Other Transformations:

1. Reflection
2. Shearing

Translations

Displacement of an object in a given distance and direction from its original position.

- Rigid body transformation that moves object without deformation
- Initial Position point P (x,y)
- The new point P'
  (x', y') where
  x' = x + tx , y' = y + ty , tx and ty is the displacement in x and y respectively.

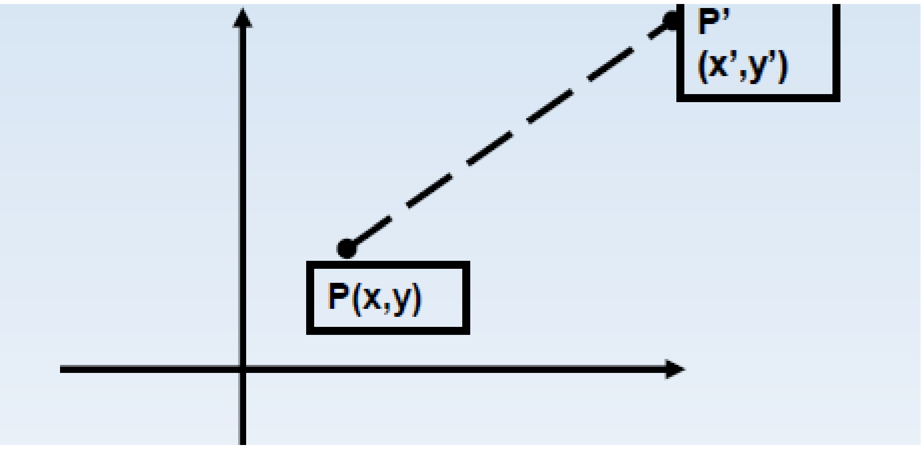


Fig 2.1 Translation from P to P'

The translation pair (tx, ty) is called a translation vector or shift vector

Problem:

- Assume you are given a point at (x,y)=(2,1). Where will the point be if you move it 3 units to the right and 1 unit up? Ans: (x',y') = (5,2). How was this obtained? - (x',y') = (x+3,y+1). That is, to move a point by some amount *dx* to the right and *dy up*, you must add *dx* to the x-coordinate and add *dy* to they-coordinate.
- What was the required transformation to move the green triangle to the red triangle? Here the green triangle is represented by 3points

triangle = { p1=(1,0), p2=(2,0), p3=(1.5,2) }

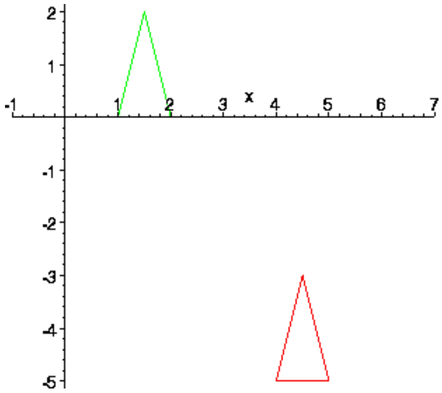


Fig 2.2 Example for Translation

Matrix/Vector Representation of Translations

A translation can also be represented by a pair of numbers, $t=(t_x,t_y)$ where t_x is the change in the x-coordinate and $t_y$is the change in y coordinate. To translate the point p by t, we simply add to obtain the new (translated) point.

$$p' = p + t.$$

$$\begin{bmatrix} x \\ y \end{bmatrix} + \begin{bmatrix} tx \\ ty \end{bmatrix} = \begin{bmatrix} x+tx \\ y+ty \end{bmatrix}$$

Rotation

Rotation is applied to an object by repositioning it along a circular path in the xy plane.

To generate a rotation, we specify

- Rotation angleθ
- Pivot point (xr ,yr)

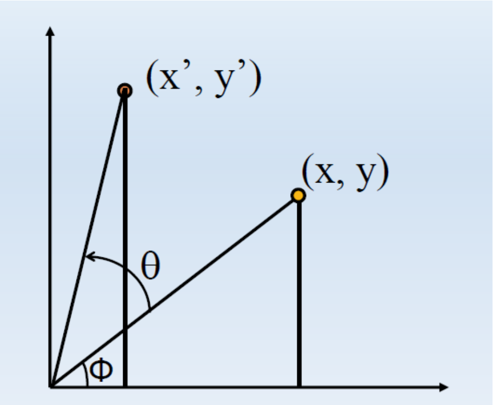
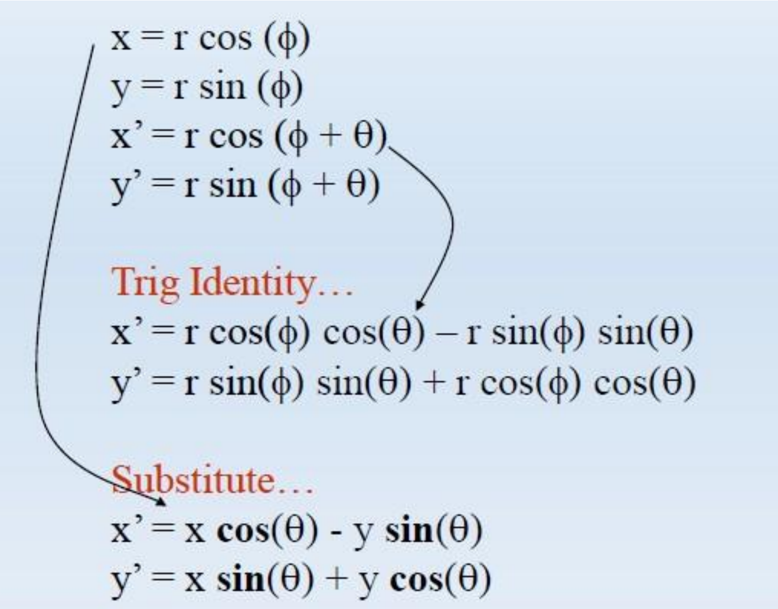


Fig 2.3 Rotation

Positive values of θ is used for counter clockwise rotation Negative values of θ for clockwise rotation.



$x = r\cos(\phi)$

$y = r\sin(\phi)$

$x' = r\cos(\phi + \theta)$

$y' = r\sin(\phi + \theta)$

Trig Identity…

$x' = r\cos(\phi)\cos(\theta) - r\sin(\phi)\sin(\theta)$

$y' = r\sin(\phi)\sin(\theta) + r\cos(\phi)\cos(\theta)$

Substitute…

$x' = x\,\mathbf{cos}(\theta) - y\,\mathbf{sin}(\theta)$

$y' = x\,\mathbf{sin}(\theta) + y\,\mathbf{cos}(\theta)$

Matrix Representation of

P’=R.P

$$R = \begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix}$$

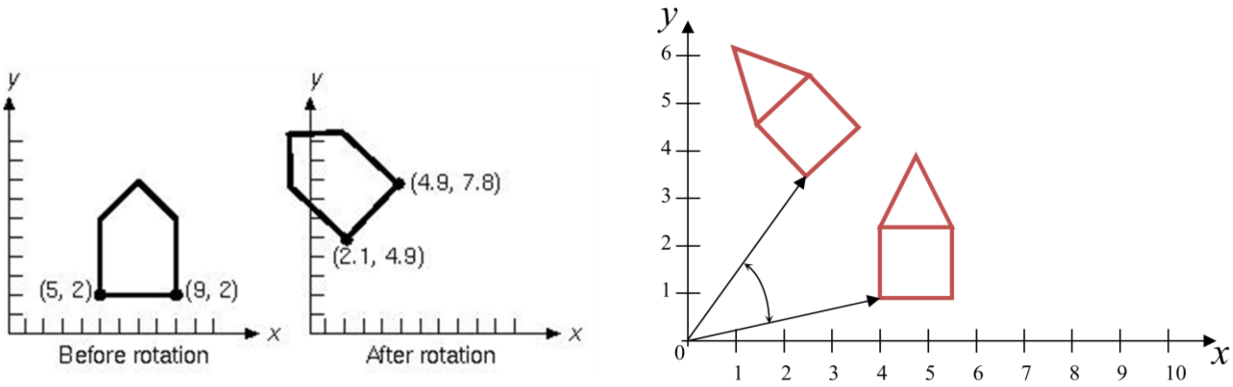


Fig 2.4 Example for rotation

Scaling

- Scaling alters the size of anobject.
- Operation can be carried out by multiplying each of its components by ascalar
- Uniform scaling means this scalar is the same for all components
- Non-uniform scaling: different scalars per component

$$x' = x * sx$$
$$y' = y * sy$$

In matrix form:

$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} sx & 0 \\ 0 & sy \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix}$$

eg., When Sx=2 and Sy=2

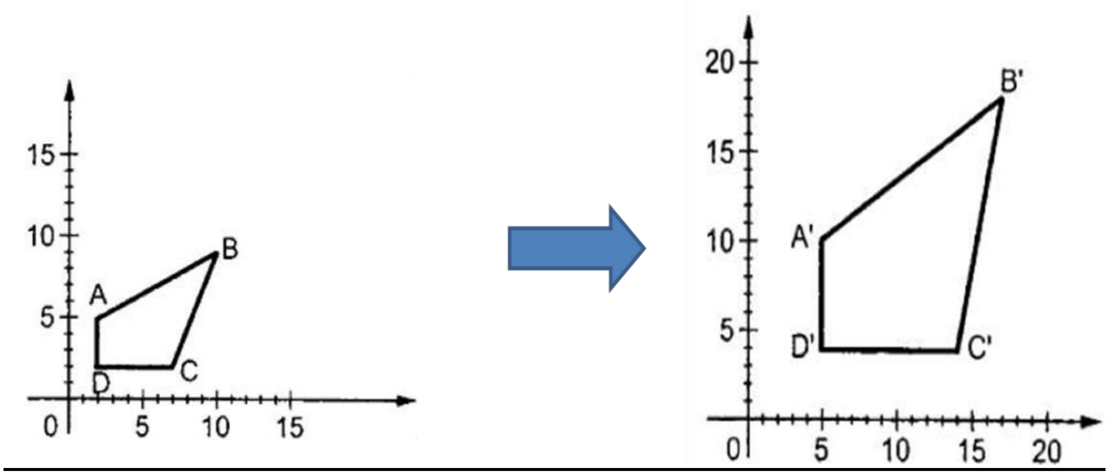


Fig 2.5 Example for Scaling

Reflection

A reflection is a transformation that produces a mirror image of an object Generated relative to an axis of reflection

1. Reflection along xaxis
2. Reflection along yaxis
3. Reflection relative to an axis perpendicular to the xy plane and passing through the coordinate origin
4. Reflection of an object relative to an axis perpendicular to the xy plane and passing through point P
5. Reflection of an object with respect to the liney=x.

Reflection about X-Axis :

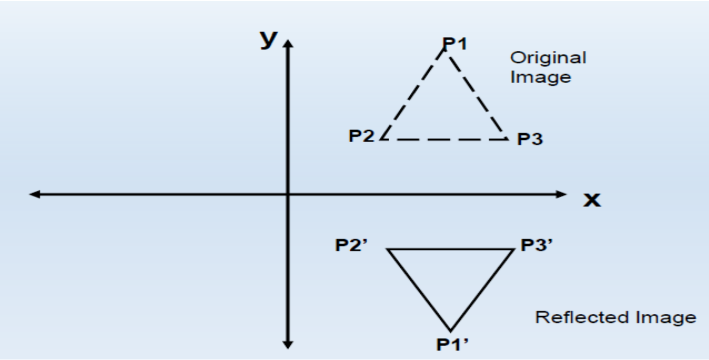
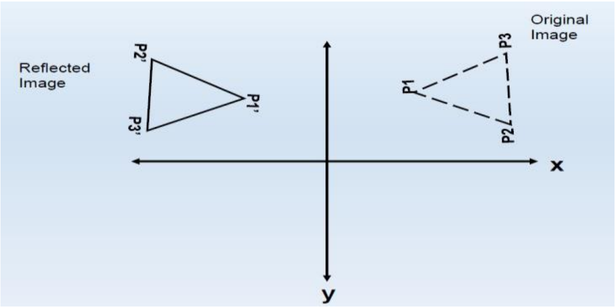


Fig 2.4 Example for reflection about X-axis

$$M = \begin{bmatrix} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

Reflection about y-axis:



$$M = \begin{bmatrix} -1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

Fig 2.5 Example for reflection about Y-axis

Reflection relative to an axis perpendicular to the xy plane and passing through the coordinate origin:

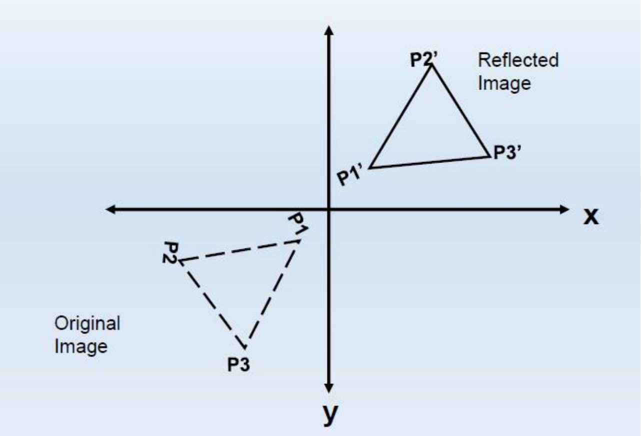


Fig 2.6 Example for reflection about XY plane

$$M = \begin{bmatrix} -1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

Reflection of an object with respect to the line y=x

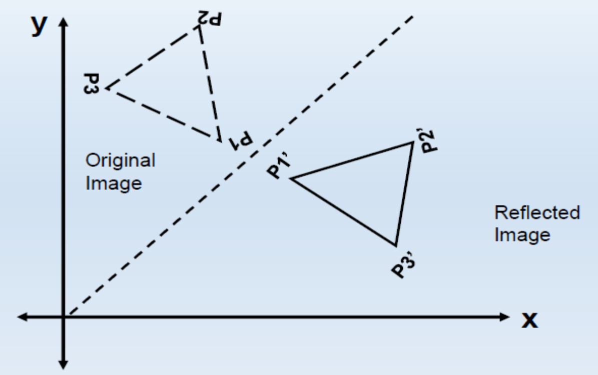


Fig 2.7 Example for reflection about Y=X

$$M = \begin{bmatrix} 0 & 1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

Shearing

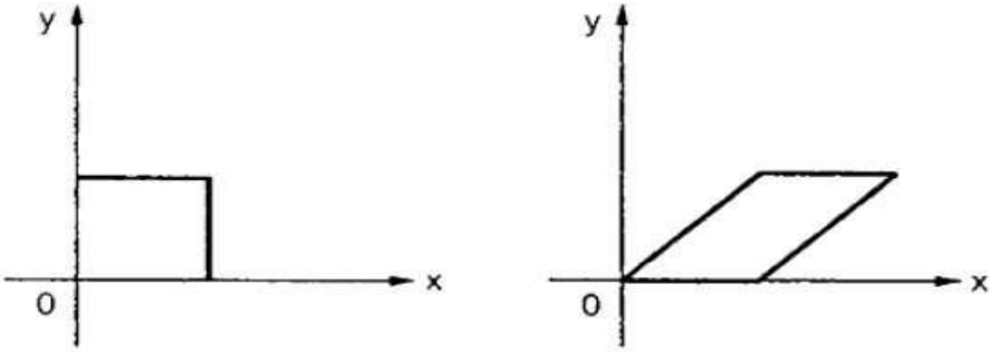
A transformation that distorts the shape of an object such that the transformed object appears as if the object were composed of internal layers that had been caused to slide over each other.

Shear relative tothe x-axis

$$\begin{bmatrix} 1 & sh_x & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

Shear relative to they-axis

$$\begin{bmatrix} 1 & sh_y & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$



(a) Original object

(b) Object after x shear

Fig 2.8 Example for X- Shearing

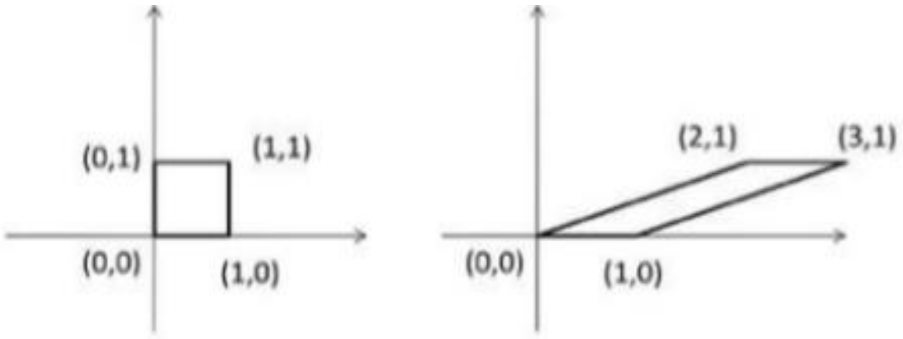


Fig 2.9 Example for Y- Shearing

2D VIEWING

The mapping of a 2D world coordinate system to device coordinates is called a two-dimensional viewing transformation. The **clipping window** is the section of the 2D scene that is selected for viewing. The **display window** is where the scene will be viewed. The **viewport** controls the placement of the scene within the display window

A window-viewport transformation describes the mapping of a (rectangular) window in one coordinate system into another (rectangular) window in another coordinate system. This transformation is defined by the section of the original image that is transformed (clipping window), the location of the resulting window (viewport), and how the window is translated, scaled or rotated.

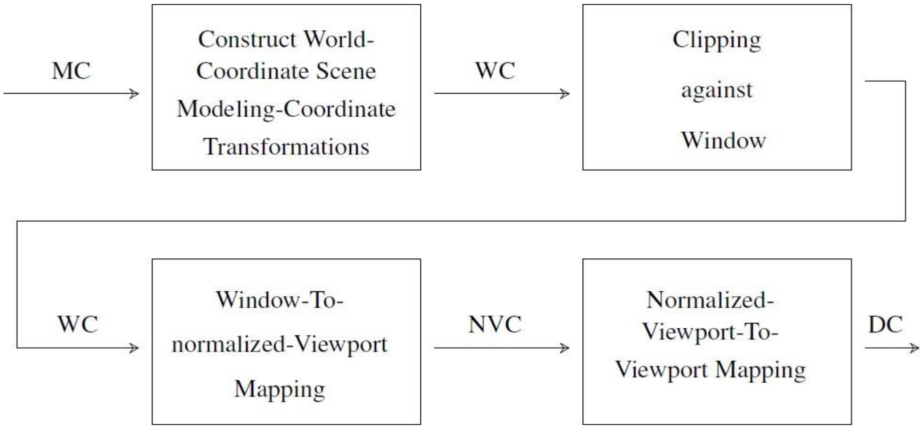

MC
Construct World-Coordinate Scene Modeling-Coordinate Transformations
WC
Clipping against Window
WC
Window-To-normalized-Viewport Mapping
NVC
Normalized-Viewport-To-Viewport Mapping
DC

Fig 2.10 Steps involved with window to viewport mapping

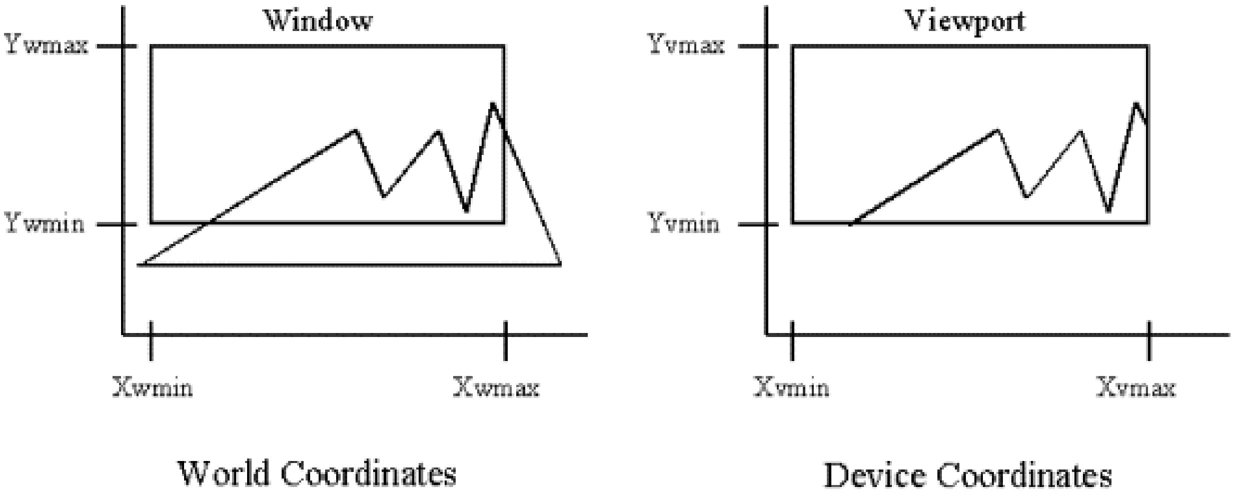


Fig 2.11 window and viewport

Window to Viewport coordinate transformation

To maintain the same relative placement in view port as in window. The conversion is performed with the following sequence of transformations:

1. Perform a scaling transformation using point position of (xw min, yw min) that scales the window area to the size of view port.
2. Translate the scaled window area to the position of view port. Relative proportions of objects are maintained if scaling factor are the same(Sx=Sy).

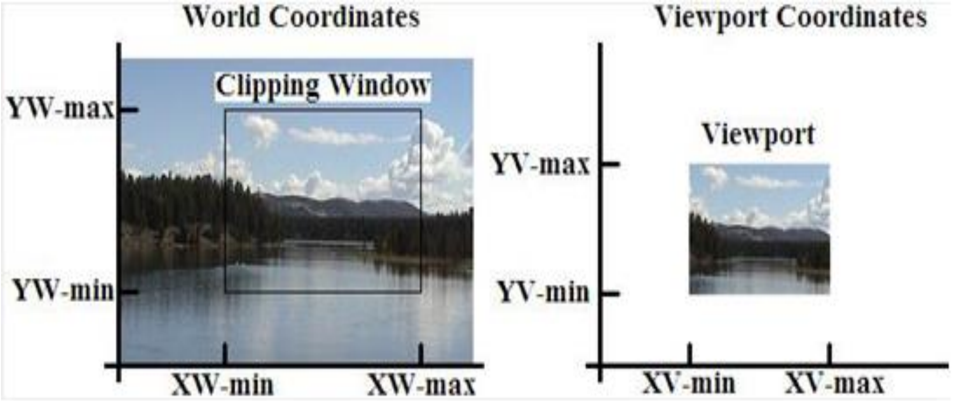


Fig 2.12 Example for window and viewport

Formula for window to viewport transformation

World coordinate – It is the Cartesian coordinate defined by X_{wmin}, X_{wmax}, Y_{wmin}, Y_{wmax}
Device Coordinate –It is the screen coordinate where the objects is to be displayed, like **X_{vmin}, X_{vmax}, Y_{vmin}, Y_{vmax}**
Window –It is the area on world coordinate selected for display.
ViewPort –It is the area on device coordinate where graphics is to be displayed.

$$\text{Normalized Point on Window} \quad \left(\frac{X_w - X_{wmin}}{X_{wmax} - X_{wmin}} , \frac{Y_w - Y_{wmin}}{Y_{wmax} - Y_{wmin}} \right)$$

$$\text{Normalized Point on Viewport} \quad \left(\frac{X_v - X_{vmin}}{X_{vmax} - X_{vmin}} , \frac{Y_v - Y_{vmin}}{Y_{vmax} - Y_{vmin}} \right)$$

Now the relative position of the object in Window and Viewport are same

$$\frac{X_w - X_{wmin}}{X_{wmax} - X_{wmin}} = \frac{X_v - X_{vmin}}{X_{vmax} - X_{vmin}} \qquad \frac{Y_w - Y_{wmin}}{Y_{wmax} - Y_{wmin}} = \frac{Y_v - Y_{vmin}}{Y_{vmax} - Y_{vmin}}$$

From the above equations :

$$X_v = X_{vmin} + (X_w - X_{wmin})\, S_x \qquad Y_v = Y_{vmin} + (Y_w - Y_{wmin})\, S_y$$

in which

$$S_x = \frac{X_{vmax} - X_{vmin}}{X_{wmax} - X_{wmin}} \qquad S_y = \frac{Y_{vmax} - Y_{vmin}}{Y_{wmax} - Y_{wmin}}$$

Example :

Let $X_{wmin} = 20$, $X_{wmax} = 80$, $Y_{wmin} = 40$, $Y_{wmax} = 80$ and $X_{vmin} = 30$, $X_{vmax} = 60$, $Y_{vmin} = 40$, $Y_{vmax} = 60$.

Given a point (X_w, Y_w) be **(30, 80)** on the window. Find its position on the viewport.

STEP 1 :

Calculate scaling factor of x coordinate S_x and scaling factor of y coordinate S_y

$$S_x = \frac{X_{vmax} - X_{vmin}}{X_{wmax} - X_{wmin}} \qquad S_y = \frac{Y_{vmax} - Y_{vmin}}{Y_{wmax} - Y_{wmin}}$$

Sx = (60 – 30) / (80 -20) = 30 /60
Sy = (60-40)/(80 -40) = 20/40

STEP 2 : Find the point on the view port using the formula given below :

$$X_v = X_{vmin} + (X_w - X_{wmin})\, S_x \qquad Y_v = Y_{vmin} + (Y_w - Y_{wmin})\, S_y$$

Xv = 30+(30 – 20) * 30/60 = 30 + 10*30/60 = 35

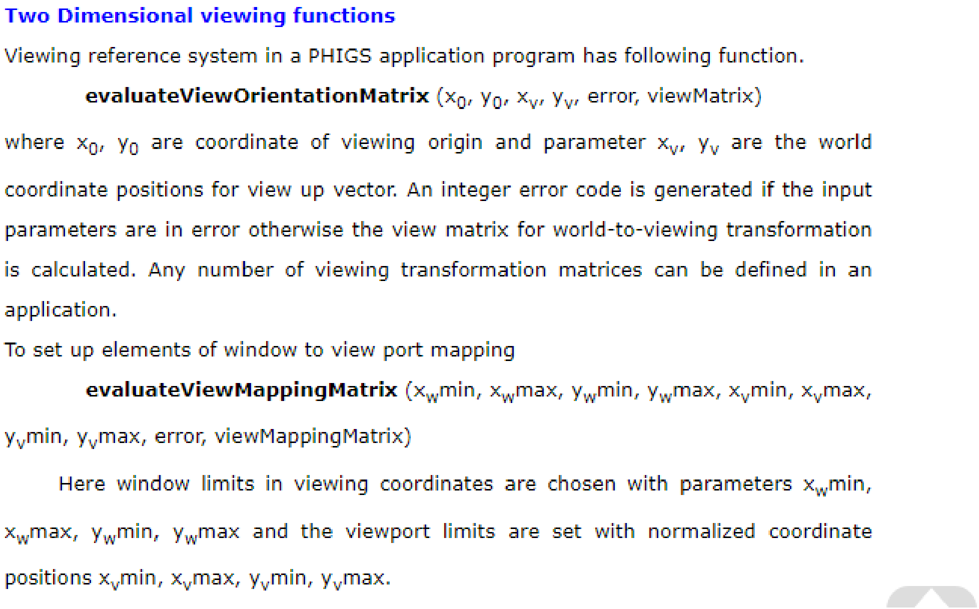
Yv = 40+(80 -40) * 20/40 = 40 + 40 *20/40 = 60

Thus the viewport coordinates are **Xv = 35 and Yv = 60**

Advantages

1. The position of the viewport can be changed allowing objects to be viewed at different positions on the Interface Window.
2. Multiple viewports can also be used to display different sections of a scene at different screen positions. Also, by changing the dimensions of the viewport, the size and proportions of the objects being displayed can be manipulated.
3. Thus, a zooming affect can be achieved by successively mapping different dimensioned clipping windows on a fixed sized viewport.
4. If the aspect ratio of the world window and the viewport are different, then the image may look distorted.

2D viewing functions



Two Dimensional viewing functions

Viewing reference system in a PHIGS application program has following function.

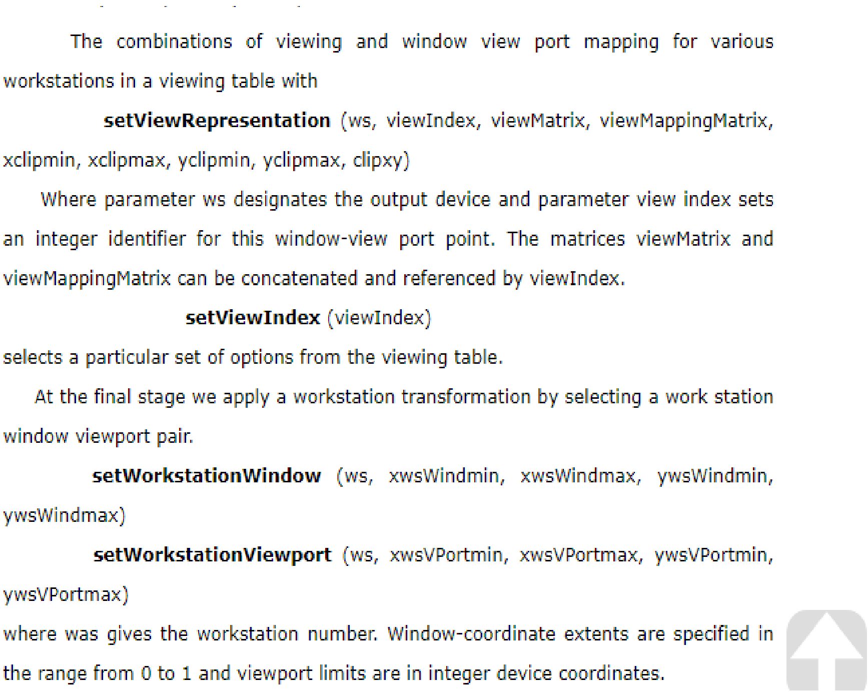
evaluateViewOrientationMatrix (x_0, y_0, x_v, y_v, error, viewMatrix)

where x_0, y_0 are coordinate of viewing origin and parameter x_v, y_v are the world coordinate positions for view up vector. An integer error code is generated if the input parameters are in error otherwise the view matrix for world-to-viewing transformation is calculated. Any number of viewing transformation matrices can be defined in an application.

To set up elements of window to view port mapping

evaluateViewMappingMatrix ($x_w$min, $x_w$max, $y_w$min, $y_w$max, $x_v$min, $x_v$max, $y_v$min, $y_v$max, error, viewMappingMatrix)

Here window limits in viewing coordinates are chosen with parameters $x_w$min, $x_w$max, $y_w$min, $y_w$max and the viewport limits are set with normalized coordinate positions $x_v$min, $x_v$max, $y_v$min, $y_v$max.



The combinations of viewing and window view port mapping for various workstations in a viewing table with

setViewRepresentation (ws, viewIndex, viewMatrix, viewMappingMatrix, xclipmin, xclipmax, yclipmin, yclipmax, clipxy)

Where parameter ws designates the output device and parameter view index sets an integer identifier for this window-view port point. The matrices viewMatrix and viewMappingMatrix can be concatenated and referenced by viewIndex.

setViewIndex (viewIndex)

selects a particular set of options from the viewing table.

At the final stage we apply a workstation transformation by selecting a work station window viewport pair.

setWorkstationWindow (ws, xwsWindmin, xwsWindmax, ywsWindmin, ywsWindmax)

setWorkstationViewport (ws, xwsVPortmin, xwsVPortmax, ywsVPortmin, ywsVPortmax)

where was gives the workstation number. Window-coordinate extents are specified in the range from 0 to 1 and viewport limits are in integer device coordinates.

CLIPPING OPERATION

1. Point Clipping
2. Line Clipping
3. Area Clipping
4. Curve Clipping
5. Text Clipping

1. Point Clipping

In computer graphics our screen act as a 2-D coordinate system. it is not necessary that each and every point can be viewed on our viewing pane(i.e. our computer screen). We can view points, which lie in particular range (0,0) and (Xmax, Ymax). So, clipping is a procedure that identifies those portions of a picture that are either inside or outside of our viewing pane.

In case of point clipping, we only show/print points on our window which are in range of our viewing pane, others points which are outside the range are discarded.

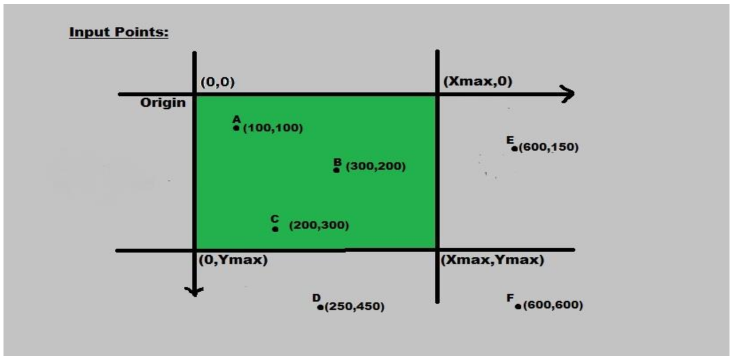


Fig 2.13 Input of point clipping

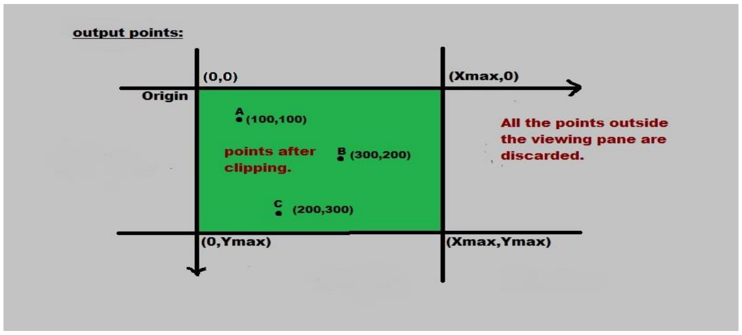


Fig 2.14 Output of point clipping

Algorithm :

1. Get the minimum and maximum coordinates of both viewing pane.
2. Get the coordinates for a point.
3. Check whether given input lies between minimum and maximum coordinate of viewing pane.
4. If yes display the point which lies inside the region otherwise discard it.

2. LINE CLIPPING

i) COHEN –SUTHERLAND LINE CLIPPING algorithm

Given a set of lines and a rectangular area of interest, the task is to remove lines which are outside the area of interest and clip the lines which are partially inside the area.

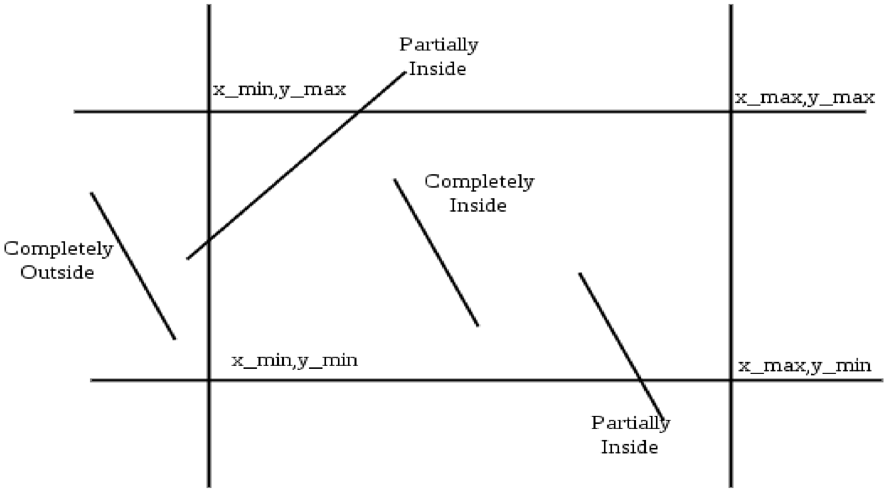
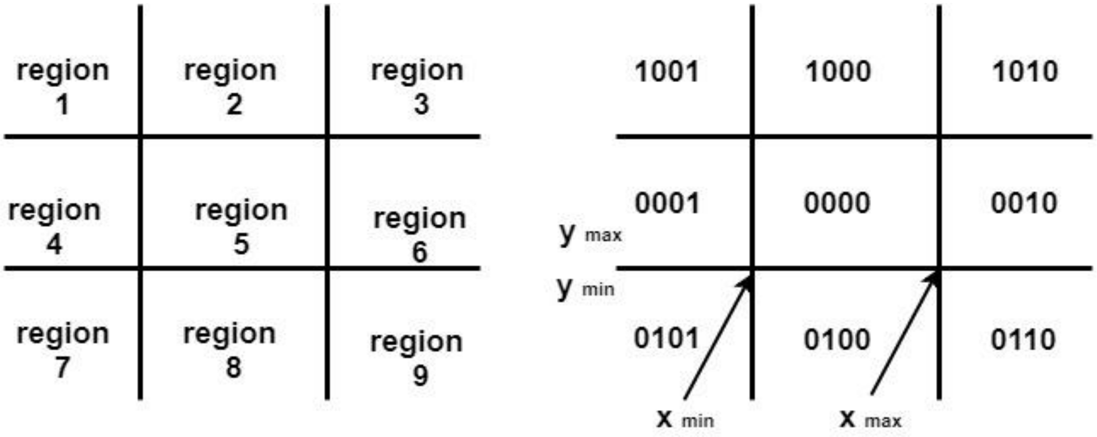


Fig 2.15 Clipping window

Cohen-Sutherland algorithm divides a two-dimensional space into 9 regions and then efficiently determines the lines and portions of lines that are inside the given rectangular area.



9 region

bits assigned to 9 regions

Fig 2.16 Nine regions of Clipping window

Set first Bit to 1 if Points lies to left of window (x < xmin)
Set second Bit to 1 if Points lies to right of window (x > xmax)
Set third Bit to 1 if Points lies to bottom of window (y < ymin)
Set fourth Bit to 1 if Points lies to top of window (y > ymax)
Order is TBRL (Top Bottom Right Left)

There are three possible cases for any given line.

1. Completely inside the given rectangle : Bitwise OR of region of two end points of line is 0 (Both points are inside the rectangle)
2. Completely outside the given rectangle : Both endpoints share at least one outside region which implies that the line does not cross the visible region. (bitwise AND of endpoints != 0).

3. Partially inside the window : Both endpoints are in different regions. In this case, the algorithm finds one of the two points that is outside the rectangular region. The intersection of the line from outside point and rectangular window becomes new corner point and the algorithm repeats

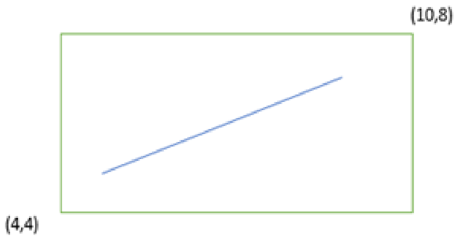
Algorithm :

```
Step1:Calculate positions of both endpoints of the line
Step2:Perform OR operation on both of these end-points
Step3:If the OR operation gives 0000 Then
            line is considered to be completely inside the window
    else
            Perform AND operation on both endpoints
        If And $\neq$ 0000
            then the line is completely outside
        else
            And=0000
            Line is partially inside
Step4:If a line is clipped case, find an intersection with boundaries of the window
            $m=(y_2-y_1)/(x_2-x_1)$
(a) If bit 1 is "1" line intersects with left boundary of rectangle window
            $y_3=y_1+m(x-X_1)$
            where $X = X_{wmin}$
            where $X_{wmin}$is the minimum value of X co-ordinate of window
(b) If bit 2 is "1" line intersect with right boundary
            $y_3=y_1+m(X-X_1)$
            where $X = X_{wmax}$
            where X more is maximum value of X co-ordinate of the window
(c) If bit 3 is "1" line intersects with bottom boundary
            $X_3=X_1+(y-y_1)/m$
                where $y = y_{wmin}$
            $y_{wmin}$ is the minimum value of Y co-ordinate of the window
(d) If bit 4 is "1" line intersects with the top boundary
            $X_{3=x}1+(y-y_1)/m$
                where $y = y_{wmax}$
            $y_{wmax}$ is the maximum value of Y co-ordinate of the window
```

Example 1:

Input : Rectangular area of interest defined by
xmin = 4, ymin = 4, xmax = 10, ymax = 8

line 1 : x1 = 5, y1 = 5, x2 = 7, y2 = 7

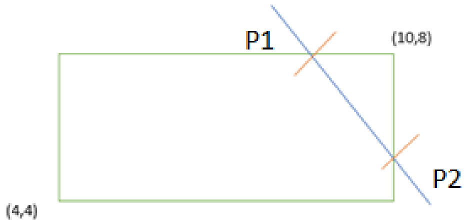


LINE LIES COMPLETELY INSIDE
ACCEPTED

Example 2 :

Input : Rectangular area of interest defined by
xmin = 4, ymin = 4, xmax = 10, ymax = 8

Line 2 : x1 = 7, y1 = 9, x2 = 11, y2 = 4



LINE LIES PARTIALLY INSIDE

To find P1 :
m = 4-9/11-7 = -5/4 = -5/4
$X_{3=x}1+(y_{max}-y_1)/m$
$Y = Y_{max}$

$X_{3=}$ 7+(8-9) * -4/5

= 7 -1 * -4/5

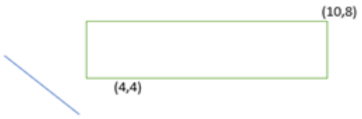
= 7+ 4/5 = 7.8

Thus X = 7.8, Y = 8

Example 3

Input : Rectangular area of interest defined by
xmin = 4, ymin = 4, xmax = 10, ymax = 8

Line 3 : x1 = 1, y1 = 5, x2 = 4, y2 = 1



LINE LIES COMPLETELY OUTSIDE

REJECTED

Advantages of line clipping

1. It will extract part we desire.
2. For identifying the visible and invisible area in the 3D object.
3. For creating objects using solid modeling.
4. For drawing operations.
5. Operations related to the pointing of an object.
6. For deleting, copying, moving part of an object.

Limitation

The algorithm is merely applicable to rectangular windows and not to the other convex shaped window.

ii) LIANG-BARSKY LINE CLIPPING

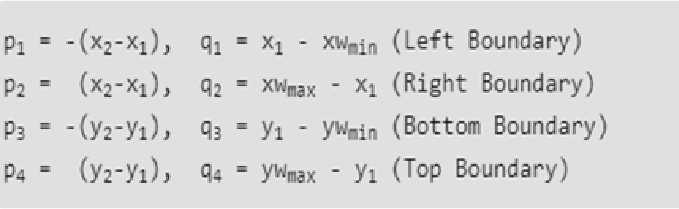
Based on analysis of parametric equation of a line segment, faster line clippers have been developed, which can be written in the form :
$x = x1 + u\,\Delta x$
$y = y1 + u\,\Delta y$ where $0 <= u <= 1$ and where $\Delta x = (x2 - x1)$ and $\Delta y = (y2 - y1)$

In the Liang-Barsky approach we first the point clipping condition in parametric form
$xwmin <= x1 + u\,\Delta x <=.\ xwmax$
$ywmin <= y1 + u\,\Delta y <= ywmax$

Each of these four inequalities can be expressed as $\mu p_k <= q_k$, k=1,2,3,4

The parameters p and q are defined as :

$p1 = -\Delta x$ $q1 = x1 - xwmin$
$p2 = \Delta x$ $q2 = xwmax - x1$
$P3 = -\Delta y$ $q3 = y1 - ywmin$
$P4 = \Delta y$ $q4 = ywmax - y1$


$p_1 = -(x_2-x_1)$, $q_1 = x_1 - xw_{min}$ (Left Boundary)
$p_2 = (x_2-x_1)$, $q_2 = xw_{max} - x_1$ (Right Boundary)
$p_3 = -(y_2-y_1)$, $q_3 = y_1 - yw_{min}$ (Bottom Boundary)
$p_4 = (y_2-y_1)$, $q_4 = yw_{max} - y_1$ (Top Boundary)

line that is parallel to one of the clipping boundaries have pk=0 for values of k corresponding to boundary k=1,2,3,4 correspond to left, right, bottom and top boundaries. For values of k, find qk

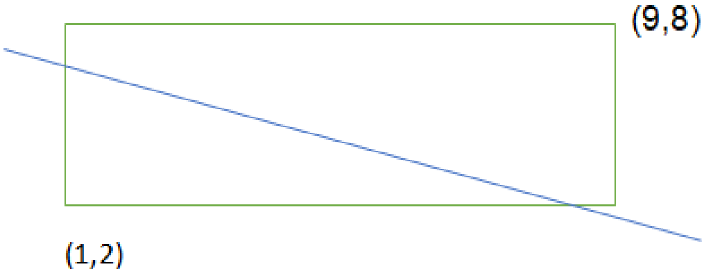
CONDITION	POSITION OF LINE
$p_k = 0$	parallel to the clipping boundaries
$p_k = 0$ and $q_k < 0$	completely outside the boundary
$p_k = 0$ and $q_k >= 0$	inside the parallel clipping boundary
$p_k < 0$	line proceeds from outside to inside
$p_k > 0$	line proceeds from inside to outside

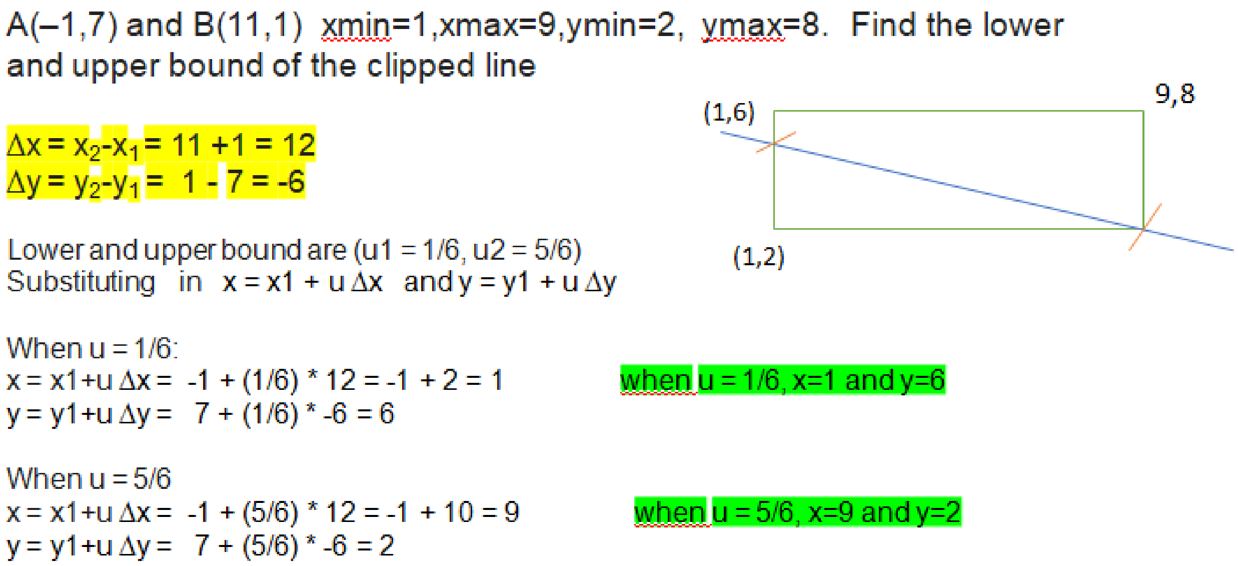
Cases of Selection :

1. $p_k = 0$
   - Line is parallel to boundaries
     - If for the same k, $q_k < 0$, reject
     - Else, accept
2. $p_k < 0$
   - Line starts outside this boundary
     - $r_k = q_k / p_k$
     - $u_1 = \max(0, r_k, u_1)$
3. $p_k > 0$
   - Line starts inside this boundary
     - $r_k = q_k / p_k$
     - $u_2 = \min(1, r_k, u_2)$
4. If $u_1 > u_2$, the line is completely outside

Example :

A line AB with end points A(–1,7) and B(11,1) is to be clipped against a rectangular window with xmin=1,xmax=9,ymin=2, ymax=8. Find the lower and upper bound of the clipped line





A(–1,7) and B(11,1) xmin=1,xmax=9,ymin=2, ymax=8. Find the lower and upper bound of the clipped line

$\Delta x = x_2 - x_1 = 11 + 1 = 12$
$\Delta y = y_2 - y_1 = 1 - 7 = -6$

Lower and upper bound are ($u1 = 1/6$, $u2 = 5/6$)
Substituting in $x = x1 + u\,\Delta x$ and $y = y1 + u\,\Delta y$

When $u = 1/6$:
$x = x1 + u\,\Delta x = -1 + (1/6) * 12 = -1 + 2 = 1$
$y = y1 + u\,\Delta y = 7 + (1/6) * -6 = 6$

when $u = 1/6$, $x=1$ and $y=6$

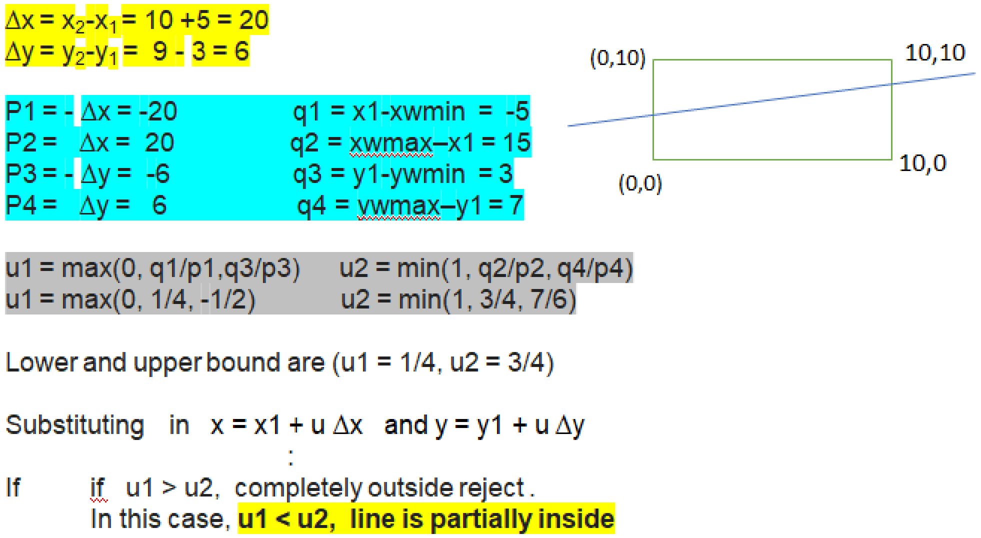
When $u = 5/6$
$x = x1 + u\,\Delta x = -1 + (5/6) * 12 = -1 + 10 = 9$
$y = y1 + u\,\Delta y = 7 + (5/6) * -6 = 2$

when $u = 5/6$, $x=9$ and $y=2$

Thus Clipped lines are (x=1, y=6) and (x=9, y=2)

Example 2

A(–5,3) and B(15,9) xmin=0, xmax=10,ymin=0,ymax=10. Find the lower and upper bound of the clipped line



$\Delta x = x_2 - x_1 = 10 + 5 = 20$
$\Delta y = y_2 - y_1 = 9 - 3 = 6$

$P1 = -\Delta x = -20$ $q1 = x1 - xwmin = -5$
$P2 = \Delta x = 20$ $q2 = xwmax - x1 = 15$
$P3 = -\Delta y = -6$ $q3 = y1 - ywmin = 3$
$P4 = \Delta y = 6$ $q4 = ywmax - y1 = 7$

$u1 = \max(0, q1/p1, q3/p3)$ $u2 = \min(1, q2/p2, q4/p4)$
$u1 = \max(0, 1/4, -1/2)$ $u2 = \min(1, 3/4, 7/6)$

Lower and upper bound are ($u1 = 1/4$, $u2 = 3/4$)

Substituting in $x = x1 + u\,\Delta x$ and $y = y1 + u\,\Delta y$
:

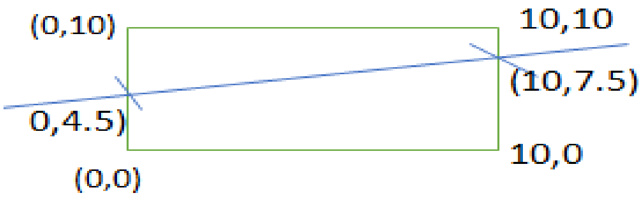
If if $u1 > u2$, completely outside reject .
In this case, **$u1 < u2$, line is partially inside**

X = -5 + ¼ * 20 = -5 + 5 = **0**

Y= 3+1/4 * 6 = 3+ 1.5 = **4.5**

X = -5 + ¾ * 20 = -5+15 = **10**

Y = 3+3/4 * 6 = 3 + 4.5 = **7.5**



Thus , the clipped points are (0,4.5 and 10,7.5)

3. POLYGON CLIPPING

An algorithm that clips a polygon is rather complex. Each edge of the polygon must be tested against each edge of the clipping window, usually a rectangle. As a result, new edges may be added, and existing edges may be discarded, retained, or divided. Multiple polygons may result from clipping a single polygon. We need an organized way to deal with all of these cases.

SUTHERLAND HODGEMAN POLYGON CLIPPING

The Sutherland and Hodgman's polygon clipping algorithm is used in this tool. This algorithm is based on a divide- and-conquer strategy that solves a series of simple and identical problems that, when combined, solve the overall problem. The simple problem is to clip a polygon against a single infinite clipping edge. This process outputs the series of vertices that define the clipped polygon. Four clipping edges, each defining one boundary of the clipping window, are used to successively to fully clip the polygon.

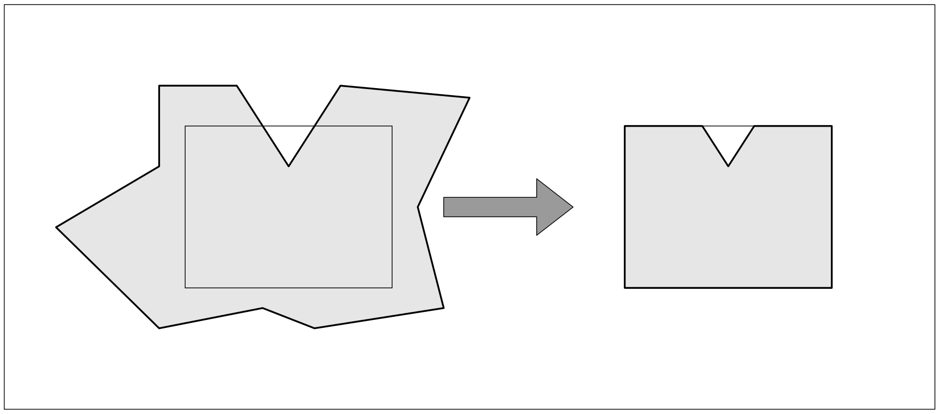
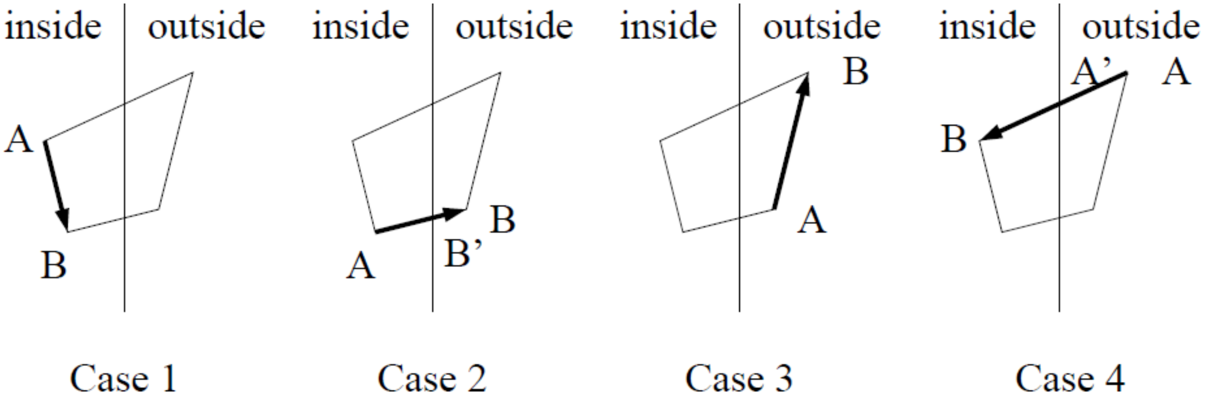


Fig 2.17 Area clipping

How to clip against an edge of clipping area?

1. **Both vertices are inside :** Only the second vertex is added to the output list
2. **First vertex is outside while second one is inside :** Both the point of intersection of the edge with the clip boundary and the second vertex are added to the output list
3. **First vertex is inside while second one is outside :** Only the point of intersection of the edge with the clip boundary is added to the output list

4. **Both vertices are outside :** No vertices are added to the output list



Case 1 Case 2 Case 3 Case 4

Fig 2.18 Cases of Polygon clipping

Assuming vertex A has already been processed,

Case 1 — vertex B is added to the output list

Case 2 — vertex B’ is added to the output (edge AB is clipped to AB’) Case

Case 3 — no vertex added (segment AB is clipped out)

Case 4 – Vertices A’ and B’ are added to the output

SamplePolygon **After Clipping**

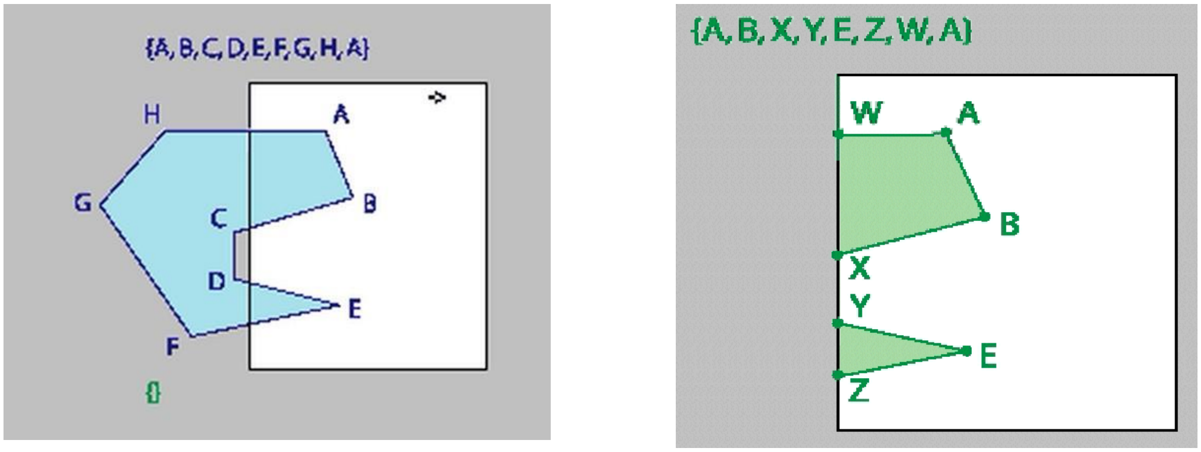


Fig 2.19 Polygon Clipping

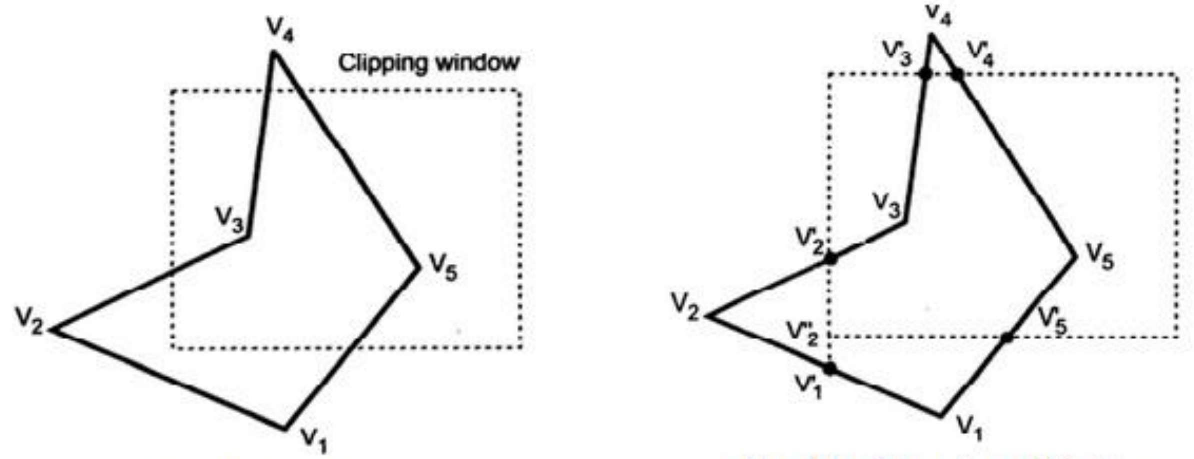


Fig. Before Clipping

Fig. After Boundary Clipping

After left clipping : $V_1, V_1', V_2', V_3, V_4, V_5$

After right clipping : $V_1, V_1', V_2', V_3, V_4, V_5$

After top clipping : $V_1, V_1', V_2', V_3, V_3', V_4', V_5$

After bottom clipping : $V_2'', V_2', V_3, V_3', V_4', V_5, V_5'$

Fig 2.20 Example for Polygon Clipping

Drawback of Sutherland Hodgeman Algorithm:

Clipping of the concave polygon ◎Can produce two CONNECTED areas

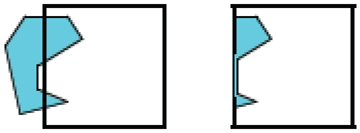


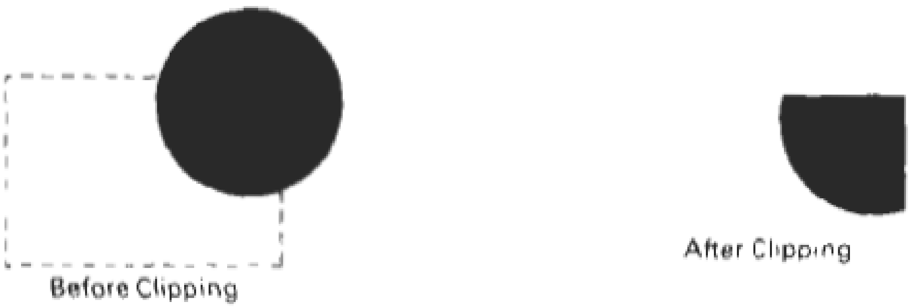
Fig 2.21 Connected polygons

5. Curve Clipping

Curve Clipping involves complex procedures as compared to line clipping. Curve clipping requires more processing than for object with linear boundaries. Consider window which is rectangular in shape. The circle is to consider against rectangle window.

If circle is completely inside boundary of the window, it is considered visible. So save the circle. If a circle is in outside window, discard it. If circle cut the boundary then consider it to be clipping case.

The below figure illustrates circle clipping against a rectangular window. On the first pass, we can clip the bounding rectangle of the object against the bounding rectangle of the clip region. If the two regions overlap, we will need to solve the simultaneous line-curve equations to obtain the clipping intersection points


Before Clipping

After Clipping

Fig 2.21 Curve Clipping

Exterior Clipping

It is opposite to previous clipping. Here picture which is outside the window is considered. The picture inside the rectangle window is discarded. So part of the picture outside the window is saved.

Uses of Exterior Clipping:

1. It is used for displaying properly the pictures which overlap each other.
2. It is used in the concept of overlapping windows.
3. It is used for designing various patterns of pictures.
4. It is used for advertising purposes.
5. It is suitable for publishing.
6. For designing and displaying of the number of maps and charts, it is also used.

5.TEXT CLIPPING

Various techniques are used to provide text clipping in a computer graphics. It depends on the methods used to generate characters and the requirements of a particular application. There are three methods for text clipping which are listed below −

- All or none string clipping
- All or none character clipping
- Text clipping

The following figure shows all or none string clipping −

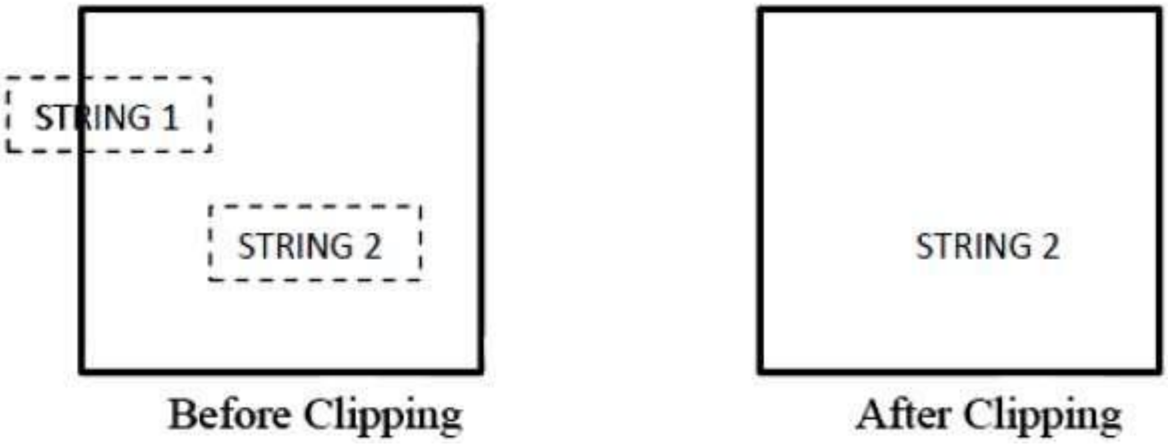


Fig 2.22 Text Clipping Example -1

In all or none string clipping method, either we keep the entire string or we reject entire string based on the clipping window. As shown in the above figure, STRING2 is entirely inside the clipping window so we keep it and STRING1 being only partially inside the window, we reject.

The following figure shows all or none character clipping −

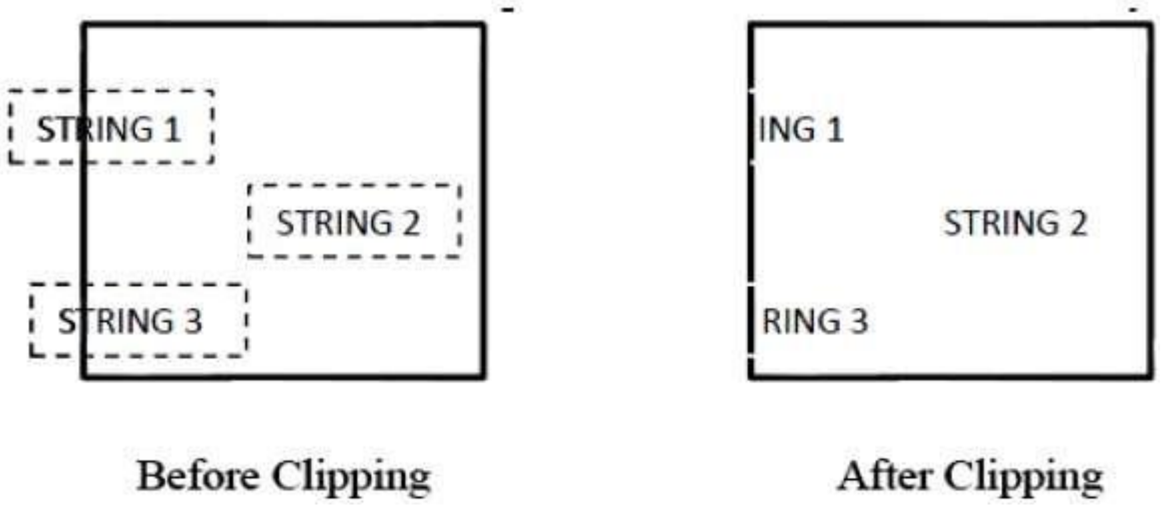


Fig 2.23 Text Clipping Example -2

This clipping method is based on characters rather than entire string. In this method if the string is entirely inside the clipping window, then we keep it. If it is partially outside the window, then −

- You reject only the portion of the string being outside
- If the character is on the boundary of the clipping window, then we discard that entire character and keep the rest string.

The following figure shows text clipping −

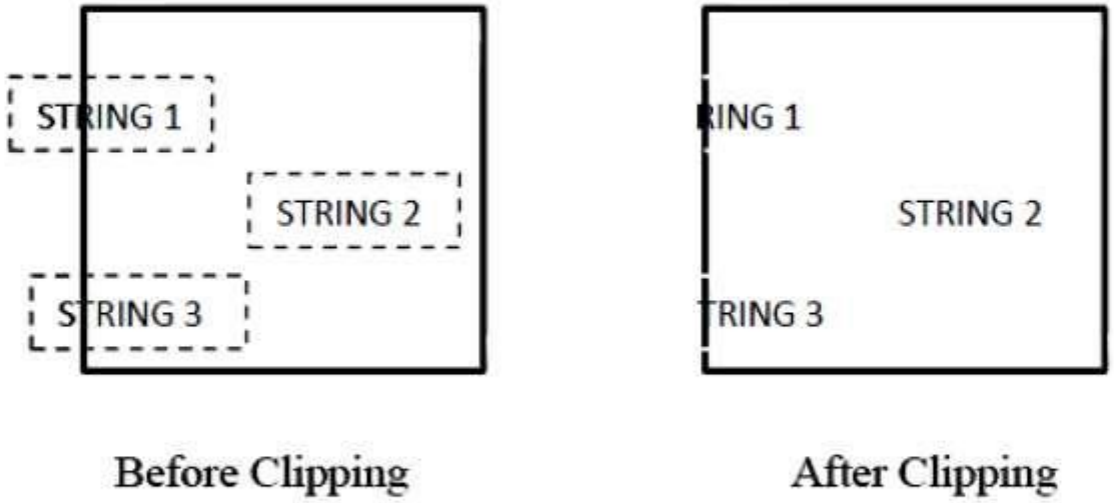


Fig 2.24 Text Clipping Example -3

This clipping method is based on characters rather than the entire string. In this method if the string is entirely inside the clipping window, then we keep it. If it is partially outside the window, then

- You reject only the portion of string being outside.
- If the character is on the boundary of the clipping window, then we discard only that portion of character that is outside of the clipping window.

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SCHOOL OF COMPUTING

DEPARTMENT OF COMPUTER SCIENCE

UNIT – III – Computer Graphics and Multimedia – SBS1303

Three Dimensional Concepts - 3D Geometric and Modeling Transformations – Three-Dimensional Viewing - Visible-Surface Detection Methods: Back-Face Detection - Depth-Buffer Method -Scan Line Method - A-Buffer Method-Depth Sorting Method-BSP Tree Method-Area Subdivision Method.

THREE DIMENSIONAL TRANSFORMATIONS

Basic Transformations:

1.Translation
2.Rotation
3.Scaling

Other Transformations:

1.Reflection
2.Shearing

1. Translation

A translation in space is described by tx, ty and tz. It is easy to see that this matrix realizes the equations:

x2=x1+tx
y2=y1+ty
z2=z1+tz

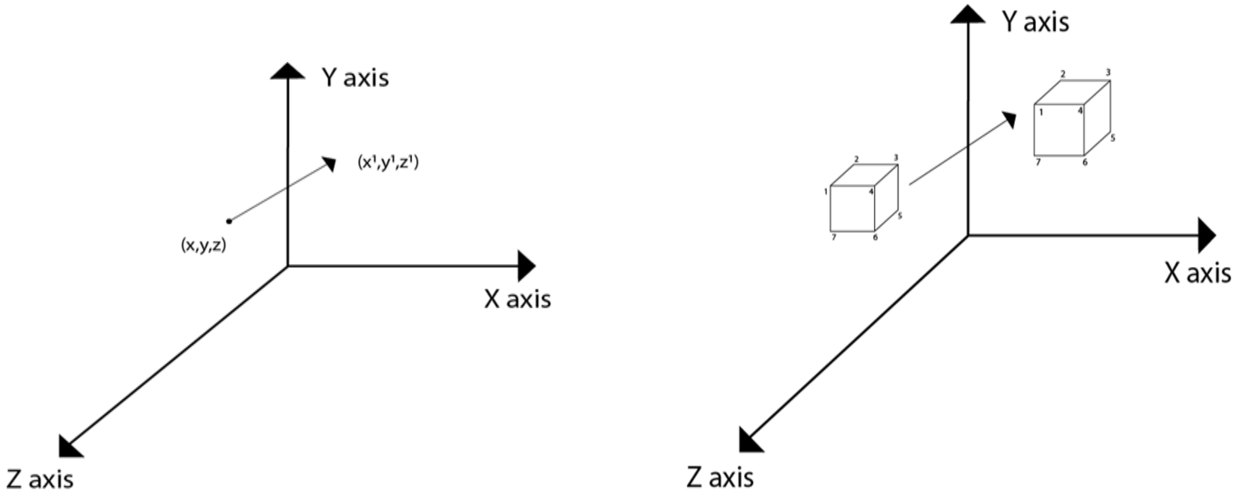


Fig. 3.1 Example for Translation

Matrix for Translation

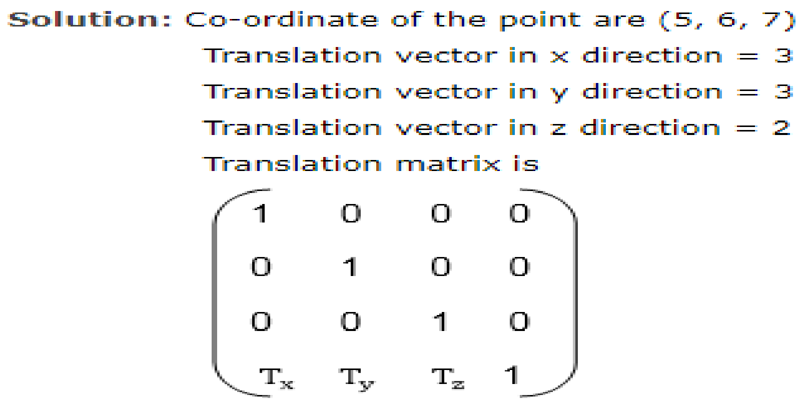
$$\begin{Bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ T_x & T_y & T_z & 1 \end{Bmatrix} \text{ or } \begin{Bmatrix} 1 & 0 & 0 & T_x \\ 0 & 1 & 0 & T_y \\ 0 & 0 & 1 & T_z \\ 0 & 0 & 0 & 1 \end{Bmatrix}$$

A point P(x,y,z) after translation will be P'(X',Y',Z') :

$$\begin{bmatrix} x^1 \\ y^1 \\ z^1 \\ 1 \end{bmatrix} = \begin{pmatrix} 1 & 0 & 0 & T_x \\ 0 & 1 & 0 & T_y \\ 0 & 0 & 1 & T_z \\ 0 & 0 & 0 & 1 \end{pmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

Example :

A point has coordinates in the x, y, z direction i.e., (5, 6, 7). The translation is done in the x-direction and y direction by 3 coordinate. Three coordinates and in the z- direction by two coordinates. Shift the object. Find coordinates of the new position.



Solution: Co-ordinate of the point are (5, 6, 7)

Translation vector in x direction = 3

Translation vector in y direction = 3

Translation vector in z direction = 2

Translation matrix is

$$\begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ T_x & T_y & T_z & 1 \end{pmatrix}$$

Multiply co-ordinates of point with translation matrix:

$$(x^1 y^1 z^1) = (5,6,7,1) \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 3 & 3 & 2 & 1 \end{pmatrix} \quad = 8 \; 9 \; 9 \; 1$$

Thus x ‘ = 8
y’ = 9
z’ = 9

2. Rotation

3D rotation is not same as 2D rotation. In 3D rotation, we have to specify the angle of rotation along with the axis of rotation. We can perform 3D rotation about X, Y, and Z axes. They are represented in the matrix form as below :

$$R_x(\theta) = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & cos\theta & -sin\theta & 0 \\ 0 & sin\theta & cos\theta & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} R_y(\theta) = \begin{bmatrix} cos\theta & 0 & sin\theta & 0 \\ 0 & 1 & 0 & 0 \\ -sin\theta & 0 & cos\theta & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}.$$

$$R_z(\theta) = \begin{bmatrix} cos\theta & -sin\theta & 0 & 0 \\ sin\theta & cos\theta & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

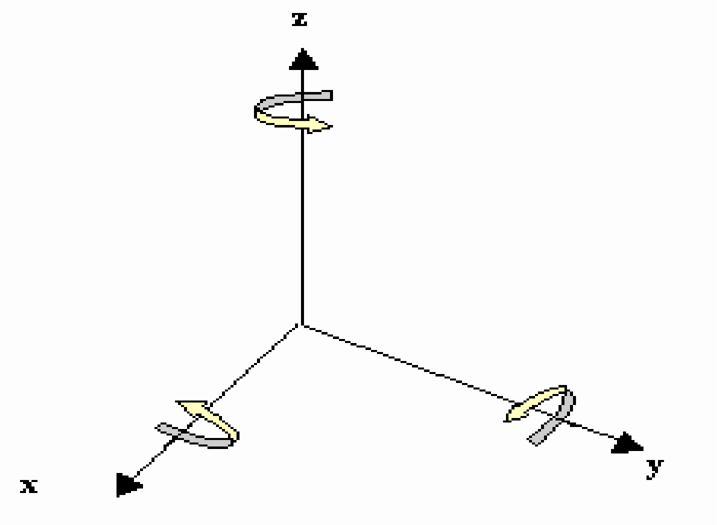


Fig. 3. 2 Rotation representation

Example 1 :

Given a homogeneous point (1, 2, 3). Apply rotation 90 degree towards X, Y and Z axis and find out the new coordinate points.

Coordinates : (1, 2,3) , Angle : 90^0

Rotation along X-axis :

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & cos\theta & -sin\theta & 0 \\ 0 & sin\theta & cos\theta & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{vmatrix} 1 \\ 2 \\ 3 \\ 1 \end{vmatrix} = \begin{vmatrix} 1 & 0 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{vmatrix} \begin{vmatrix} 1 \\ 2 \\ 3 \\ 1 \end{vmatrix} = \begin{vmatrix} 1 \\ -3 \\ 2 \\ 0 \end{vmatrix}$$

The new transformed points are : (1, -3, 2)

Example 2 :

Coordinates : (1, 2,3) , Angle : 90^0

Rotation along Y-axis :

$$\begin{bmatrix} cos\theta & 0 & sin\theta & 0 \\ 0 & 1 & 0 & 0 \\ -sin\theta & 0 & cos\theta & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} * \begin{vmatrix} 1 \\ 2 \\ 3 \\ 1 \end{vmatrix} = \begin{vmatrix} 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 0 \\ -1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{vmatrix} \begin{vmatrix} 1 \\ 2 \\ 3 \\ 1 \end{vmatrix} = \begin{vmatrix} 3 \\ 2 \\ -1 \\ 0 \end{vmatrix}$$

The new transformed points are : (3, 2, -1)

Example 3 :

Coordinates : (1, 2,3) , Angle : 90^0

Rotation along Z-axis :

$$\begin{bmatrix} cos\theta & -sin\theta & 0 & 0 \\ sin\theta & cos\theta & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} * \begin{vmatrix} 1 \\ 2 \\ 3 \\ 1 \end{vmatrix} = \begin{vmatrix} 0 & -1 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 \end{vmatrix} \begin{vmatrix} 1 \\ 2 \\ 3 \\ 1 \end{vmatrix} = \begin{vmatrix} -2 \\ 1 \\ 3 \\ 0 \end{vmatrix}$$

The new transformed points are : (-2, 1, 3)

3. Scaling

We can change the size of an object using scaling transformation. In the scaling process, you either expand or compress the dimensions of the object. Scaling can be achieved by multiplying the original coordinates of the object with the scaling factor to get the desired result.

In 3D scaling operation, three coordinates are used. Let us assume that the original coordinates are (X, Y, Z), scaling factors are (S_x,S_y,S_z) respectively, and the produced coordinates are (X', Y', Z'). This can be mathematically represented as shown below:

$$S = \begin{bmatrix} S_x & 0 & 0 & 0 \\ 0 & S_y & 0 & 0 \\ 0 & 0 & S_z & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$P' = P \cdot S$$

$$[X' \quad Y' \quad Z' \quad 1] = [X \quad Y \quad Z \quad 1] \begin{bmatrix} S_x & 0 & 0 & 0 \\ 0 & S_y & 0 & 0 \\ 0 & 0 & S_z & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$= [X.\,S_x \quad Y.\,S_y \quad Z.\,S_z \quad 1]$$

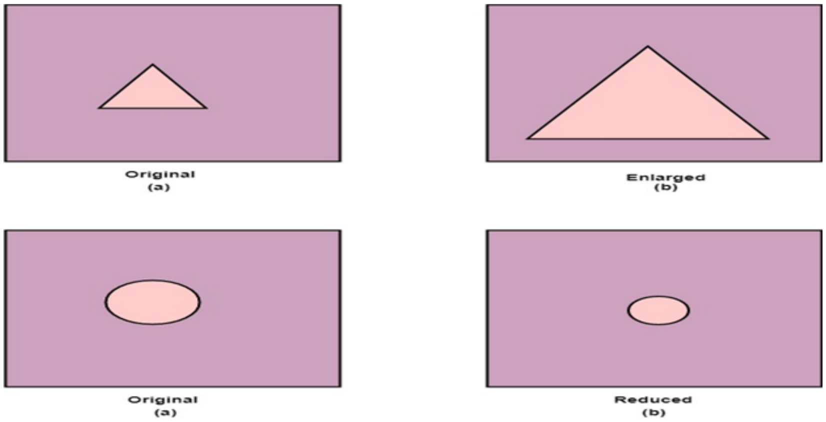


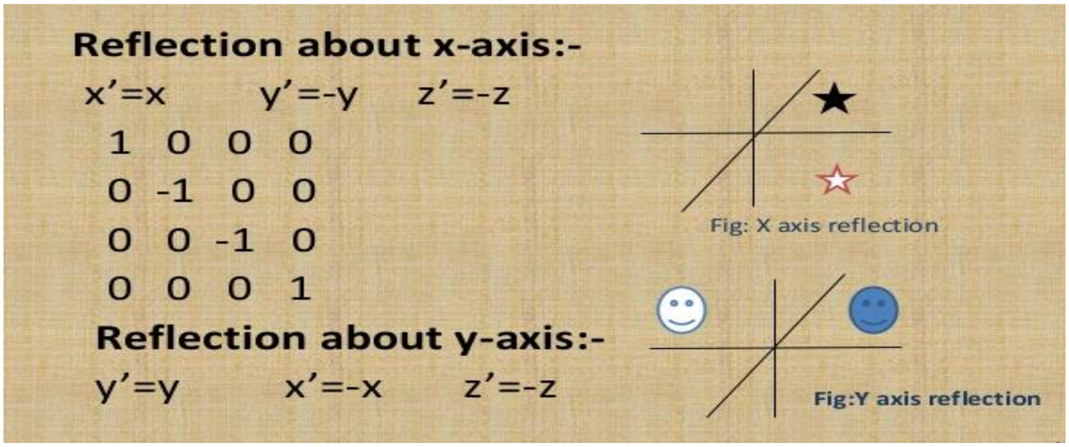
Fig. 3. 3 Scaling

Reflection

A transformation that gives the mirror image of the object.

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

We can mirror the different planes by using scaling factor -1 on the axis that is placed normally on the plane. Notice the matrix to the left. It mirrors around the xy-plane, and changes the coordinates from a right hand system to a left handsystem.



Reflection about x-axis:-

x'=x y'=-y z'=-z

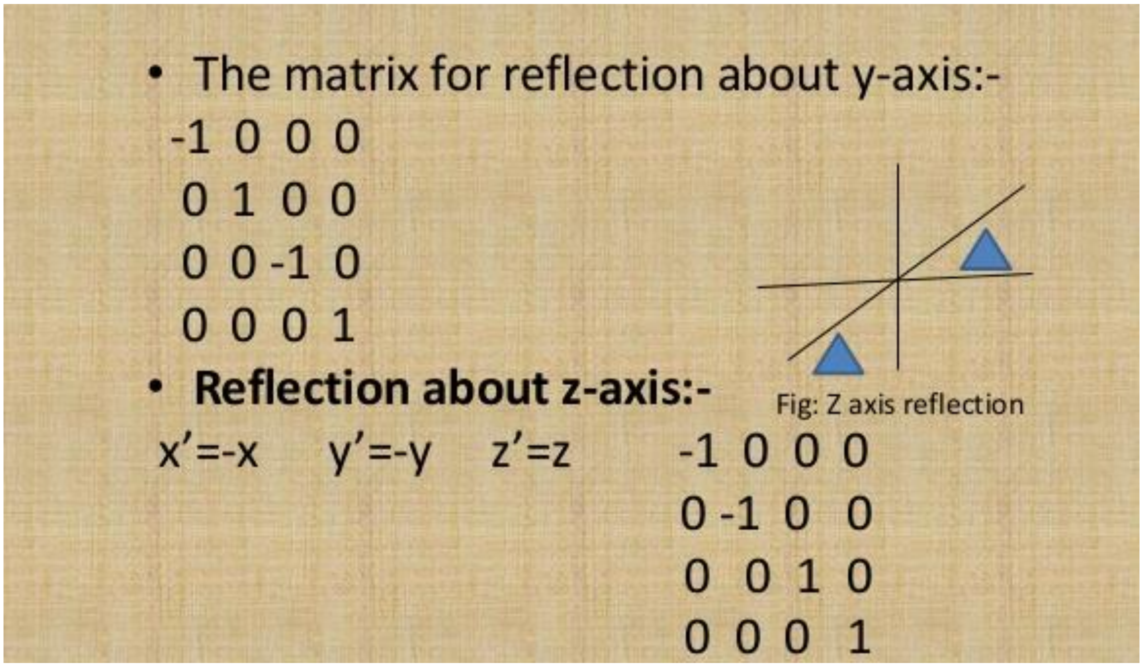
$$\begin{matrix} 1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 1 \end{matrix}$$

Fig: X axis reflection

Reflection about y-axis:-

y'=y x'=-x z'=-z

Fig:Y axis reflection



- The matrix for reflection about y-axis:-

$$\begin{matrix} -1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 1 \end{matrix}$$

- **Reflection about z-axis:-**

$x'=-x \quad y'=-y \quad z'=z$

$$\begin{matrix} -1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{matrix}$$

Fig: Z axis reflection

Shear

A transformation that slants the shape of an object is called the shear transformation. Like in 2D shear, we can shear an object along the X-axis, Y-axis, or Z-axis in 3D.

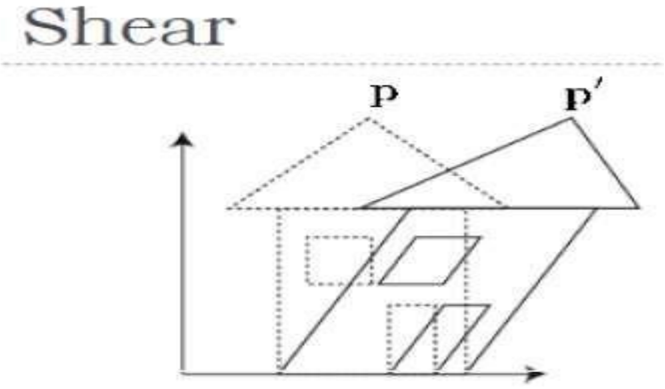


Fig. 3. 4 Shearing

As shown in the above figure, there is a coordinate P. You can shear it to get a new coordinate P', which can be represented in 3D matrix form as below

$$Sh = \begin{bmatrix} 1 & sh_x^y & sh_x^z & 0 \\ sh_y^x & 1 & sh_y^z & 0 \\ sh_z^x & sh_z^y & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\mathrm{P}' = \mathrm{P} \cdot \mathrm{Sh}$$

$$X' = X + Sh_x^y Y + Sh_x^z Z$$

$$Y' = Sh_y^x X + Y + sh_y^z Z$$

$$Z' = Sh_z^x X + Sh_z^y Y + Z$$

Problems

i) Given a 3D object with coordinate points A(0, 3, 3), B(3, 3, 6), C(3, 0, 1), D(0, 0, 0). Apply the scaling parameter 2 towards X axis, 3 towards Y axis and 3 towards Z axis and obtain the new coordinates of the object.

Solution-

Given :

Old coordinates of the object = A (0, 3, 3), B(3, 3, 6), C(3, 0, 1), D(0, 0, 0)
Scaling factor along X axis = 2
Scaling factor along Y axis = 3
Scaling factor along Z axis = 3

Coordinates of the object = A (0, 3, 3), B(3, 3, 6), C(3, 0, 1), D(0, 0, 0)

For Coordinates A(0, 3, 3)

Let the new coordinates of A after scaling = (X_{new}, Y_{new}, Z_{new}).

Applying the scaling equations, we have-

$X_{new} = X_{old} \times S_x = 0 \times 2 = 0$
$Y_{new} = Y_{old} \times S_y = 3 \times 3 = 9$
$Z_{new} = Z_{old} \times S_z = 3 \times 3 = 9$

Thus, New coordinates of corner A after scaling = (0, 9, 9).

For Coordinates B(3, 3, 6)

Let the new coordinates of B after scaling = (X_{new}, Y_{new}, Z_{new}).

Applying the scaling equations, we have-

$X_{new} = X_{old} \times S_x = 3 \times 2 = 6$
$Y_{new} = Y_{old} \times S_y = 3 \times 3 = 9$
$Z_{new} = Z_{old} \times S_z = 6 \times 3 = 18$

Thus, New coordinates of corner B after scaling = (6, 9, 18).

For Coordinates C(3, 0, 1) :

Let the new coordinates of C after scaling = (X_{new}, Y_{new}, Z_{new}).

Applying the scaling equations, we have-
$X_{new} = X_{old} \times S_x = 3 \times 2 = 6$
$Y_{new} = Y_{old} \times S_y = 0 \times 3 = 0$
$Z_{new} = Z_{old} \times S_z = 1 \times 3 = 3$

Thus, New coordinates of corner C after scaling = (6, 0, 3).

For Coordinates D(0, 0, 0)

Let the new coordinates of D after scaling = (X_{new}, Y_{new}, Z_{new}).

Applying the scaling equations, we have-
$X_{new} = X_{old} \times S_x = 0 \times 2 = 0$
$Y_{new} = Y_{old} \times S_y = 0 \times 3 = 0$
$Z_{new} = Z_{old} \times S_z = 0 \times 3 = 0$

Thus, New coordinates of corner D after scaling = (0, 0, 0).

Example ii) Given a 3D object with coordinate points A(0, 3, 1), B(3, 3, 2), C(3, 0, 0), D(0, 0, 0). Apply the translation with the distance 1 towards X axis, 1 towards Y axis and 2 towards Z axis and obtain the new coordinates of the object.

Solution-

Given-

Old coordinates of the object = A (0, 3, 1), B(3, 3, 2), C(3, 0, 0), D(0, 0, 0)

Translation vector = (T_x, T_y, T_z) = (1, 1, 2)

For Coordinates A(0, 3, 1) :

Let the new coordinates of A = (X_{new}, Y_{new}, Z_{new}).

Applying the translation equations, we have-

$X_{new} = X_{old} + T_x = 0 + 1 = 1$
$Y_{new} = Y_{old} + T_y = 3 + 1 = 4$
$Z_{new} = Z_{old} + T_z = 1 + 2 = 3$

Thus, New coordinates of **A = (1, 4, 3).**

For Coordinates B(3, 3, 2) :

Let the new coordinates of B = (X_{new}, Y_{new}, Z_{new}).

Applying the translation equations, we have-
$X_{new} = X_{old} + T_x = 3 + 1 = 4$
$Y_{new} = Y_{old} + T_y = 3 + 1 = 4$
$Z_{new} = Z_{old} + T_z = 2 + 2 = 4$

Thus, New coordinates of B = (4, 4, 4).

For Coordinates C(3, 0, 0) :

Let the new coordinates of C = (X_{new}, Y_{new}, Z_{new}).

Applying the translation equations, we have-
$X_{new} = X_{old} + T_x = 3 + 1 = 4$
$Y_{new} = Y_{old} + T_y = 0 + 1 = 1$
$Z_{new} = Z_{old} + T_z = 0 + 2 = 2$

Thus, New coordinates of C = (4, 1, 2).

For Coordinates D(0, 0, 0) :

Let the new coordinates of D = (X_{new}, Y_{new}, Z_{new}).

Applying the translation equations, we have-
$X_{new} = X_{old} + T_x = 0 + 1 = 1$
$Y_{new} = Y_{old} + T_y = 0 + 1 = 1$
$Z_{new} = Z_{old} + T_z = 0 + 2 = 2$

Thus, New coordinates of D = (1, 1, 2).
Thus, New coordinates of the object **= A (1, 4, 3), B(4, 4, 4), C(4, 1, 2), D(1, 1, 2).**

THREE DIMENSIONAL VIEWING

- ParallelProjection
- PerspectiveProjection
- DepthCueing
- Visible Line and SurfaceIdentification
- SurfaceRendering
- Exploded and CutawayViews
- Three-Dimensional and Stereoscopic Views

Parallel Projection

In this method a view plane is used. z co-ordinate is discarded. The 3 d view is constructed by extending lines from each vertex on the object until they intersect the view plane. Then connect the projected vertices by line segments which correspond to connections on the original object.

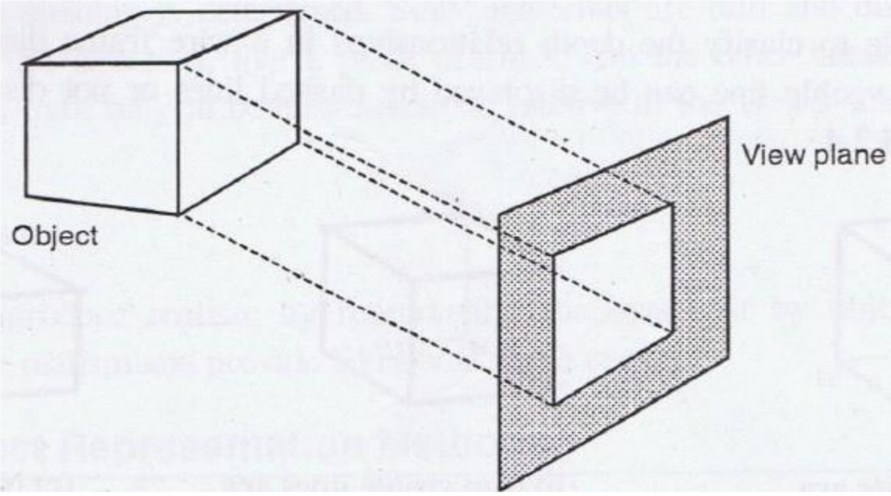


Fig. 3. 5 Parallel Projection

Perspective Projection

Here the lines of projection are not parallel. Instead, they all converge at a single point called the`center of projection' or `projection reference point'. The object positions are transformed to the view plane along these converged projection lines. In this method, Objects farther from the viewing position appear smaller.

- Perspective projection is located as a finite point whereas Parallel projection is located at infinite points.
- Perspective projection form a realistic picture of object whereas Parallel projection do not form realistic view of object.
- Perspective projection can not preserve the relative proportion of an object whereas Parallel projection can preserve the relative proportion of an object.
- Perspective projection represents the object in three dimensional way whereas Parallel projection projection represents the object in a different way like telescope.
- The lines of perspective projection are not parallel whereas The lines of parallel projection are parallel.

- Perspective projection can not give the accurate view of object whereas Parallel projection projection can give the accurate view of object

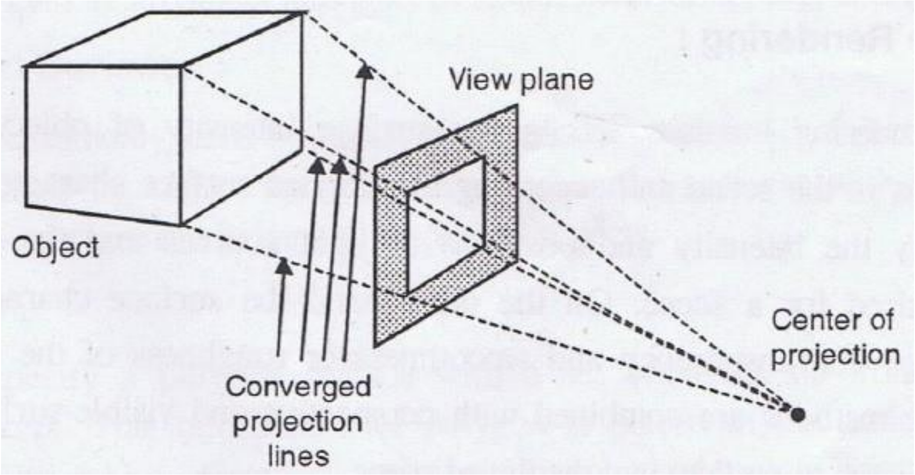


Fig. 3.6 Perspective Projection

Depth Cueing

Depth information is added. The depth of an object can be represented by the intensity of the image. The parts of the objects closest to the viewing position are displayed with the highest intensities. Objects farther away are displayed with decreasing intensities.

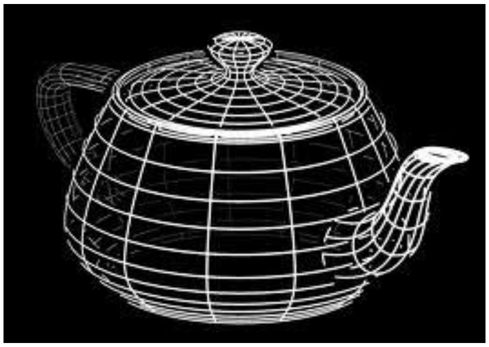
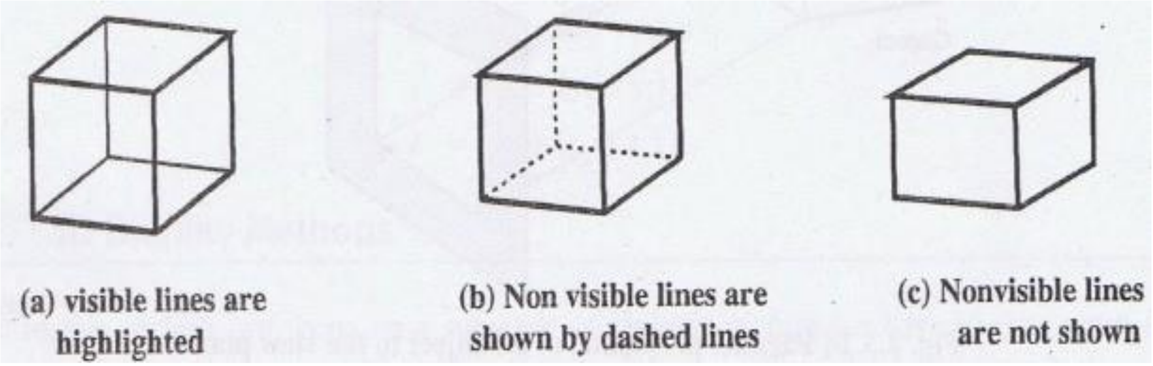


Fig. 3.7 Depth Cueing

Visible Line and Surface Identification

Visible lines are displayed in different color. Invisible lines either displayed in dashed lines or not at all displayed. Removing invisible lines also removes the info about the backside of the object. Surface rendering can be applied for the visible surfaces, so that hidden surfaces will become obscured.


(a) visible lines are highlighted

(b) Non visible lines are shown by dashed lines

(c) Nonvisible lines are not shown

Fig. 3.7 Visible surface identification

Surface Rendering

Surface intensity of objects will be according to the lighting conditions in the scene and according to assigned surface characteristics. This method is usually combined with the previous method to attain a degree of realism.

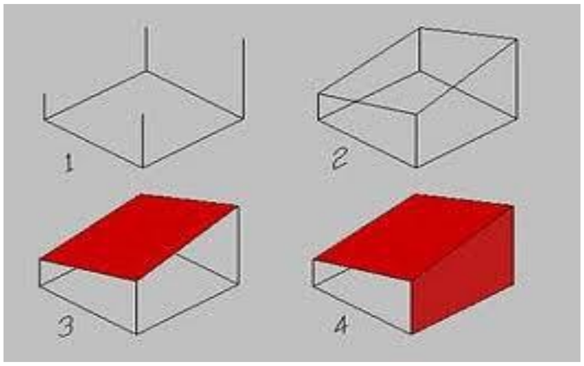


Fig. 3.8 Surface Rendering

Exploded and Cutaway Views

To show the internal details, we can define the object in hierarchical structure

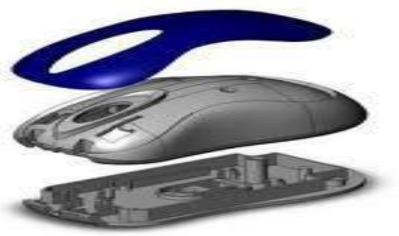


Fig. 3.7 Exploded View

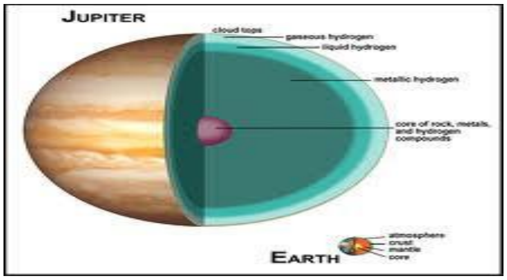


Fig. 3.8 Cutaway View

VISIBLE SURFACE DETECTION METHODS

Introduction

- To generate realistic graphicsdisplays.
- Todeterminewhatisvisiblewithinascenefromachosen viewingposition.
- For3Dworlds,thisisknownasvisiblesurfacedetectionorhiddensurfaceelimination.
- So many methods and algorithms areavailable.
- Some require more memory space, some require more processingtime.
- Which method? For which application? Depends on which object to be displayed, available equipment, complexity of the scene,etc..

Basic classification

Two basic classifications –based on either an object or projected image , which is going to be displayed

- **Object-space Methods :**

  This method compares objects and parts of objects to each other within a scene definition to determine which surfaces are visible
- **Image-space Methods :**
  In this method visibility is determined point-by point a each pixel position on the projection plane.
- **Image-space Method** is the most commonly used method

1. Back-face detection

This method adopts Object Space Method. This algorithm is used find the back faces of a polyhedron.

Consider a polygon surface with parameters A,B,C and D.

A point (x,y,z) is inside the polyhedrons' backface only if

$$Ax+By+Cz+D < 0$$

A fast and simple object-space method for identifying the back faces of a polyhedron is based on the "**inside-outside**" tests.

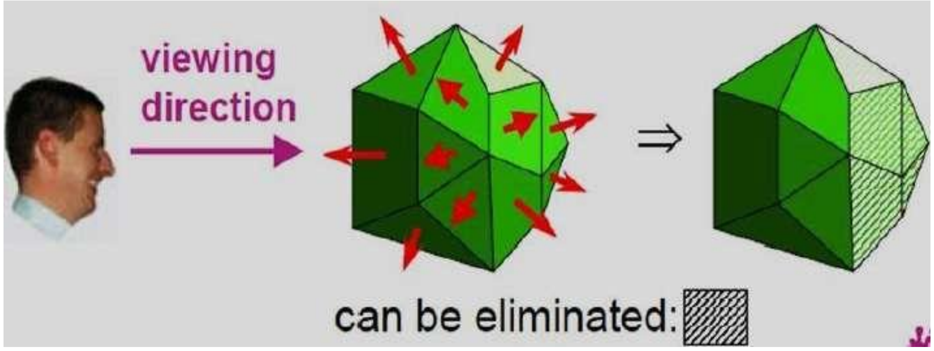


Fig. 3.9 Inside-outside Test

We can simply say that the z component of the polygon's normal is less than zero, then the point is on the back face.

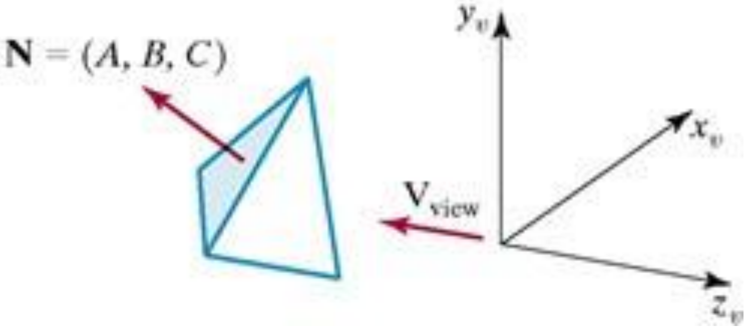


Fig. 3.10 Back face Detection

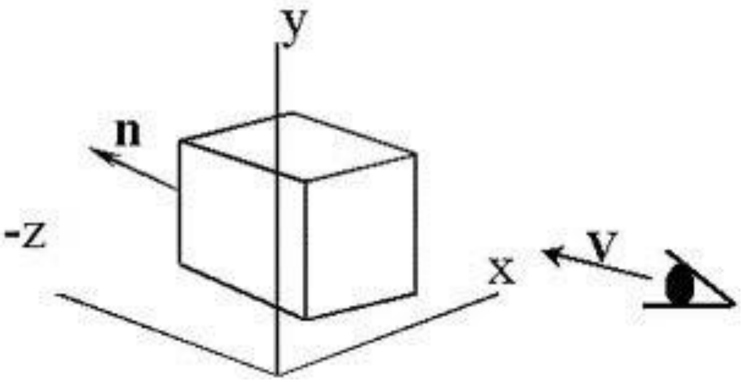


Fig. 3.11 Back face Detection from a given view plane

If we take V as the vector in the viewing direction from the eye and N as the normal vector on the polygon’s surface, then we can state the condition as :

$V.N>0$, then that face is the back face.

- It eliminates about half of the polygon surfaces in a scene from further visibility tests.

2. Depth buffer method or z-buffer method

- It adopts Image SpaceMethod.
- Compares surface depths at each pixel position throughout the scene on the projection plane.
- It is usually applied to images containing polygons.
- Very fast method

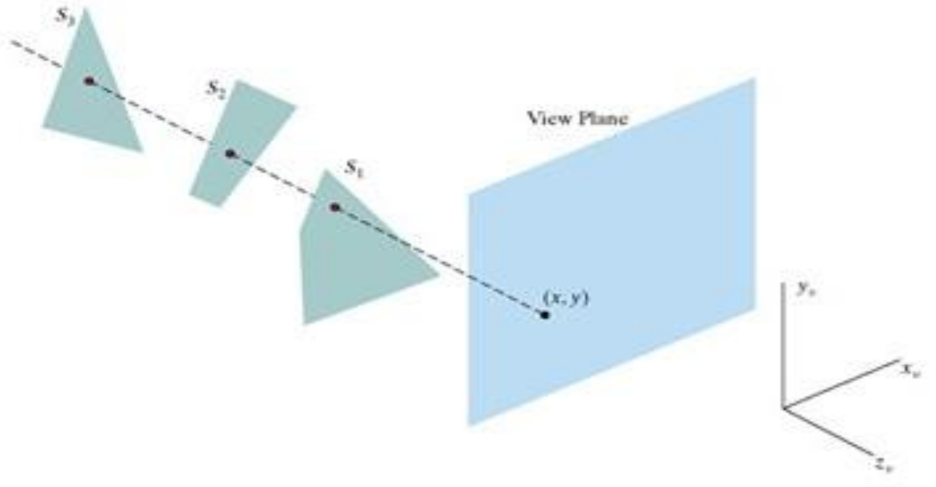


Fig. 3.11 Depth Buffer

The depth-buffer algorithm proceeds by starting at the top vertex of the polygon. Then we recursively calculate the *x*-coordinate values down a left edge of the polygon. The *x* value for the beginning position on each scan line can be calculated from the previous one using the formula given below :

$$z = \frac{-Ax - By - D}{C}$$

$$z' = \frac{-A(x+1) - By - D}{C}$$

The depth-buffer algorithm proceeds by starting at the top vertex of the polygon. Then we recursively calculate the *x*-coordinate values down a left edge of the polygon. The *x* value for the beginning position on each scan line can be calculated from the previous one using the formula given below :

Depth buffer algorithm :

```
Step-1 :   Set the buffer values
               Depthbuffer x,y = 0
               Framebuffer x,y= background color

Step-2 − Process each polygon one at a time
           For each projected x,y pixel position of a polygon, calculate depth z.
           If Z > depthbuffer x,y :
               Compute surface color,
               set depthbuffer x,y = z,
               framebuffer x,y = surfacecolor x,y
```

The depth-buffer algorithm proceeds by starting at the top vertex of the polygon.
Then we recursively calculate the *x*-coordinate values down from left edge of the polygon
The *x* value for the beginning position on each scan line can be calculated
from the previous one.

Advantages:

- It is easy to implement.
- It reduces the speed problem if implemented in hardware.
- It processes one object at a time

Drawbacks

- It requires large memory.
- It is time consuming process.

3. A-buffer Algorithm

It is the extension of Depth-buffer ->**accumulationbuffer(A-Buffer - A-** Antialiased, Area-averaged, Accumulation –Buffer)

Drawback of Depth-buffer algorithm :
Can find one visible surface at each pixel position.
Cannot accumulate intensity values for more than one surface.

Each buffer position can reference a linked-list Each position has 2 fields.

Depth field – stores a positive or negative real number
Intensity field- stores surface intensity information or a pointer value.

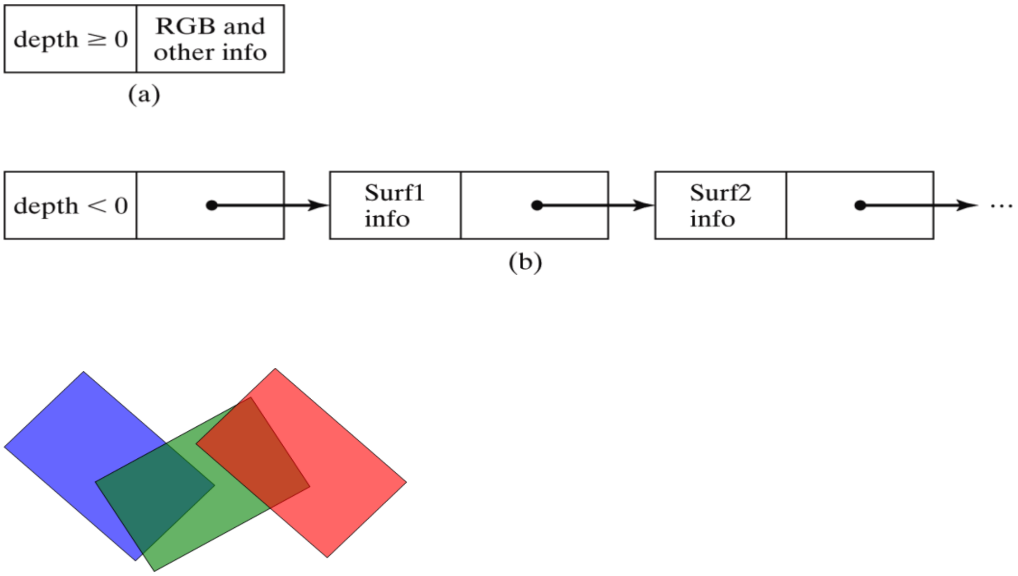


Fig. 3.12 A –Buffer

If **depth >= 0,** the number stored at that position is the depth of a single surface overlapping the corresponding pixel area. The intensity field then stores the RGB components of the surface color at that point and the percent of pixel coverage.

If **depth < 0**, it indicates multiple-surface contributions to the pixel intensity. The intensity field then stores a pointer to a linked list of surface data. The surface buffer in the A-buffer includes :

- RGB intensity components
- Opacity Parameter
- Depth
- Percent of area coverage
- Surface identifier

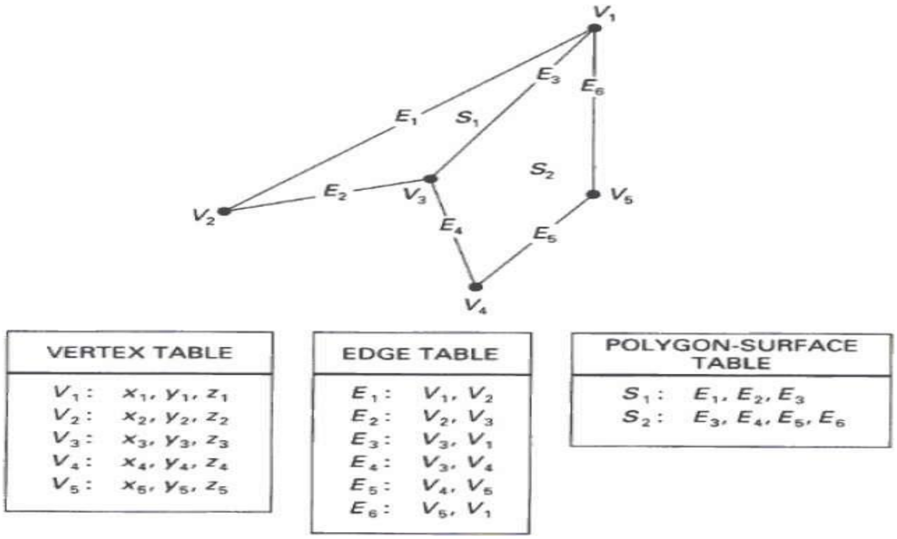
The algorithm proceeds just like the depth buffer algorithm. The **depth and opacity values** are used to determine the **final color of a pixel.**

4. Scan-line method

It is an image-space method to identify visible surface. This method has a depth information for only single scan-line. In order to require one scan-line of depth values, we must group and process all polygon intersecting a given scan-line at the same time before processing the next scan-line.

Two important tables, **edge table** and **polygon table,** are maintained for this.

- **The Edge Table** − It contains coordinate endpoints of each line in the scene, the inverse slope of each line, and pointers into the polygon table to connect edges to surfaces.
- **The Polygon Table** − It contains the plane coefficients, surface material properties, other surface data, and may be pointers to the edge table.



VERTEX TABLE	
V_1 :	x_1, y_1, z_1
V_2 :	x_2, y_2, z_2
V_3 :	x_3, y_3, z_3
V_4 :	x_4, y_4, z_4
V_5 :	x_5, y_5, z_5

EDGE TABLE	
E_1 :	V_1, V_2
E_2 :	V_2, V_3
E_3 :	V_3, V_1
E_4 :	V_3, V_4
E_5 :	V_4, V_5
E_6 :	V_5, V_1

POLYGON-SURFACE TABLE	
S_1 :	E_1, E_2, E_3
S_2 :	E_3, E_4, E_5, E_6

Fig. 3.13 Vertex Table, Edge Table and Polygon-Surface Table

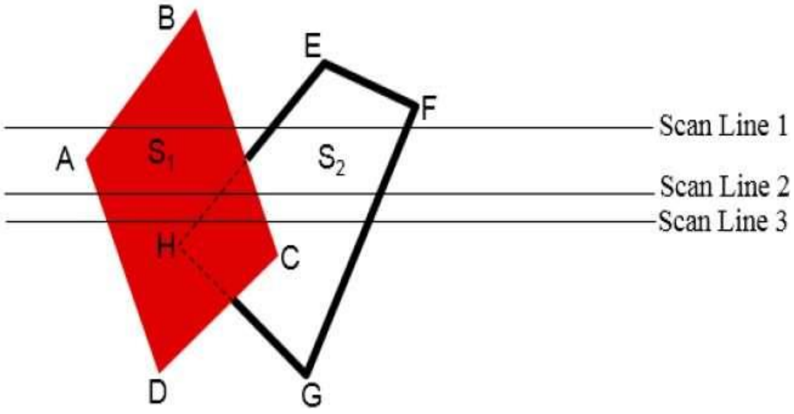


Fig. 3.14 Scan Line conversion method

To search surfaces crossing a given scan-line, an active list of edges is formed. The active list stores only those edges that cross the scan-line in order of increasing x. Also a flag is set for each surface to indicate whether a position along a scan-line is either inside or outside the surface. Pixel positions across each scan-line are processed from left to right.At the left intersection with a surface, the surface flag is turned on and at the right, the flag is turned off. You only need to perform depth calculations when multiple surfaces have their flags turned on at a certain scan-line position.

5. Depth- sorting or painter’s algorithm

- Sort the objects by distance from the viewer.
- Draw objects in order from farthest to nearest.
- Nearer objects will “overwrite” farther ones.

- If 2 objects DO overlap :

Need to find a plane to split one polygon by so that each new polygon is entirely in front of or entirely behind the other

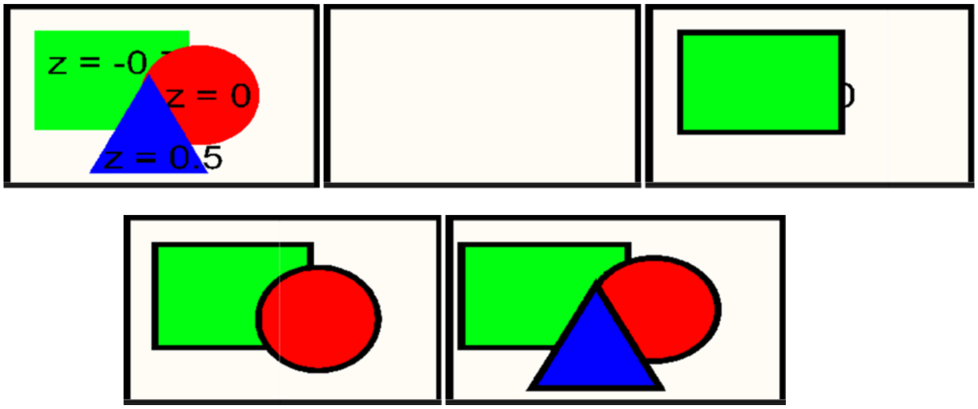
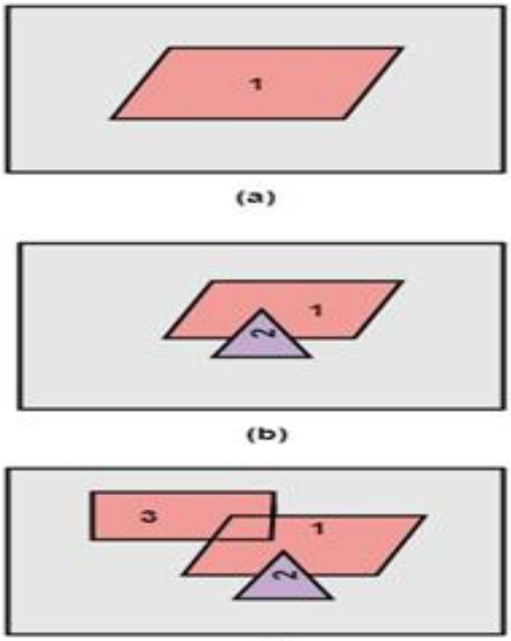


Fig. 3.15 Painter's algorithm



(a)

(b)

(c)

Fig. 3.16 Addition of surfaces one by one and painting done using painter's algorithm

6. BSP Tree Method

- A BSP (Binary Space-Partitioning) tree is formed by first choosing a triangle from the set of all triangles in the scene.
- The plane that contains this triangle is called P. Classify all other triangles into two groups: One group in front of P, and the other group behind P. All triangles that are intersected by P are split into multiple smaller triangles, each of which is either in front of P or behind P
- Within each group, recursively pick another triangle and partition all the triangles in this group into two sub-groups.

Do this until there is only one triangle in each group.

The result is a tree

BSP Algorithm

```
Procedure DisplayBSP(tree: BSP_tree)
      Begin
   If tree is not empty then
    If viewer is in front of the root then
         Begin
            DisplayBSP(tree.back_child)
            displayPolygon(tree.root)
            DisplayBSP(tree.front_child)
         End
       Else
        Begin
           DisplayBSP(tree.front_child)
           displayPolygon(tree.root)
           DisplayBSP(tree.back_child)
      End
     End
```

This algorithm is suitable for a static group of 3D polygons to be viewed from a number of view points. - based on the observation that hidden surface elimination of a polygon is guaranteed if all polygons on the other side of it as the viewer is painted first, then itself, then all polygons on the same side of it as the viewer.

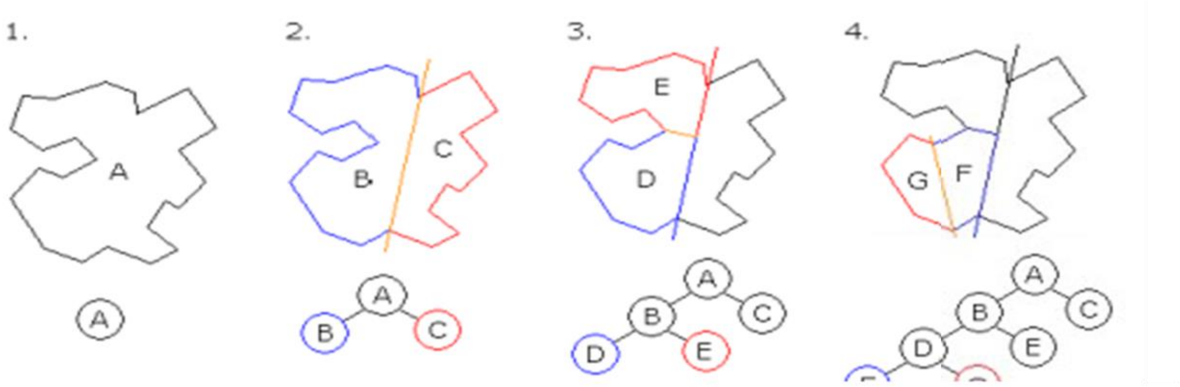


Fig. 3.17 BSP Tree representation

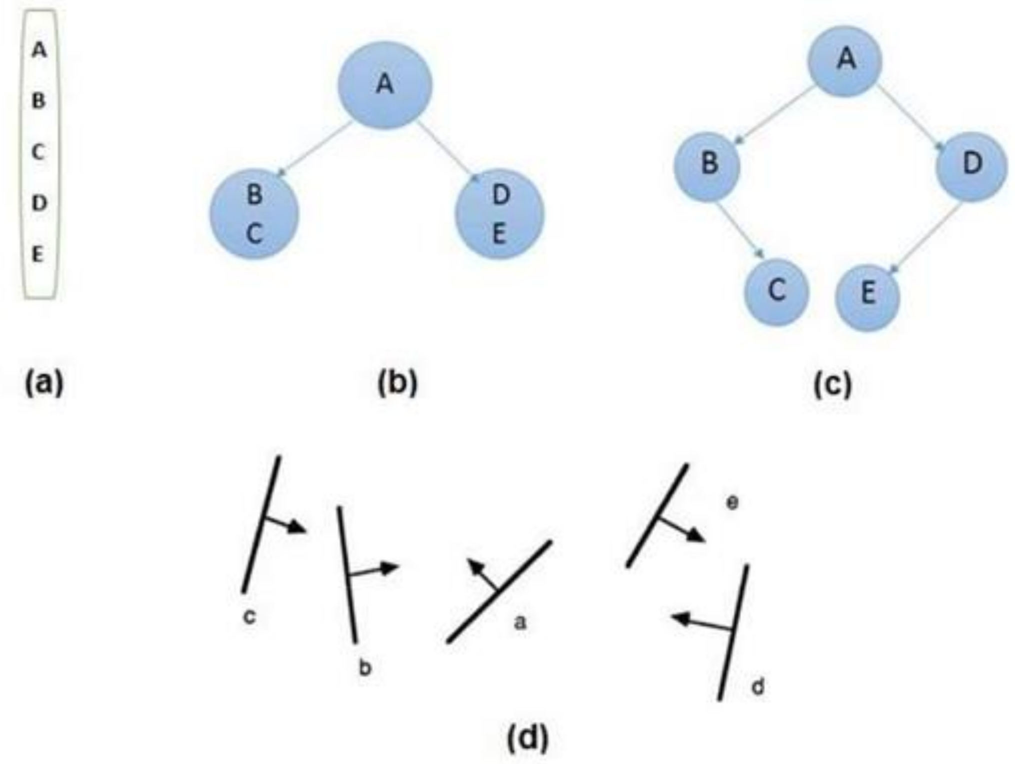


Fig. 3.18 Example for BSP Tree representation

- From the above figure, first take **A** as a root.
- Make a list of all nodes in figure aa.
- Put all the nodes that are in front of root **A** to the left side of node **A** and put all those nodes that are behind the root **A** to the right side
- Process all the front nodes first and then the nodes at the back.
- First process the node **B**.
- As there is nothing in front of the node **B**, we have put NIL.

However, we have node **C** at back of node **B**, so node **C** will go to the right side of node **B**. Repeat the same process for the node **D**

7. AREA SUBDIVISION METHOD

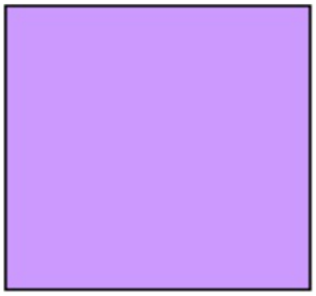
It is based on a divide & conquer method. It uses fundamental of area coherence. It is used to resolve the visibility of algorithms. It classifies polygons in two cases i.e. **trivial** and **non-trivial.** Trivial cases are easily handled. Non trivial cases are divided into four equal sub windows. The windows are again further subdivided using recursion until all polygons classified trivial and non trivial.

The area-subdivision method takes advantage of area coherence in a scene by locating those view areas that represent part of a single surface. Divide the total viewing area into smaller and smaller rectangles until each small area is the projection of part of a single visible surface or no surface at all. Successively divide the area into four equal parts at each step. There are four possible relationships that a surface can have with a specified area boundary.

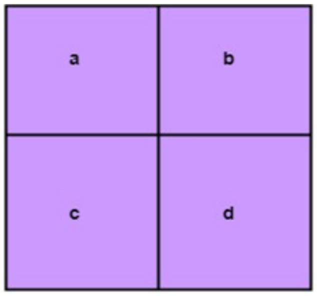
- **Surrounding surface** − One that completely encloses the area.
- **Overlapping surface** − One that is partly inside and partly outside the area.
- **Inside surface** − One that is completely inside the area.
- **Outside surface** − One that is completely outside the are

If any of the following condition is true, then, no subdivision of this area is needed.

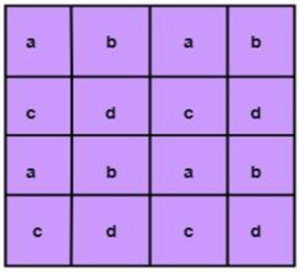
a. All surfaces are outside the area.
b. Only one surface is inside, overlapping or surrounding surface is in the area.
c. A surrounding surface obscures all other surfaces within the area boundaries.
For cases b and c, the color of the area can be determined from that single surface.



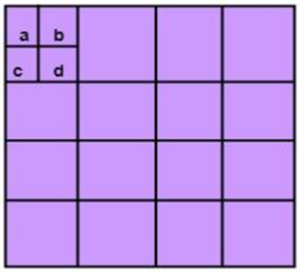
Original area
(a)



First division or subdivision of area
(b)



Second division
(c)



Third subdivision
(d)

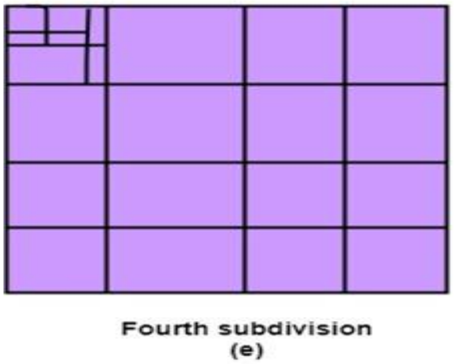


Fig. 3.19 Area subdivision representation

Example :

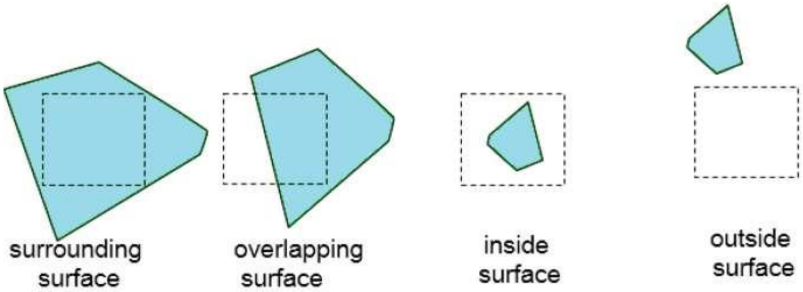


Fig. 3.20 Example for Area subdivision

The tests for determining surface visibility are based on the given classifications: No further subdivisions of a specified area are needed if one of the following conditions is true :

- **All surfaces are outside surfaces with respect to the area**
- **Only inside**
- **Overlapping or surrounding surface is in the area.**
- **A surrounding surface obscures all other surfaces within the area boundaries.**

8. Octree Methods

When a colour is encountered in an octree node, the corresponding pixel in the frame buffer is painted only if no previous color has been loaded into the same pixel position.

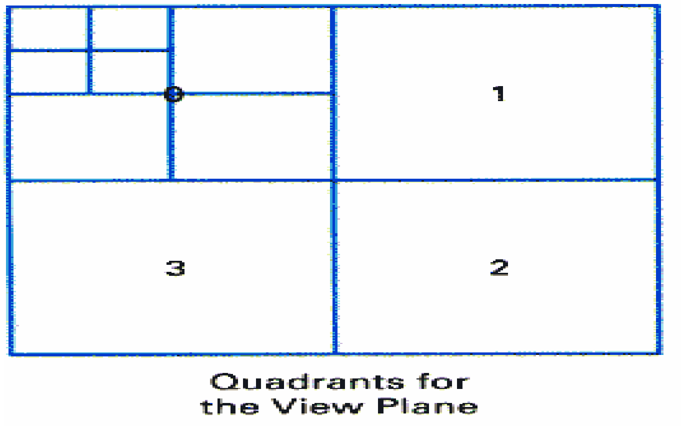


Fig. 3.21 **Octtree representation**

In most cases, both a front and a back octant must be considered in determining the correct color values for a quadrant. But

- If the front octant is homogeneously filled with some color, we do not process the back octant.
- If the front is empty, it is necessary only to process the rear octant.
- If the front octant has heterogeneous regions, it has to be subdivided and the sub-octants are handled recursively.

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SCHOOL OF COMPUTING

DEPARTMENT OF COMPUTER SCIENCE

UNIT – IV – Computer Graphics and Multimedia – SBS1303

Multimedia – Definition- Introduction-Multimedia Software- Basic Tools- Multimedia Authoring Tools- Multimedia Building Blocks: Text- Font Editing and Design Tools – Hypermedia and Hypertext – Multimedia System Sounds – MIDI Versus Digital Audio – Making MIDI Audio – Audio File Formats– Adding Sound to Your Multimedia Project.

INTRODUCTION TO MULTIMEDIA

Multimedia is a combination of text, graphic art, and sound, animation and video elements. Multimedia as name suggests is the combination of Multi and Media that is many types of media (hardware/software) used for communication of information.

The IBM dictionary of computing describes multimedia as "comprehensive material, presented in a combination of text, graphics, video, animation and sound.

Any system that is capable of presenting multimedia, is called a multimedia system". A multimedia application accepts input from the user by means of a keyboard, voice or pointing device. Multimedia applications involve using multimedia technology for business, education and entertainment. Multimedia is now available on standard computer platforms. It is the best way to gain attention of users and is widely used in many fields as follows:

- Business - In any business enterprise, multimedia exists in the form of advertisements, presentations, video conferencing, voice mail, etc.
- Schools - Multimedia tools for learning are widely used these days. People of all ages learn easily and quickly when they are presented information with the visual treat.
- Home PCs equipped with CD-ROMs and game machines hooked up with TV screens have brought home entertainment to new levels. These multimedia titles viewed at home would probably be available on the multimedia highway soon.
- Public places - Interactive maps at public places like libraries, museums, airports and

the stand-alone terminal

- Virtual Reality (VR) - This technology helps us feel a 'real life-like' experience. Games using virtual reality effect is very popular.

COMPONENTS OF MULTIMEDIA

1. **Text**
   All multimedia productions contain some amount of text. The text can have various types of fonts and sizes
2. **Graphics**
   Graphics make the multimedia application attractive. Graphics are used more often than text to explain a concept, present background information etc.

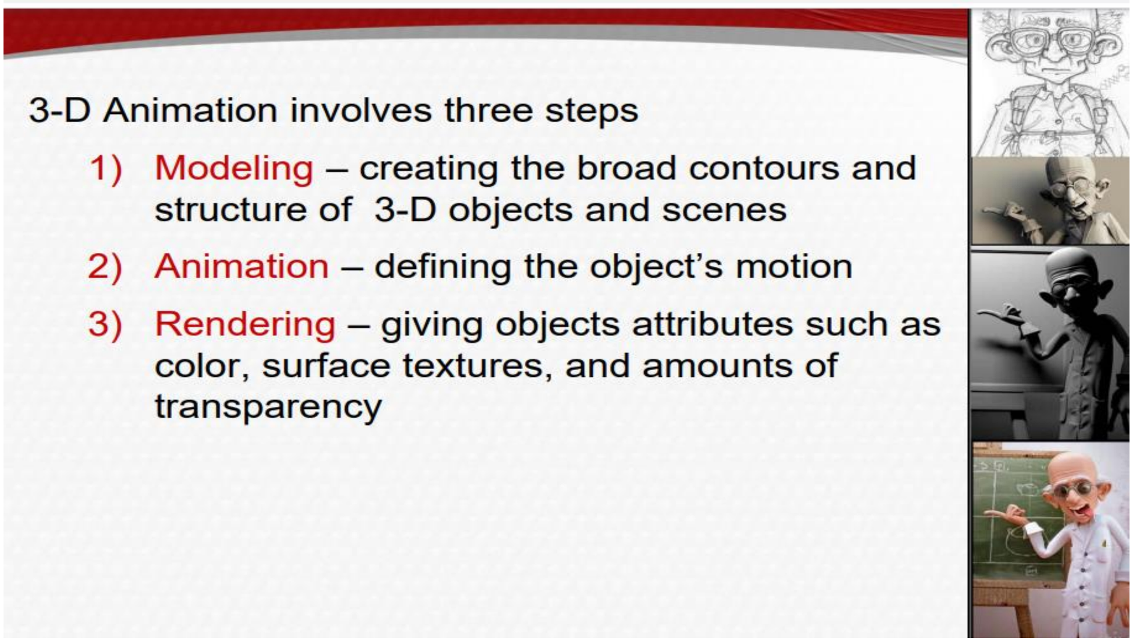
   Graphic can be a : Chart, Photograph, Background, Drawing, LOGO. Banners, Painting, Navigation button, etc.

   There are two types of Graphics:
   - **i)** **Bitmap images**- Bitmap images are real images that can be captured from devices such as digital cameras or scanners. Generally, bitmap images are not editable. Bitmap images require a large amount of memory.
   - **ii)** **Vector Graphics**- Vector graphics are drawn on the computer and only require a small amount of memory. These graphics are editable.

3. **Audio**: A multimedia application may require the use of speech, music and sound effects. These are called audio or sound element of multimedia. Speech is also a perfect way for teaching. Audio are of **analog** and **digital** types. **Analog audio or sound** refers to the original sound signal. Computer stores the sound in digital form. Therefore, the sound used in multimedia application is digital audio.

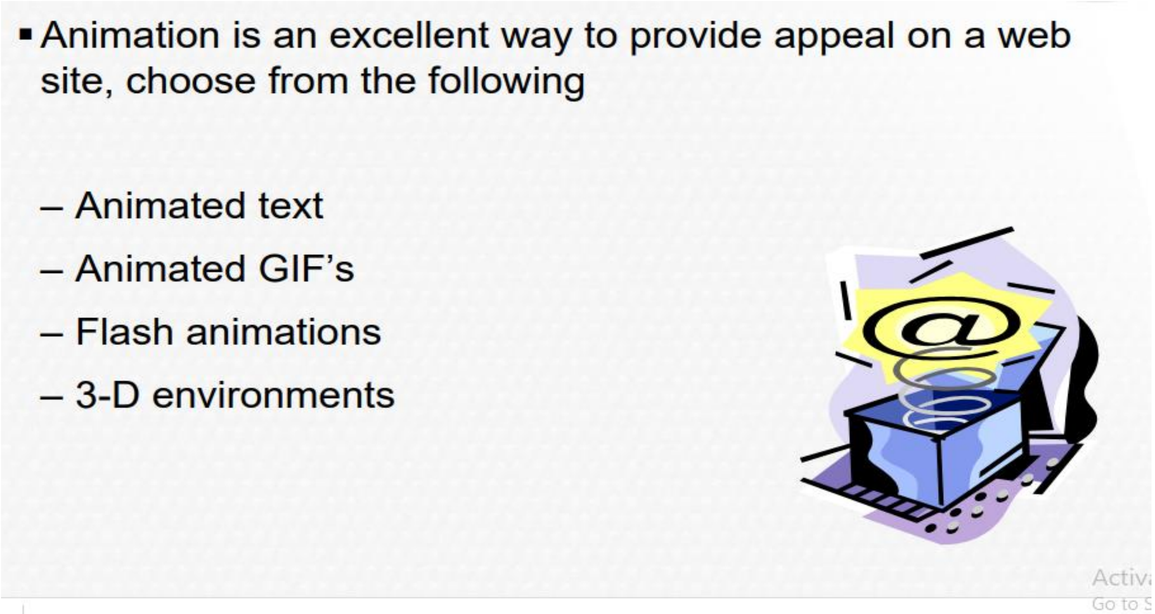
4. **Video:** The term video refers to the moving picture, accompanied by sound such as a picture in television. Digital video is useful in multimedia application for showing real life objects. Video have highest performance demand on the computer memory and on the bandwidth if placed on the internet.

5. **Animation**: Animation is a process of making a static image look like it is moving. An animation is just a continuous series of still images that are displayed in a sequence. The animation can be used effectively for attracting attention. Animation also makes a presentation light and attractive. Animation is very popular in multimedia application



3-D Animation involves three steps

1) Modeling – creating the broad contours and structure of 3-D objects and scenes
2) Animation – defining the object's motion
3) Rendering – giving objects attributes such as color, surface textures, and amounts of transparency



- Animation is an excellent way to provide appeal on a web site, choose from the following
  - Animated text
  - Animated GIF's
  - Flash animations
  - 3-D environments

MULTIMEDIA ELEMENTS

High-impact multimedia applications, such as presentations, training and messaging, require the use of moving images such as video and image animation, as well as sound intermixed with document images and graphical text displays.

Multimedia applications require dynamic handling of data consisting of a mix of text, voice, audio components, video components, and image animation. Integrated multimedia applications allow the user to cut sections of all or any of these components and paste them in a new document or in another application such as an animated sequence of events, a. desktop publishing system, or a spreadsheet.

i) **Facsimile** : Facsimile transmissions were the first practical means of transmitting document images over telephone lines. The basic technology, now widely used, has evolved to allow higher scanning density for better-quality fax

ii) **Document images** : Document images are used for storing business documents that must be retained for long periods of time or may need to be accessed by a large number of people. Providing multimedia access to such documents removes the need for making several copies of the original for storage or distribution

iii) **Photographic images**: Photographic images are used for a wide range of applications . such as employee records for instant identification at a security desk, real estate's systems with photographs of houses in the database containing the description of houses, medical case histories, and so on.

iv) Geographic information systems map (GIS) :
Map created in a GIS system are being used wildly for natural resources and wild life management as well as urban planning. These systems store the geographical information of the map along with a database containing information relating highlighted map elements with statistical or item information such as wild life statistics or details of the floors and rooms and workers in an office building

v) Voice commands and voice synthesis : Voice commands and voice synthesis are used for hands-free operations of a computer program. Voice synthesis is used for presenting the results of an action to the user in a synthesized voice. Applications such as a patient monitoring system in a surgical theatre will be prime beneficiaries of these capabilities. Voice commands allow the user to direct computer operation by spoken commands.

Audio message : Annotated voice mail already uses audio or voice message as attachments to memos and documents such as maintenance manuals.

Video messages : Video messages are being used in a manner similar to annotated voice mail.

vi) Holographic images

All of the technologies so for essentially present a flat view of information. Holographic images extend the concept of virtual reality by allowing the user to get "inside" a part, such as, an engine and view its operation from the inside.

vi) Fractals

Fractals started as a technology in the early 1980s but have received serious attention only recently. This technology is based on synthesizing and storing algorithms that describes the information.

MULTIMEDIA AUTHORING TOOLS

Multimedia authoring tools give an integrated environment for joining together the different elements of a multimedia production. It gives the framework for organizing and editing the components of a multimedia project. It enables the developer to create interactive presentation by combining text, audio, video, graphics and animation.

Features of Authoring Tools

- Editing Features- Most authoring environment and packages exhibit capabilities to create edit and transform different kinds of media that they support. For example, Macromedia Flash comes bundled with its own sound editor. This eliminates the need for buying dedicated software to edit sound data. So authoring systems include editing tools to create, edit and convert multimedia components such as animation and video clips.
- Organizing Features- The process of organization, design and production of multimedia involve navigation diagrams or storyboarding and flowcharting. Some of the authoring tools provide a system of visual flowcharting or overview facility to showcase your project's structure at a macro level. Navigation diagrams help to organize a project. Many web-authoring programs like Dreamweaver include tools that create helpful diagrams and links among the pages of a website.
- Visual programming with icons or objects- It is simplest and easiest authoring process. For example, if you want to play a sound then just clicks on its icon.
- Programming with a scripting language- Authoring software offers the ability to write scripts for software to build features that are not supported by the software itself. With script you can perform computational tasks - sense user input and respond, character creation, animation, launching other application and to control external multimedia devices.
- Document Development tools- Some authoring tools offers direct importing of pre-formatted text, to index facilities, to use complex text search mechanism and to use hypertext link-ing tools.
- Interactivity Features- Interactivity empowers the end users to control the content and flow of information of the project. Authoring tools may provide one or more levels of interactivity.
- Simple branching- Offers the ability to go to another section of the multimedia production.
- Conditional branching- Supports a go to base on the result of IF-THEN decision or events.
- Playback Features- When you are developing multimedia project, you will continousally assembling elements and testing to see how the assembly looks and performs. Therefore authoring system should have playback facility.

- Supporting CD-ROM or Laser Disc Sources- This software allows over all control of CD-drives and Laser disc to integrate audio, video and computer files. CD-ROM drives, video and laserdisc sources are directly controlled by authoring programs.
- Supporting Video for Windows- Videos are the right media for your project which are stored on the hard disk. Authoring software has the ability to support more multimedia elements like video for windows.
- Hypertext- Hypertext capabilities can be used to link graphics, some animation and other text. The help system of window is an example of hypertext. Such systems are very useful when a large amount of textual information is to be represented or referenced.
- Cross-Platform Capability- Some authoring programs are available on several platforms and provide tools for transforming and converting files and programs from one to the other.
- Run-time Player for Distribution- Run time software is often included in authoring software to explain the distribution of your final product by packaging playback software with content. Some advanced authoring programs provide special packaging and run-time distribution for use with devices such as CD-ROM.
- Internet Playability- Due to Web has become a significant delivery medium for multimedia, authoring systems typically provide a means to convert their output so that it can be delivered within the context of HTML or DHTML.

Authoring Tools Classification

1. Card or Page based authoring tools

In these authoring systems, elements are organized as pages of a book or a stack of cards. In the book or stack there are thousands of pages or cards available. These tools are best used when the bulk of your content consists of elements that can be viewed individually, for example the pages of a book or file cards in card file. You can jump from page to page because all pages can be interrelated. In the authoring system you can organize pages or cards in the sequences manner. Every page of the book may contain many media elements like sounds, videos and animations.

One page may have a hyperlink to another page that comes at a much later stage and by clicking on the same you might have effectively skipped several pages in between. Some examples of card or page tools are:

- Hypercard (Mac)
- Tool book (Windows)
- PowerPoint (Windows)
- Supercard (Mac)

Advantages:

- Easy to understand.
- One screen is equal to 1card or 1page.

- Easy to use as these tools provide template.
- Short development time.

Disadvantages:

- Some run only on one platform.
- Tools not as powerful as equivalent stand alones.

2. Icon based or Event driven authoring tools

Icon-based tools give a visual programming approach to organizing and presenting multimedia. First you build a structure or flowchart of events, tasks and decisions by dragging appropriate icons from a library. Each icon does a specific task, for example- plays a sound, open an image etc. The flowchart graphically displays the project's logic. When the structure is built you can add your content text, graphics, animation, video movies and sounds. A nontechnical multimedia author can also build sophisticated applications without scripting using icon based authoring tools.

Some examples of icon- based tools are:

- Authorware Professional (Mac/Windows)
- Icon Author (Windows)

Advantages:

- Clear Structure.
- Easy editing and updating

Disadvantages:

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- Difficult to learn.
- Expensive.

3. Time based authoring tools

Time based authoring tools allow the designer to arrange various elements and events of the multimedia project along a well-defined timeline. By timeline, we simply mean the passage of time. As the time advances from starting point of the project, the events begin to occur, one after another. The events may include media files playback as well as transition from one portion of the project to another. The speed at which these transitions occur can also be accurately controlled. These tools are best to use for those projects, wherein the information flow can be directed from beginning to end much like the movies. Some example of Time- based tools are:

- Macromedia's Director
- Macromedia Flash

Advantages

- Good for creating animation.
- Branching, user control, interactivity facilities.

Disadvantages

- Expensive
- Large file size
- Steep learning curve to understand various features.

4. Object-Oriented authoring tools:

Object oriented authoring tools support environment based on object. Each object has the following two characteristics:

1. State or Attributes - The state or attributes refers to the built in characteristics of an object. For example, a color T.V has the following attributes:
    - Color receiver
    - Volume control
    - Picture control
    - 128 channels
    - Remote control unit
2. Behavior or Operations - The behavior or operations of an object refers to its action. For example, a T.V can behave in any of the following manner at a given point of time:
    - Switched on
    - Switched off
    - Displays picture and sound from
        - A TV cable connection
        - A TV transmitter
        - A DVD
        - A VCR

MULTIMEDIA BUILDING BLOCKS

Building blocks are things or modules required to create anything. Multimedia building blocks are parts which are combined together to form a project. The basic Multimedia Building blocks are :

- TEXT
- AUDIO
- IMAGES
- VIDEO
- ANIMATION

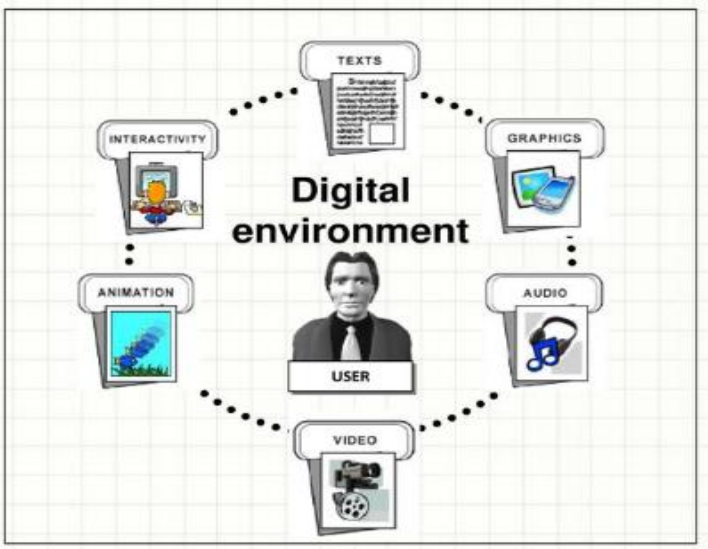


Fig 4.1 Elements of Multimedia

1.Text

Written text came into use about 6000 years ago. Initially text was written using symbols as shown below:

Fig 4.2 Text Symbols

A key component of any multimedia product is Text. Multimedia product depends on text for various reasons such as :

Page title, Content of the information, Label and instruction, etc.

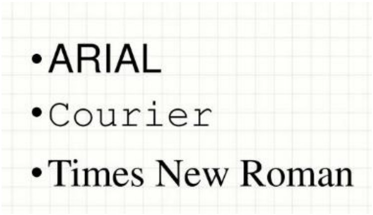
- Word must be chosen carefully in such a way as to provide precise and accurate meaning to the context as well as it must be chosen to illustrate to a few meanings.
- Word appears in titles, menus and navigational aids.
- Test the words that you plan to use on several users and observe their reaction.

Factors affecting legibility of text

- Size
- Background and Foreground color
- Style
- Leading

Types terminology

i)Typeface : It is a family of similar characters that may include many sizes and styles.



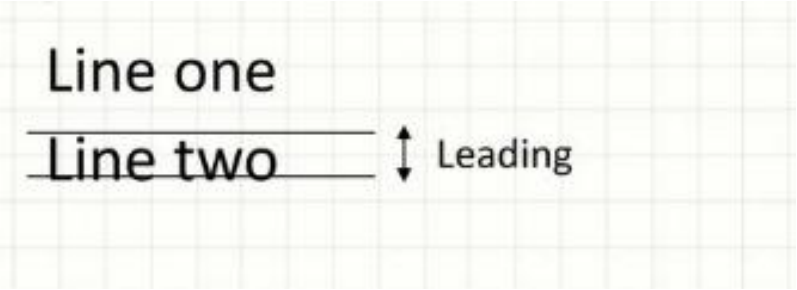
- ARIAL
- Courier
- Times New Roman

ii) Font : Characters of a single size and style, which are part of the same fontface family.
e.g) Arial, Arial Italic, Arial Narrow, Times, Times bold , etc.

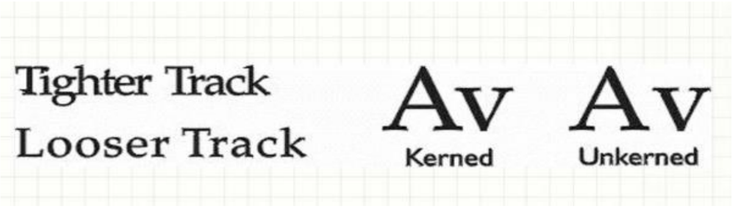
iii) Style : Attributes of font such as *italic*, bold, underline, shadow, etc.

iv) Point : The font size is usually measured in point (A point is 1/72 of an inch)

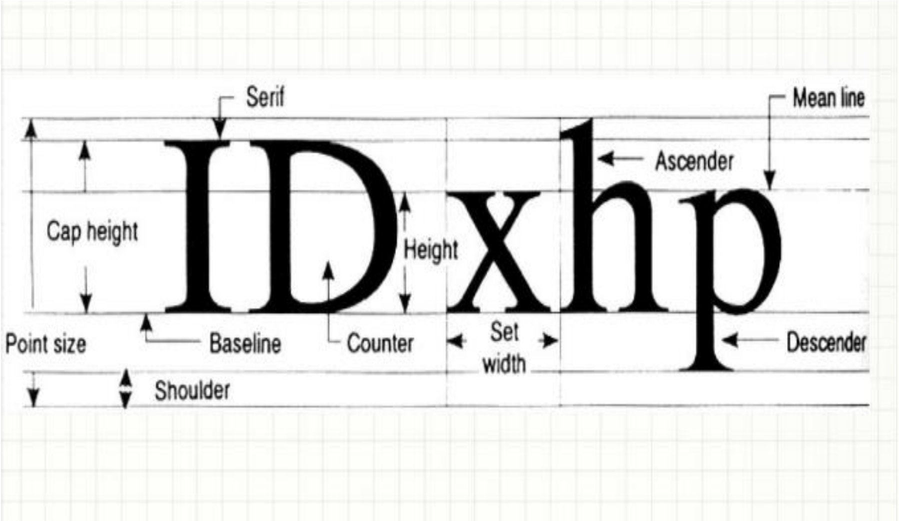
Leading : Indicates the vertical space between lines of text



Kerning : Indicates the spacing between two characters



Character Metrics: The general measurements of individual characters



Cases :

Capital letters are called uppercase
small letters are called lowercase
Text is generally easier to read with mixed uppercase and lowercase letters

Issues when designing with Text

1. Font compatibility: Not all font is available in every operating system
2. Commonly only certain fonts such as Arial, Times New Roman, Courier are used
3. If you want to use a specific font, it should be installed in your system first

DESIGNING MENU AND ICON

While designing Menu, choose word with precise meaning

ICON / SYMBOLS has very few meaning for interpretation, as they pictorially represent the meaning.

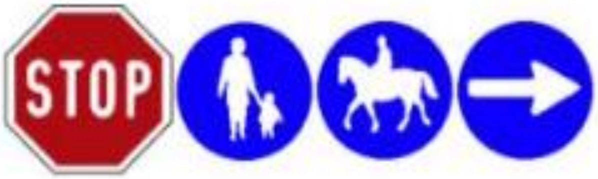


Fig 4.3 Menus using icon

2.AUDIO

There are many different types of audio files, and the each have their of distinct advantages. The most important audio file is the MP3. MP3's have become the standard audio files on most devices and on most websites.

The advantage of MP3 file over different formats is their small size. MP3 files can be compressed, as they do not contain the inaudible sections of an audio track. While this results in good quality audio, while taking up a small amount of space, in certain situation, audio quality can suffer. The compression of MP3 file can distort vocal sounds and can result in a 'tinny' sound.

Because, some computers, primarily Windows-based PC's use WAV files to store audio files. These files are uncompressed, so they take up a large amount of space, but they are of better quality than most MP3 files. As most desktop PC's have room to spare, better audio quality is substitutes for more space used. Another file type common on windows computers is WMA. This format is optimized for use by Windows Media Player.

Another common audio file is DCT. This type of file is encrypted and used for medical applications where patient confidentiality is needed.

3. GRAPHICS

GIF and PNG are two different formats which images are available in. GIF simply means Graphics Interchange Format and is typically used for animations and sometimes single images as well. The images are compressed or made smaller; they are using what is called loss-less data compression. This compression makes it so that the image does not lose quality even if it is compressed due to its ability to have uniformed color with well-defined edges.

GIF is not the best quality format for images because of its limit of colors, which is one of the reasons that PNG was created.

PNG are Portable Network Graphics. Their ability to compress is higher quality and allows for alpha transparency, which is basically creating the image with a background so that it looks transparent either partially or fully. They can store more color depth but also take up more space than GIFs in some cases. In cases where this does not apply it is because their ability to have better compression in 8-bit data ends up being smaller than GIFs.

PNGs are unlike GIFs because they do not support animations and are a single-image based format. These formats are used in many Web pages today.

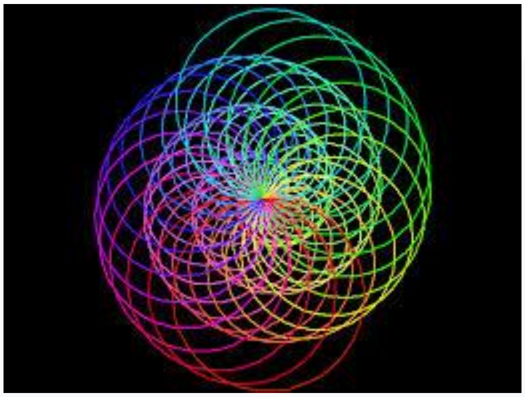


Fig 4.4 Example for GIF

Fig 4.5 Example for PNG

The Joint Photographic Experts Group committee created the file format that is otherwise known as JPEG. JPEG is a technique and file format used to compress color images, digital photos, and other digital graphics. Many users who store photographs on their computer will recognize the JPEG file extension recognized as ".jpeg", or "jpg". The file size of a selected image can be optimized for different uses, otherwise known as editing a photo to the desired sizes. The file format does so by using a type of compression of the image known as "lossy compression". The definition of lossy compression is defined as the ability for the image to decrease in file size, taking away a slight decrease in image quality.

JPEG files are widely used by consumers as a way to save photos on their computer to view at their desire. However, a user may have interest in sharing these images through e-mail, or a website. As considering using a JPEG file on a website or through email, a user must consider the file size in comparison to the amount of quality of the image. For instance, if a user is interested in posting a photograph on a website of theirs, they must consider file size and formatting. Also, with e-mail, a user must consider the quality of the image they will be sending. The higher the quality of the image being sent, the larger the file size must be. If a user is sending this file over their cellular phone, it may require the use of more data to send a larger file size.

Fig. 4.6 Eg for JPEG file

4.VIDEO

Video provides a powerful impact in a multimedia program. It starts with continuous event and breaks it up to frames, whereas an animation starts with frames. Video formats are made up of container and codec(s). The container describes the structure of the file like where the various pieces are stored, how they are interleaved, and which codecs are used by which pieces.

A codec is a way of compressing the file to decrease file size, while maintaining quality.

Some of the most common video file formats are Audio-Video Interleave (.avi), Flash Video Format (.flv), Moving Picture Experts Group 2 (.mp2), Moving Picture Experts Group 4 (.mp4), QuickTime (.mov), and Windows Media Video (.wmv).

In multimedia applications, the digital video is gaining popularity because the video clips can be edited easily, it can be stored like any other files in the computer and the quality of the video can still be maintained, and the video can be transferred within a computer network which allows non-linear editing in any part of the video.

Just like in audio, in streaming video the traveling information is a stream of data from a server. In 2006, people watched more than a million streaming videos a day on YouTube.

5.ANIMATION

Animation is the rapid display of a sequence of images of 2-D artwork or model positions to create an illusion of movement. It is an optical illusion of motion due to the phenomenon of persistence of vision and can be created and demonstrated in a number of ways.

- Animation is defined as the act of making something come alive
- It is concerned with the visual or aesthetic aspect of the project
- Animation is an object moving across or into or out of the screen
- Animation is the **rapid display of a sequence of images of 2-D artwork** or model positions in order to create an illusion of movement.
- It is an optical illusion of motion due to the phenomenon of **persistence of vision** and can be created and demonstrated in a number of ways.

Usage of Animation

Artistic Purposes
Storytelling
Displaying data (scientific visualization)
Instructional purposes

Types of Animation :

Animation can be rendered in :

i) 2D Space : 2D animations are very simple and static
It is the art of creating movement in 2D space
This includes characters, creatures,FX and backgrounds
It is a simple animation drawn with simple motions.
The object can move in two axes, either up or down or left or right.

They are generated by creating continuous consecutive images, or "frames", thus forming motion by each image showing the next in a gradual progression of steps.

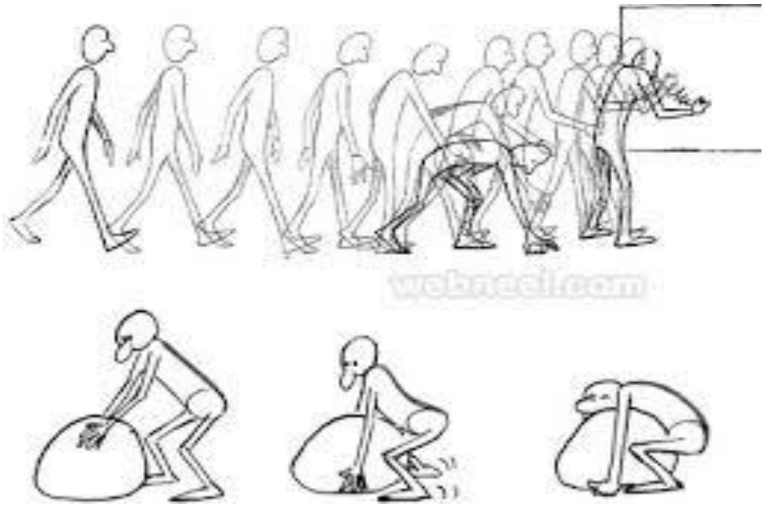


Fig. 4.7 Eg for 2D Animation

ii) 2-1/2D Space : An illusion of depth is created through shadowing, highlighting and forced perspective, though in reality the image rests in two dimensions.

Animators achieve this look by strategically manipulating scenes with tools such as layering, shadowing, perspective adjustments, and morphing.

These artistic manipulations can be imposed on either a static image or a set of images in an animation in order to give the 2D space the same movement and fluidity as a real 3D animation.

iii) 3D Space : Complicated and realistic animations are done in 3D space. 3D animation is the art of using motion to bring characters, vehicles, props, and more to life within TV shows, films, and games.

3D animation has great popularity in movies, games and virtual reality. 3D animation is also known as CGI animation and lights and cameras can also be animated in this variation of animation. This form of computer animation also makes use of frames. Some of the top 3D animation programmes are Autodesk, Cinema 4D, Houdini, Poser, Unity and Blender.

- 3D animation is performed using two methods which include:
- **Keyframe animation**: keyframe refers to the editing of spacing, position, shape or timing of an object in successive frames. Unlike 2D animation, 3D animation makes keyframe animation easier by connecting the in-between frames.
- **Motion capture**: In this method, a character is placed in a special motion capture suit that contains sensors which record the movement of the character’s limbs. The data collected is transferred to 3D animation tools where it is added to the animation of the 3D character.

Methods of creating Animation :

1. Cel Animation

Cel Animation is one in which a series of progressively different graphics are used on each frame of movie film. The term **“cel”** is derived from the clear celluloid sheets that were used for drawing each frame. Cel animation is based on a series of frames or cels in which the object is redrawn in each consecutive cel to depict motion. Cel comes from the word celluloid (a transparent sheet material) which was first used to draw the images and place them on a stationary background.

2. Path Animation :

Path based animation is the simplest form of animation and is easy to learn. It moves an object along a predetermined path on the screen. The path could be a straight line or it could include any number of curves. Often the object does not change, although it might be resized or reshaped.

Animation File Formats :

- Graphic Interchange Format (GIF)
- Flash FLA Project File Format (FLA)
- Flash (SWF)
- Multi-image Network Graphics (MNG)

Difference between Animation and Video

Video takes continuous motion and breaks it up into discrete frames. Animation starts with independent pictures and puts them together to form the illusion of continuous motion

FONT EDITING AND DESIGN TOOLS

Special font editing tools can be used to make your own type, so you can communicate an idea or graphic feeling exactly. With these tools, professional typographers create distinct text and display faces. Graphic designers, publishers, and ad agencies can design instant variations of existing type face.

Three dimensional modelling programs allow you to create a character, add depth to it, shade and light it, and manipulate it into other shapes.

Macromedia director allows spinning of text it its place. Cool3d and Vertigo 3D HotText let you extrude, twist and rotate character and adjust light and texture effect for high-impact 3-d titles.

Two of the popular font editors are FontCreator and Fontographer.

Fontographer:

Fontographer supplied by macromedia is a specialized graphics editor for both Mac and Windows platforms.

Features:

- You can use it to develop PostScript, True Type and bitmapped fonts for Mac and windows etc.
- Designers can also modify existing typefaces, incorporate PostScript artwork, automatically trace scanned images and create designs from scratch.
- It includes freehand drawing tool to create professional and precise inline and outline drawings of calligraphic and script character, using either the mouse or alternative input methods.
- It allows the creation of multiple font designs from two existing typefaces, and you can design lighter or heavier fonts by modifying the weight of an entire typeface.
- You can create condensed, expanded and oblique version of the same font or modify any of those fonts to suit your design needs.
- One character, several characters or entire fonts can be scaled, rotated, and skewed to create new and unique typefaces.
- A metric window provides complete control over character width, spacing, offset, and kerning.

FontCreator

FontCreator puts font creation within the grasp of the average PC user, typographers and graphic designers. The editor lets you easily select and modify the entire character set of any TrueType font and fonts based on OpenType font technology. Features include the ability to convert images to outlines, thus enabling you to create fonts with your own signature, logo and handwriting. The sensitive interface makes FontCreator the perfect tool for both new and experienced users. The advanced validation features make the design process easy and help you avoid common mistakes.

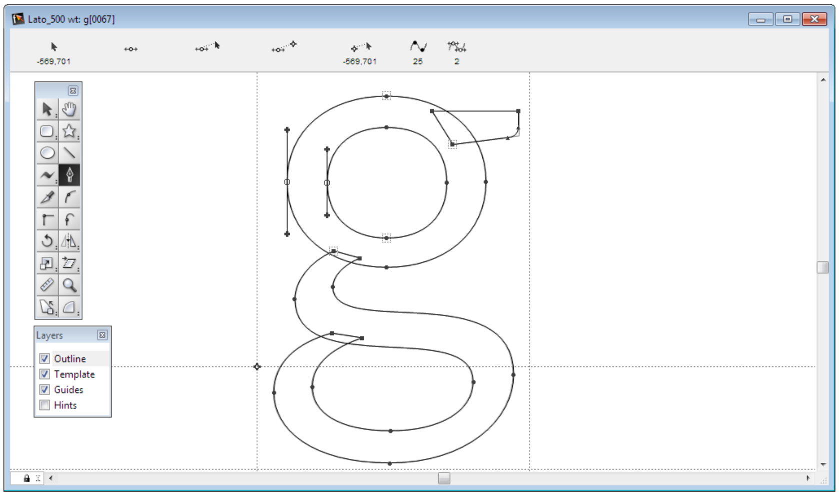


Fig. 4.8 Creating letters using FontCreator

1.The most impressive new feature that makes designing fonts so much faster is direct import of vector based images.
2. Create and edit TrueType and OpenType fonts.
3. Redesign existing characters and add missing characters.
4. Convert vector and raster based (e.g. a signature, logo or handwriting character) into outlines.
5. Edit or regenerate font names and fix character mappings.
6. Correct fonts that display incorrectly add or correct composite glyphs.
7. Generate, modify and clean up kerning pairs.
8. Transform individual glyphs or an entire font (e.g. to make a bold version) and Preview fonts before installing.
9. Install fonts in Windows, Split TrueType Collection or Extra TrueType Fonts from TrueType collection.

HYPERMEDIA AND HYPERTEXT

Hypertext is a text which contains links to other texts. The term was invented by Ted Nelson around 1965.Hypertext is therefore usually non-linear.

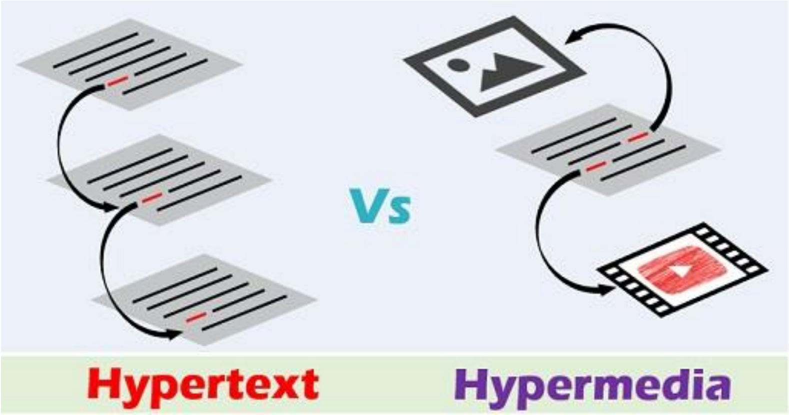


Fig. 4.9 Hypertext Vs Hypermedia

Hypertext is a powerful cross-referencing tool meant for user-driven access to an ocean wealth of interconnected information either static or dynamic in an electronic format. Simply put, hypertext may refer to plain simple text that contains links to access other chunks of text within the same or different document. It provides a means to organize and present information in a way that is easily accessible to the end users. It's more like a user-driven tool to represent textual information which are linked together to provide more flexibility and a greater degree of control. This allows users or readers to move from one location to another via hyperlinks or “go to” links. Links connect nodes to other documents and are usually activated when clicked upon by a mouse or other pointing device.

HyperMedia is not constrained to be text-based. It can include other media, e.g., graphics, images, and especially the continuous media - sound and video. Apparently, Ted Nelson was also the first to use this term. The World Wide Web (WWW) is the best example of hypermedia applications.

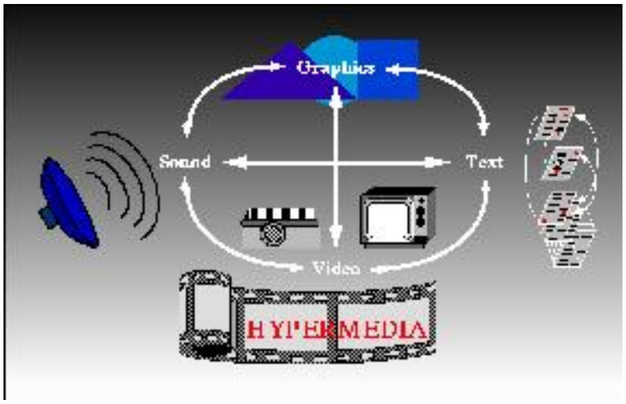
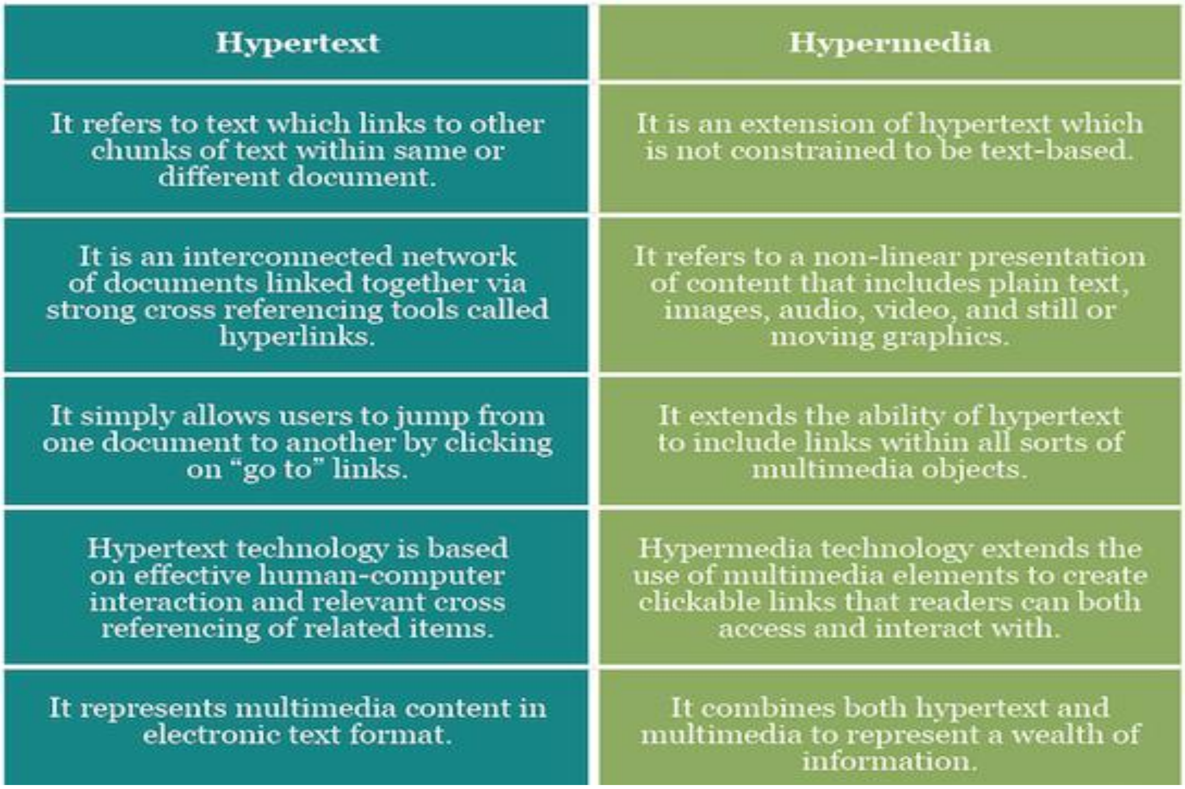


Fig. 4.10 Hypermedia

Hypermedia is an extension of hypertext that employs multiple forms of media such as text, graphics, audio or video sequences, still or moving graphics, etc. The structure of hypermedia is quite similar to that of a hypertext, except it’s not constrained to be just text-based. It extends the capabilities of hypertext systems by creating clickable links within web pages to create a network of interconnected non-linear information which user can both access and interact with for a better multimedia experience. The most common hypermedia type is image links which are often linked to other web pages. It is used in a variety of applications from problem solving and qualitative research to electronic studying and sophisticated learning.

Difference between HYPERTEXT and HYPERMEDIA



Hypertext	Hypermedia
It refers to text which links to other chunks of text within same or different document.	It is an extension of hypertext which is not constrained to be text-based.
It is an interconnected network of documents linked together via strong cross referencing tools called hyperlinks.	It refers to a non-linear presentation of content that includes plain text, images, audio, video, and still or moving graphics.
It simply allows users to jump from one document to another by clicking on "go to" links.	It extends the ability of hypertext to include links within all sorts of multimedia objects.
Hypertext technology is based on effective human-computer interaction and relevant cross referencing of related items.	Hypermedia technology extends the use of multimedia elements to create clickable links that readers can both access and interact with.
It represents multimedia content in electronic text format.	It combines both hypertext and multimedia to represent a wealth of information.

Summary

Both the terms hypertext and hypermedia follow a similar structure comprising of nodes that are interconnected by links except in hypermedia systems, the nodes can contain multiple forms of media such as text, images, audio, video, and graphics. The main difference lies in the way they are implemented. Hypertext is used to represent multimedia content in electronic text format whereas hypermedia combines both hypertext and multimedia to provide access to a wealth of information usually in a non-linear sequence. The idea of hypermedia is to extend the functionality of multimedia elements to make content more interactive and better accessible than before. The whole idea of the World Wide Web is based on the concept of hypertext and hypermedia.

MULTIMEDIA SYSTEM SOUNDS

Sound is perhaps the most important element of multimedia. It is meaningful "speech" in any language, from a whisper to a scream. It can provide the listening pleasure of music, the startling accent of special effects or the ambience of a mood setting background. Sound is the terminology used in the analog form, and the digitized form of sound is called as **audio**.

Power of Sound

When something vibrates in the air is moving back and forth it creates wave of pressure. These waves spread like ripples from pebble tossed into a still pool and when it reaches the eardrums, the change of pressure or vibration is experienced as sound. Acoustics is the branch of physics that studies sound. Sound pressure levels are measured in decibels (db); a decibel measurement is actually the ratio between a chosen reference point on a logarithmic scale and the level that is actually experienced.

Multimedia Sound Systems

The multimedia application user can use sound right off the bat on both the Macintosh and on a multimedia, PC running Windows because beeps and warning sounds are available as soon as the operating system is installed. On the Macintosh you can choose one of the several sounds for the system alert. In Windows system sounds are WAV files and they reside in the windows\Media subdirectory. There are still more choices of audio if Microsoft Office is installed. Windows makes use of WAV files as the default file format for audio and Macintosh systems use SND as default file format for audio.

Digital Audio

Digital audio is created when a sound wave is converted into numbers – a process referred to as **digitizing**. It is possible to digitize sound from a microphone, a synthesizer, existing tape recordings, live radio and television broadcasts, and popular CDs. You can digitize sounds from a natural or pre-recorded source.

Digitized sound is sampled sound. Ever nth fraction of a second, a sample of sound is taken and stored as digital information in bits and bytes. The quality of this digital recording depends upon how often the samples are taken.

Sampling rate or frequency, measured in kilohertz, or thousands of samples per second and how many numbers are used to represent the value of each sample (**bit depth**, **sample size**, resolution, or dynamic range).

The more often you take a sample and the more data you store about that sample, the finer the resolution and quality of the captured sound when it is played back.

Since the quality of your audio is based on the quality of your recording and not the device on which your end user will play the audio, digital audio is said to be **device independent.**

The three sampling rates most often used in multimedia are 44.1 kHz (**CD-quality**), 22.05 kHz, and 11.025 kHz. Sample sizes are either 8 bits or 16 bits.

The larger the sample size, the more accurately the data will describe the recorded sound.

An 8-bit sample size provides 256 equal measurement units to describe the level and frequency of the sound in that slice of time.

A 16-bit sample size, on the other hand, provides a staggering 65,536 equal units to describe the sound in that same slice of time

Preparing Digital Audio Files

Preparing digital audio files is fairly straight forward. If you have analog source materials – music or sound effects that you have recorded on analog media such as cassette tapes.

- The first step is to digitize the analog material and recording it onto a computer readable digital media.
- It is necessary to focus on two crucial aspects of preparing digital audio files: Balancing the need for sound quality against your available RAM and Hard disk resources.
- Setting proper recording levels to get a good, clean recording.

Remember that the sampling rate determines the frequency at which samples will be drawn for the recording. Sampling at higher rates more accurately captures the high frequency content of your sound. Audio resolution determines the accuracy with which a sound can be digitized.

Formula for determining the size of the digital audio

Monophonic = Sampling rate * duration of recording in seconds * (bit resolution / 8) * 1

Stereo = Sampling rate * duration of recording in seconds * (bit resolution / 8) * 2

- The sampling rate is how often the samples are taken.
- The sample size is the amount of information stored. This is called as bit resolution.

- The number of channels is 2 for stereo and 1 for monophonic.
- The time span of the recording is measured in seconds.

Sampling rate is measured in kHz, or thousand samples per second, so to convert from kHz to a whole number, you must multiply by 1,000

Eg) 10-second recording at 22.05 kHz, 8-bit resolution would be :

22050 * 10 * 8 / 8 * 1 = 220,500 bytes

A 10-second stereo recording at 44.1 kHz, 16-bit resolution would be :

44100 * 10 * 16 / 8 * 2 = 1,764,000 bytes

A 40-second mono recording at 11 kHz, 8-bit resolution would be :

11000 * 40 * 8 / 8 * 1 = 440,000 bytes.

Editing Digital Recordings

Once a recording has been made, it will almost certainly need to be edited. The basic sound editing operations that most multimedia procedures needed are described in the paragraphs that follow

1. **Multiple Tasks**: Able to edit and combine multiple tracks and then merge the tracks and export them in a final mix to a single audio file.

2. **Trimming**: Removing dead air or blank space from the front of a recording and an unnecessary extra time off the end is your first sound editing task.
3. **Splicing and Assembly**: Using the same tools mentioned for trimming, you will probably want to remove the extraneous noises that inevitably creep into recording.

4. **Volume Adjustments**: If you are trying to assemble ten different recordings into a single track there is a little chance that all the segments have the same volume.

5. **Format Conversion**: In some cases your digital audio editing software might read a format different from that read by your presentation or authoring program.

6. **Resampling or downsampling**: If you have recorded and edited your sounds at 16 bit sampling rates but are using lower rates you must resample or downsample the file.

7. **Equalization**: Some programs offer digital equalization capabilities that allow you to modify a recording frequency content so that it sounds brighter or darker.

8. **Digital Signal Processing**: Some programs allow you to process the signal with reverberation, multitap delay, and other special effects using DSP routines.

9. **Reversing Sounds**: Another simple manipulation is to reverse all or a portion of a digital audio recording. Sounds can produce a surreal, other wordly effect when played backward.

10. **Time Stretching**: Advanced programs let you alter the length of a sound file without changing its pitch. This feature can be very useful but watch out: most time stretching algorithms will severely degrade the audio quality.

MIDI VERSUS DIGITAL AUDIO

Musical Instrument Digital Interface (MIDI) is a communications standard developed in the early 1980s for electronic musical instruments and computers. It allows music and sound synthesizers from different manufacturers to communicate with each other by sending messages along cables connected to the devices.

Definition :

MIDI (Musical Instrument Digital Interface) is a protocol which allows electronic instruments and other digital musical tools to communicate with each other.

MIDI itself does not make sound, it is just a series of messages like "note on," "note off," "note/pitch," "pitchbend," and many more. These messages are interpreted by a MIDI instrument to produce sound.

Multimedia sound → 1. Digitally record
2. MIDI

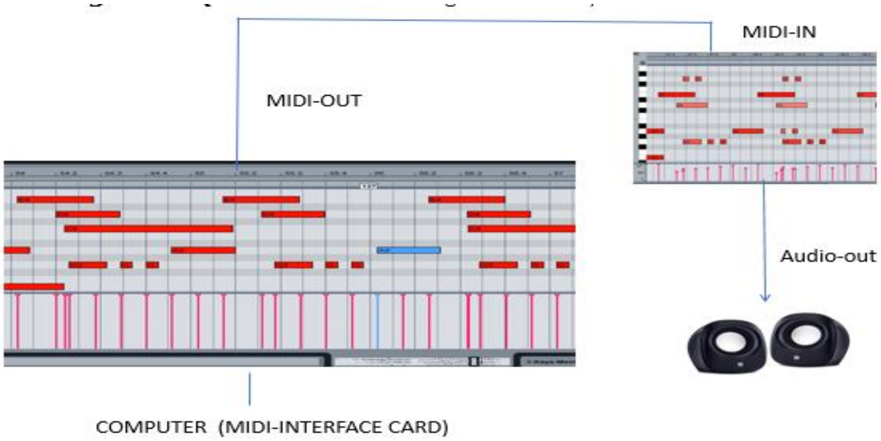


Fig. 4.11 Structure of MIDI

Components of MIDI:

1. **Synthesizer**: It is a sound generator (various pitch, loudness , tone)
   A good synthesizer has a microprocessor, keyboard,Control Panels, memory,etc.
2. **Sequencer** :It can be a stand-alone unit or a software program for a PC
   It is used as a storage server for MIDI data
3. **Track** : Is a sequencer used to organize the recordings.Track can be turned on or off or recordings or playing back
4. **Channels** : Used to separate information in MIDI system. There are 16 MIDI channels in one cable. Channel numbers are coded into each MIDI message
5. **Timbre** : Quality of sound is determined
   eg) flute sound, peano, etc.
   Multitimbral : Capable of playing many different sounds at the same time
6. **Pitch** : Musical note that the instrument plays
7. **Voice :** Voice is the portion of the synthesizer that produces sound.
8. **Patch** : Control settings

MIDI connectors :

It has three 5-pin ports found on back of every MIDI unit

1. **MIDI in** : Receives MIDI data
2. **MIDI out** :Transmits the data it generated
3. **MIDI through** : The connector by which the device echos the data receiving from MIDI in

A concise MIDI message can cause a complex sound or sequence of sounds to play on an instrument or synthesizer; so MIDI files tend to be significantly smaller (per second of sound delivered to the user) than equivalent digitized waveform files.

Composing your own original score can be one of the most creative and rewarding aspects of building a multimedia project, and MIDI is the quickest, easiest, and most flexible tool for this task. Yet creating an original MIDI score is hard work. Knowing something about music, being able to play a keyboard, and having a lot of good ideas are just the pre- requisites to building a good score; beyond that, it takes time and musical skill to work with MIDI.

The process of creating MIDI music is quite different from digitizing existing recorded audio. If you think of digitized audio as analogous to a bitmapped graphic image (both use sampling of the original analog medium to create a digital copy), then MIDI is analogous to structured or vector graphics .

Rather than recording the sound of a note, MIDI software creates data about each note as it is played on a MIDI keyboard (or another MIDI device)—which note it is, how much pressure was used on the keyboard to play the note, how long it was sustained, and how long it takes for the note to decay or fade away. This information, when played back through a MIDI device, allows the note to be reproduced exactly. Because the quality of the playback depends upon the end user's MIDI device rather than the recording, MIDI is device dependent.

An advantage of structured data such as MIDI is the ease with which you can edit the data. Let's say you have a piece of music being played on **a piano**, but your client decides he wants the sound of a **guitar** instead. If you had the music in digitized audio, you would have to re-record and redigitize the music. When it is in MIDI data, however, there is a value that designates the instrument to be used for playing back the music. To change instruments, you just change that value. Instruments that you can synthesize are identified by a **General MIDI** numbering system that ranges from 0 to 127.

MIDI Files Advantages:

- MIDI files are much more compact than digital audio files.
- MIDI files embedded in web pages load and play more quickly than their digital equivalent.
- MIDI data is completely editable. A particular instrument can be removed from the song and/or a particular instrument can be changed by another just by selecting it.
- MIDI files may sound better than digital audio files if the MIDI sound source you are using his of high quality.

MIDI Files Disadvantages:

- MIDI playback will be accurate only if the MIDI playback device is identical to the device used for production.
- MIDI cannot easily be used to play back spoken dialogue.
- working with MIDI data requires familiarity with musical scores, keyboards, notation, and audio production.
- MIDI data is device dependent (the sounds produced by MIDI music files depend on the particular MIDI device used for playback).

MAKING MIDI AUDIO

Since MIDI is device dependent and the quality of consumer MIDI playback hardware varies greatly, MIDI's true place in multimedia work may be as a production tool rather than a delivery medium. MIDI is by far the best way to create original music, so use MIDI to get the flexibility and creative control you want.

In addition to describing the instrument and the note, MIDI data can also describe the envelope of the sound: the attack (how quickly a sound's volume increases), the sustain (how long the sound continues), and the decay (how quickly the sound fades away).

In contrast to MIDI data, digital audio data is the actual representation of a sound, stored in the form of thousands of individual numbers *(samples)*. The digital data represents the instantaneous amplitude (or loudness) of a sound at discrete slices of time. That is, MIDI data is device dependent; digital data is not.

The sounds produced by MIDI music files depend on the particular MIDI device used for playback.

ADVANTAGES OF MIDI :

MIDI files are much more compact than digital audio files, and the size of a MIDI file is completely independent of playback quality. In general, MIDI files will be 200 to 1,000 times smaller than CD-quality digital audio files. Because MIDI files are small, they don't take up as much memory, disk space, or bandwidth.

Because they are small, MIDI files embedded in web pages load and play more quickly than their digital equivalents.

- In some cases, if the MIDI sound source you are using is of high quality, MIDI files may sound better than digital audio files.
- You can change the length of a MIDI file (by varying its tempo) without changing the pitch of the music or degrading the audio quality. MIDI data is completely editable—right down to the level of an individual note. You can manipulate the smallest detail of a MIDI composition (often with sub millisecond accuracy) in ways that are impossible with digital audio.
- Because they represent the pitch and length of notes, MIDI files can generally be converted to musical notation, and vice versa. This is useful when you need a printed score; in reverse, you can scan a printed score and convert it to MIDI for tweaking and editing.

RECORDING MIDI FILES

MIDI files can be generated:

i) by recording the MIDI data using MIDI instrument (electronic keyboard) as it is played.

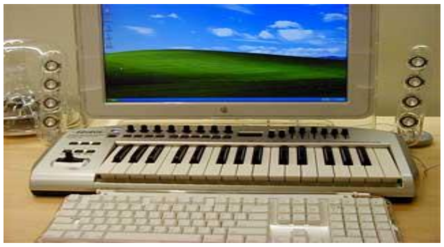


Fig. 4.12 MIDI keyboard

ii) by using a MIDI sequencer software application to record and edit (cut, paste, delete, insert).

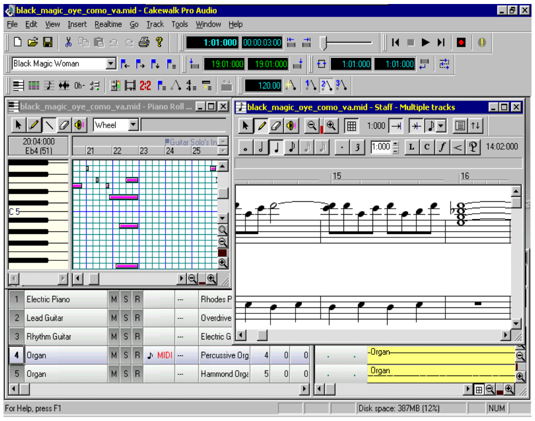

black_magic_oye_como_va.mid - Cakewalk Pro Audio
File Edit View Insert Realtime Go Track Tools Window Help
Black Magic Woman
black_magic_oye_como_va.mid - Piano Roll
black_magic_oye_como_va.mid - Staff - Multiple tracks
Wheel
C 5
1 Electric Piano
2 Lead Guitar
3 Rhythm Guitar
4 Organ
5 Organ
Rhodes P
Overdrive
Electric G
Percussive Org
Hammond Orga
Organ
Organ
For Help, press F1
Disk space: 387MB (12%)
NUM

Fig. 4.12 MIDI sequencer

MIDI is analogous to structured or vector graphics, while digitized audio is analogous to bitmapped images.

MIDI is device dependent while digitized audio is device independent.

MIDI files are much smaller than digitized audio.

MIDI files sound better than digital audio files when played on a high-quality MIDI device.

File formats compatible with multimedia authoring software being used along with delivery mediums, must be determined.

Sound playback capabilities offered by end user’s system must be studied.

Multimedia System Sound

Beeps and warning sounds are available as soon as you install the operating system. Open the Sound Control Panel to listen to your system sounds, change them, or make a new, custom sound.

In Windows, system sounds are WAV (**WAVEFORM AUDIO FILE) files, and they reside in the Windows\Media subdirectory.**

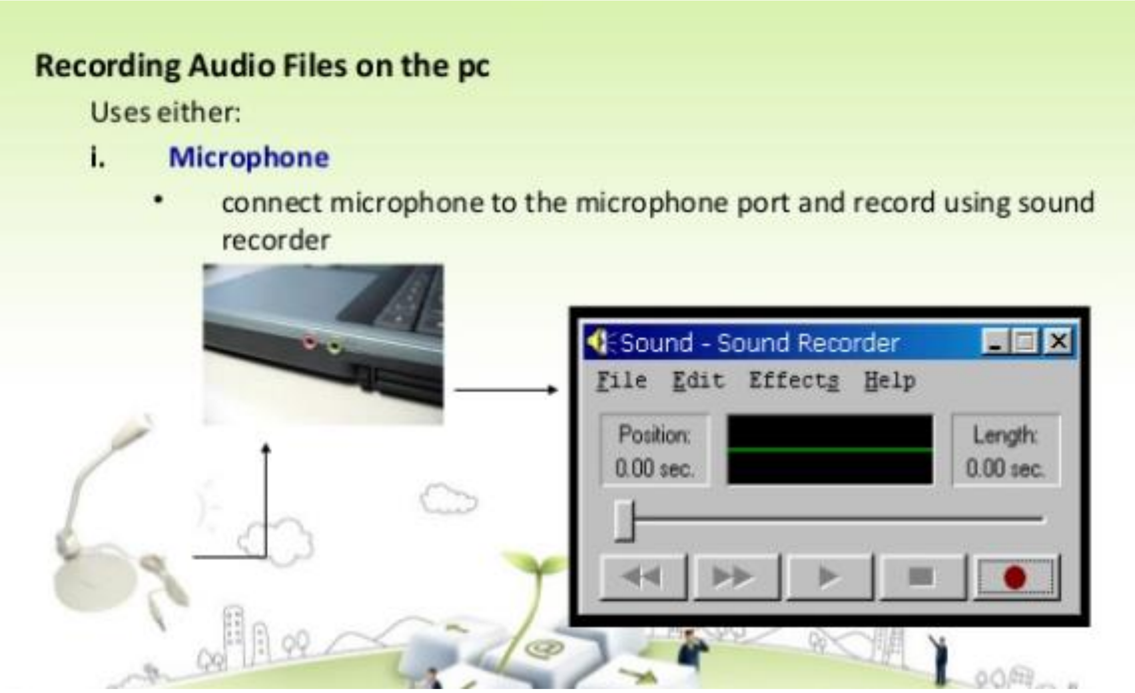
System event sounds include :

start.wav, chimes.wav, chord.wav, ding.wav, logoff.wav, notify.wav, recycle.wav, tada. wav, and the Microsoft sound.wav that typically plays when Windows starts up.

you can assign these sounds to system events such as Windows startup, warnings from other applications, or clicks outside of an open dialog box.

We can create schemes of sounds and select a particular scheme according to our mood. We can also add our own sound files and install them so they play when system events occur: place the WAV sound files into your ~\Windows\Media directory and use the Sound Control Panel to select them.

RECORDING AUDIO FILES



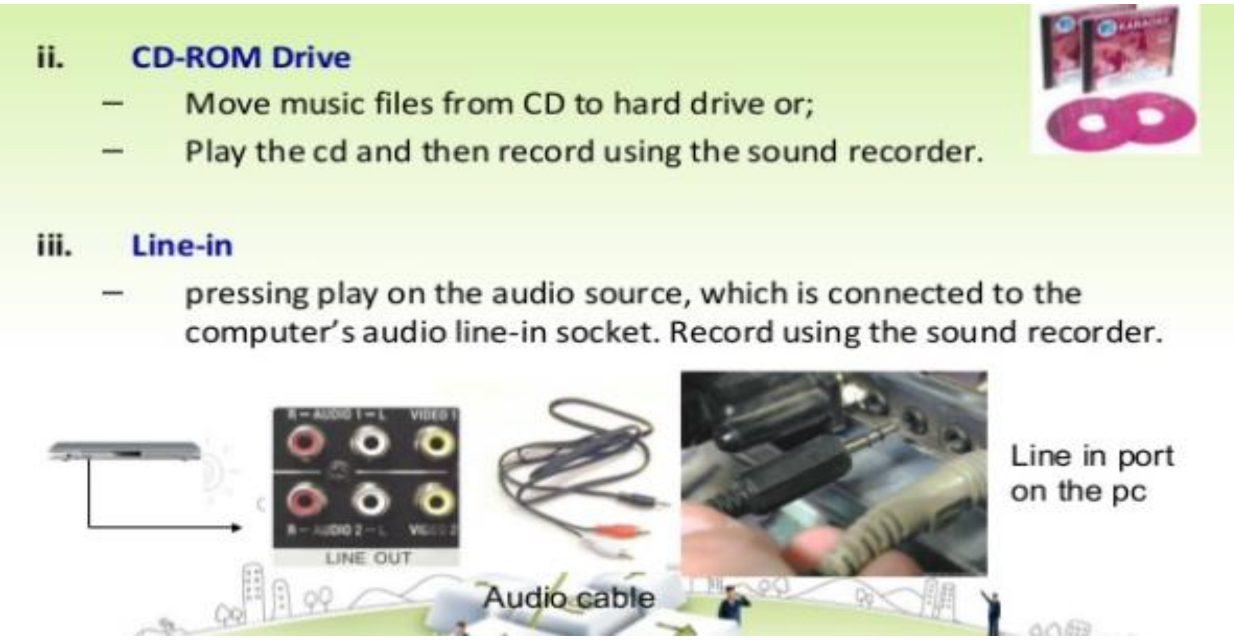
Recording Audio Files on the pc

Uses either:

i. **Microphone**

- connect microphone to the microphone port and record using sound recorder

Fig. 4.13 Recording Audio Files



ii. **CD-ROM Drive**

- Move music files from CD to hard drive or;
- Play the cd and then record using the sound recorder.

iii. **Line-in**

- pressing play on the audio source, which is connected to the computer's audio line-in socket. Record using the sound recorder.

R – AUDIO 1 – L
VIDEO 1
R – AUDIO 2 – L
VIDEO 2
LINE OUT
Audio cable
Line in port on the pc

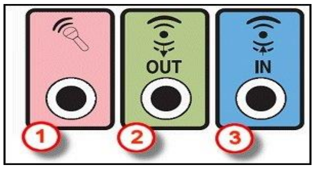
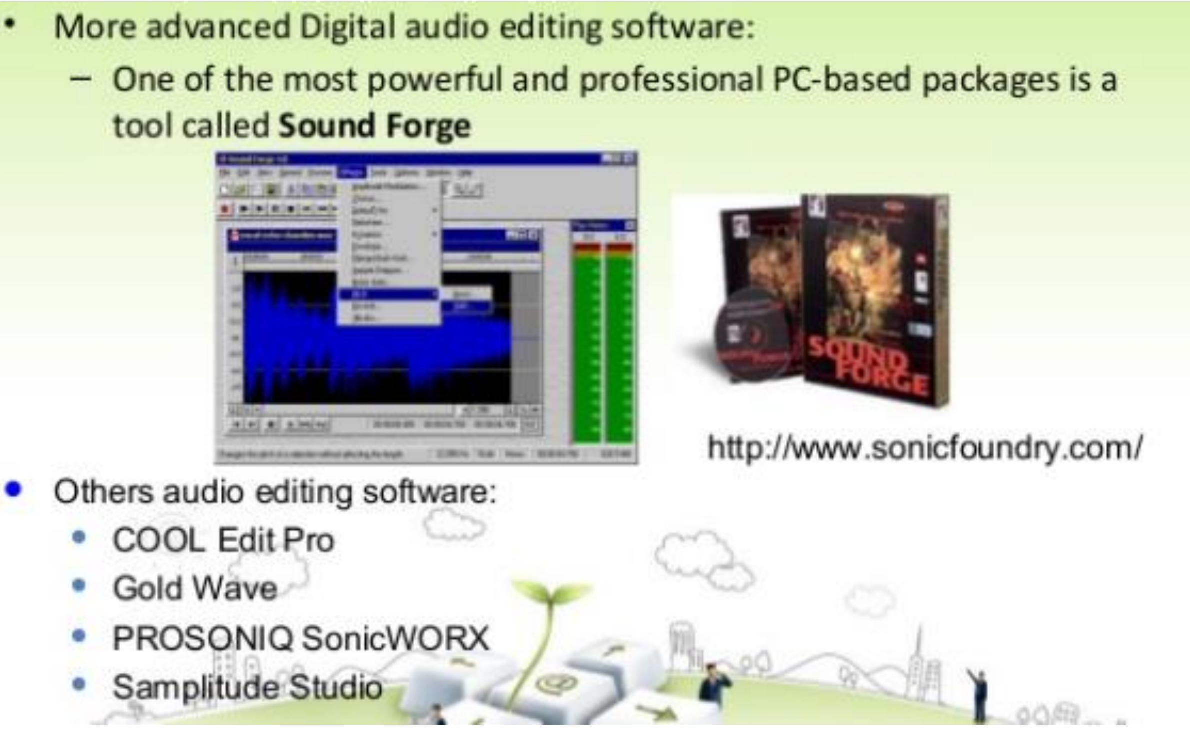


Fig. 4.14 Recording sound recorder



- More advanced Digital audio editing software:
  - One of the most powerful and professional PC-based packages is a tool called **Sound Forge**

http://www.sonicfoundry.com/

- Others audio editing software:
  - COOL Edit Pro
  - Gold Wave
  - PROSONIQ SonicWORX
  - Samplitude Studio

SOUND FORGE

Fig. 4.15 Audio Editing Softwares

In OS X on a Macintosh, you can only change your system alert sound. Put your custom sound file (in **AIF format**) into

~/System/Library/Sounds, then select it in the Sound preference pane.

AUDIO FILE FORMATS

When you create multimedia, it is likely that you will deal with file formats and translators for text, sounds, images, animations, or digital video clips.

A sound file's format is simply a recognized methodology for organizing and (usually) compressing the digitized sound's data bits and bytes into a data file. The structure of the file must be known, of course, before the data can be saved or later loaded into a computer to be edited and/or played as sound. The file name extension identifies which method of storage is used.

There are many ways to store the bits and bytes that describe a sampled waveform sound. The method used for consumer-grade music CDs is **Linear Pulse Code Modulation (LPCM),** often shortened to **PCM.**

An audio CD provides up to 80 minutes of playing time.

The CD-ROM/XA (extended architecture) format for reading and writing CDs was developed later so you could put several recording sessions of music or data onto a single CD-R (recordable) disc.

LPCM tracks from an audio CD are usually converted and stored on a computer in uncompressed AIFF (Audio Interchange File Format) or wave format (WAV) files when copied from the CD.

Audio format defines the quality and loss of audio data. Based on application different type of audio format are used. Audio formats are broadly divided into three parts:

1. Uncompressed Format
2. Lossy Compressed format
3. Lossless Compressed Format

1. Uncompressed Audio Format:

- **PCM –**
  It stands for Pulse-Code Modulation. It represents raw analog audio signals in digital form. To convert analog signal into digital signal it has to be recorded at a particular interval. Hence it has

sampling rate and bit rate (bits used to represent each sample). It a exact representation of the analog sound and do not involve compression. It is the most common audio format used in CDs and DVDs

- **WAV –**
  It stands for Waveform Audio File Format, it was developed by Microsoft and IBM in 1991. It is just a Windows container for audio formats. That means that a WAV file can contain compressed audio. Most WAV files contain uncompressed audio in PCM format. It is just a wrapper. It is compatible with both Windows and Mac.
- **AIFF –**
  It stands for Audio Interchange File Format. It was developed by Apple for Mac systems in 1988. Like WAV files, AIFF files can contain multiple kinds of audio. It contain uncompressed audio in PCM format. It is just a wrapper for the PCM encoding. It is compatible with both Windows and Mac.

2. Lossy Compressed Format:

It is a form of compression that loses data during the compression process. But difference in quality no noticeable to hear.

- **MP3 –**
  It stands for MPEG-1 Audio Layer 3. It was released in 1993 and became popular. It is most popular audio format for music files. Main aim of MP3 is to remove all those sounds which not hearable or less noticeable by humans' ears. Hence making size of music file small. MP3 is like universal format which is compatible almost every device.
- **AAC –**
  It stands for Advanced Audio Coding. It was developed in 1997 after MP3.The compression algorithm used by AAC is much more complex and advanced than MP3, so when compared a particular audio file in MP3 and AAC formats at the same bitrate, the AAC one will generally have better sound quality. It is the standard audio compression method used by YouTube, Android, iOS, iTunes, and PlayStations.
- **WMA –**
  It stands for Windows Media Audio. It was released in 1999.It was designed to remove some of the flaws of MP3 compression method. In terms of quality it is better than MP3. But is not widely used.

3. Lossless compression:

This method reduces file size without any loss in quality. But is not as good as lossy compression as the size of file compressed to lossy compression is 2 and 3 times more.

- **FLAC –**
  It stands for Free Lossless Audio Codec. It can compress a source file by up to 50% without losing data. It is most popular in its category and is open-source.
- **ALAC –**
  It stands for Apple Lossless Audio Codec. It was launched in 2004 and became free after 2011. It was developed by Apple.

- **WMA –**
  It stands for Windows Media Audio. But it is least efficient in term of compression and is not open-source. It has limited hardware support.

  The **SWF** format is a container for vector-based graphics and animations, text, video, and sound delivered over the Internet. Typically created using Adobe's Flash, **SWF files require a plug-in** or player be installed in the user's browser.
  Adobe claims that the Flash Player is installed in more than 98 percent of Web users' browsers and in more than 800 million handsets and mobile devices.
  Flash video files (FLV) contain both a video stream and an audio stream, and the FLV format has been adopted by **YouTube, Google, Yahoo, Reuters.com, BBC.com, CNN.com**, and other news providers for Internet delivery of content.

ADDING SOUND TO YOUR MULTIMEDIA PROJECT

The original 128K Macintosh, released in January 1984, was technically a multimedia-capable machine.It displayed bitmapped graphics (in black and white) and loaded with 8-bit digital audio capability on the motherboard. The very first Macintosh was introduced by Steve Jobs. Apple become the most popular provider of music in the world through its **iTunes** facility.

Steps to bring an audio recording into your multi- media project :

1. Determine the file formats that are compatible with your multi- media authoring software and the delivery medium you will be using (for file storage and bandwidth capacity).

2. Determine the sound playback capabilities (codecs and plug-ins) that the end user's system offers.

3. Decide what kind of sound is needed (such as background music, special sound effects, and spoken dialog). Decide where these audio events will occur in the flow of your project

4. Decide where and when you want to use either digital audio or MIDI data.

5. Acquire source material by creating it from scratch or purchasing it.

6. Edit the sounds to fit your project.

7. Test the sounds to be sure they are timed properly with the project's images. This may involve repeating steps 1 through 4 until every- thing is in sync.

Each multimedia authoring program or web browser handles sound a bit differently, but the process is usually fairly straight forward: just tell your software which file you want to play and when to play it. This is usually handled by an importing or "linking" process during which you identify the files to play.

In multimedia authoring environments, it is usually a simple matter to play a sound when the user clicks a button. If the user changes screens while a long file is playing, for example, you may need to program the sound to stop before leaving the current screen. If the file to be played cannot be found, you may need to code an entire section for error handling and file location. Sample code is generally provided in both printed and online documentation for software that includes sound playback. For web pages, you will need to embed a player and point to your sound file using HTML code.

The substantial amount of digital information required for high- quality sound takes up a lot of storage space, especially when the quantity is doubled for two-channel stereo. It takes about 1.94MB to store 11 seconds of uncompressed stereo sound.

Many multimedia developers use 8-bit sample sizes at 22.05 kHz sampling rates because they consider the sound to be good enough .

The following formula is used to estimate storage needs. If you are using two channels for stereo, double the result.

(sampling rate * bits per sample) / 8 = bytes per second

If you prefer to solve for kilobytes (KB), not bytes, then try:

sample rate * sample size / 8 * # seconds * 2 (if stereo) = file size in KB

For example, 60 seconds of stereo in Red Book Audio:

44.1 * 16 / 8 * 60 * 2 = 10,584KB Ξ 10.59MB

For example, if you are satisfied with 22.05 kHz in your project or are constrained to this rate by storage considerations, any consumer-grade digital or analog recorder of reasonable quality will do fine. This, of course, also applies to conversations recorded from the telephone, where a sampling rate of 11.025 kHz is adequate. Noise reduction circuits and metal tapes are helpful to remove hiss, but at a sampling rate of 22.05 kHz you are only going to be digitizing audio frequencies as high as about 11 kHz, anyway.

Digital audio tape (DAT) systems provide a tape-based 44.1 kHz,

16-bit record and playback capability. The recordings are too accurate, precisely recording glitches, background noises, microphone pops, and coughs from the next room. A good editor can help reduce the impact of these noises, but at the cost of time and money.

Audio Recording

Mobile phones can often record audio (and video), and applications and hardware attachments are available to manage external microphones and file transfer. USB and flash memory recorders range in quality, some suitable for voice only, some generating compressed MP3 files, and some recording in CD-quality stereo. Recordings can be directly downloaded as digital files using a USB cable or flash memory card reader.

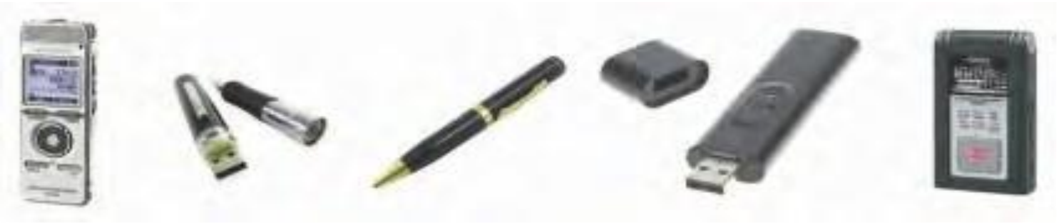
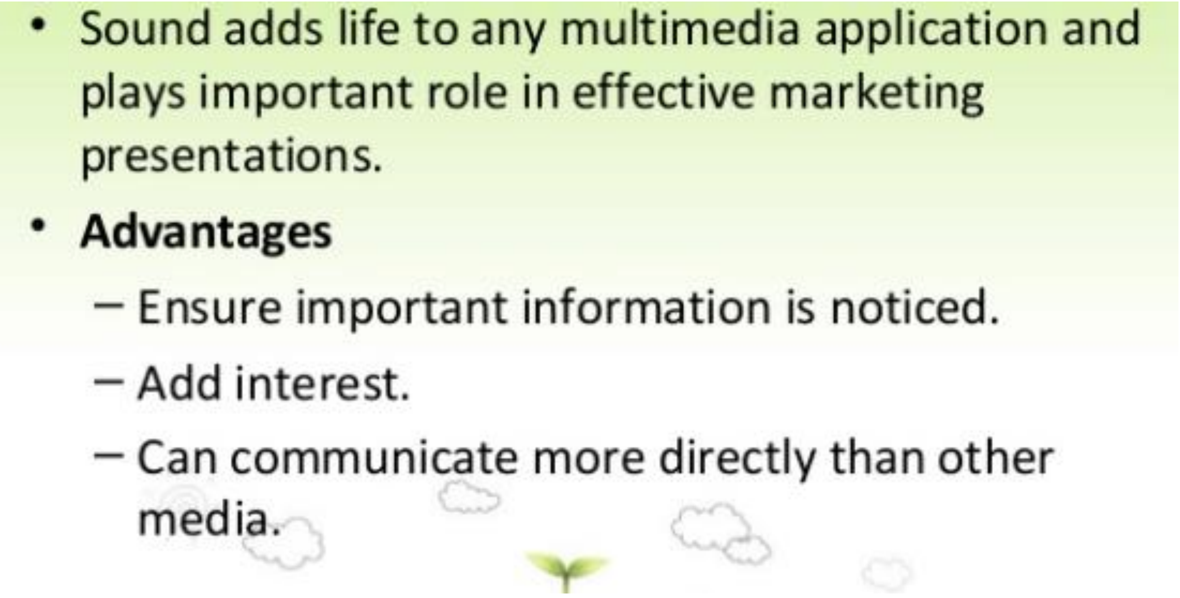
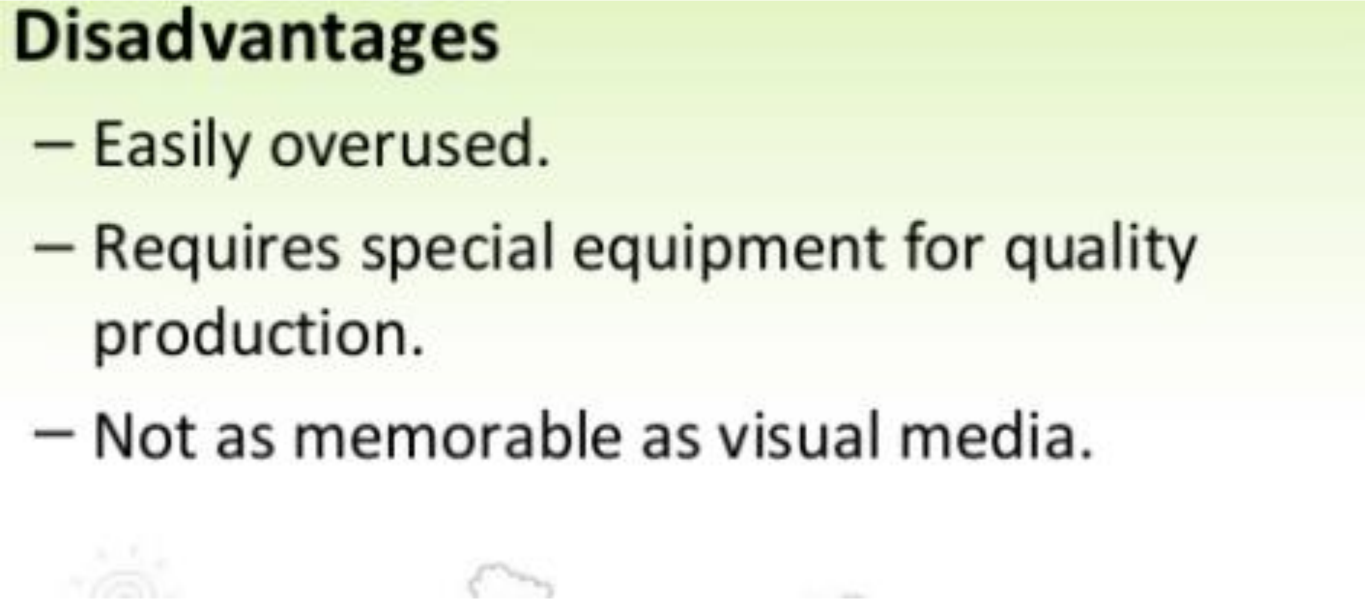


Fig. 4.16 Devices used for recording



- Sound adds life to any multimedia application and plays important role in effective marketing presentations.
- **Advantages**
  - Ensure important information is noticed.
  - Add interest.
  - Can communicate more directly than other media.



Disadvantages

- Easily overused.
- Requires special equipment for quality production.
- Not as memorable as visual media.

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UNIT – V – Computer Graphics and Multimedia – SBS1303

Images: Making Still Images – Color – Image File Formats – Animation: The Power of Motion – Principles of Animation – Making Animations that Work – Video: Using Video – How Video works - Broadcast Video Standards – Integrating Computers and Television – Shooting and Editing Video – Video Tips – Recording Formats – Digital Video-Multimedia and the Internet

MAKING STILL IMAGES

Multimedia on a computer screen is a composite of elements: text, symbols, photograph-like bitmaps, vector-drawn graphics, three-dimensional renderings, distinctive buttons to click, and windows of motion video. Still images may be small or large, or even full screen. They may be colored, placed at random on the screen, evenly geometric, or oddly shaped.

Still images may be :

- A single tree on a wintry hillside;
- an engineering drawing;
- Your neighbor's BMW car.

Whatever their form, still images are generated by the computer in two ways: as bitmaps (or paint graphics) and as vector-drawn graphics. Bitmaps may also be called "raster" images. Likewise, bitmap editors are sometimes called "painting" programs. And vector editors are sometimes called "drawing" programs.

Pictures are often described in terms of the number of colors found in the image. A simple black and white line drawing is considered to be a 1-bit picture. The word "bit" is derived from the word "binary digit" and refers to a digit in the binary number system.

Humans most often use the decimal system in which each digit can have one of 10 values (0 through 9). Computers use the binary system in which each digit can have one of two values (0 or 1). In the binary system a set of two bits (binary digits) can represent four values. The number of values that can be represented increases by a power of 2 with the addition of each bit. The use of more bits per pixel (picture element) adds more color possibilities to an image and increases the file size for the image as well.

Bits per Pixel	Number of Colors	Applications
1	2	Black and White Drawings
2	4	Simple Color Icons
3	8	Simple Color Icons
4	16	Simple Color Icons
5	32	Simple Color Icons
6	64	Color Icons
7	128	Color Icons
8	256	Icons, Low-res Photographs
16	65,536	Photographs, Video
24	16,777,216	True-color Photographs, Video

PIXEL

The unit of measurement used for computer graphics is the pixel. The term "pixel" is derived from the word "picture element". A computer screen can be measured in pixels.

Most 15-inch monitors today can be set to display a grid of pixels 640 wide by 480 tall. The horizontal and vertical pixel dimensions are referred to as the resolution. By using smaller pixels, a 15-inch monitor can also be set to display a grid of 800 by 600 pixels or 832 by 624 pixels.

Larger monitors (17-inch or 20-inch) typically can use these resolutions as well as 1024 by 768. When creating a graphic for use on a computer screen, therefore, wise content creators take care to observe the lowest common denominator and avoid creating individual graphics larger than 600 pixels wide and 400 pixels tall. The size of the graphic in pixels (resolution) and the number of colors found in the graphic are both important factors in the size of the file used to store the image.

Bitmaps are used for **photo-realistic images** and for complex drawings requiring fine detail. **Vector-drawn objects** are used for lines, boxes, circles, polygons, and other graphic shapes that can be mathematically expressed in angles, coordinates, and distances.

A drawn object can be filled with color and patterns, and you can select it as a single object. The appearance of both types of images depends on the display resolution and capabilities of your computer's graphics hardware and monitor. Both types of images are stored in various file formats and can be translated from one application to another or from one computer platform to another.

Typically, image files are compressed to save memory and disk space; many bitmap image file formats already use compression within the file itself—for example GIF, JPEG, and PNG.

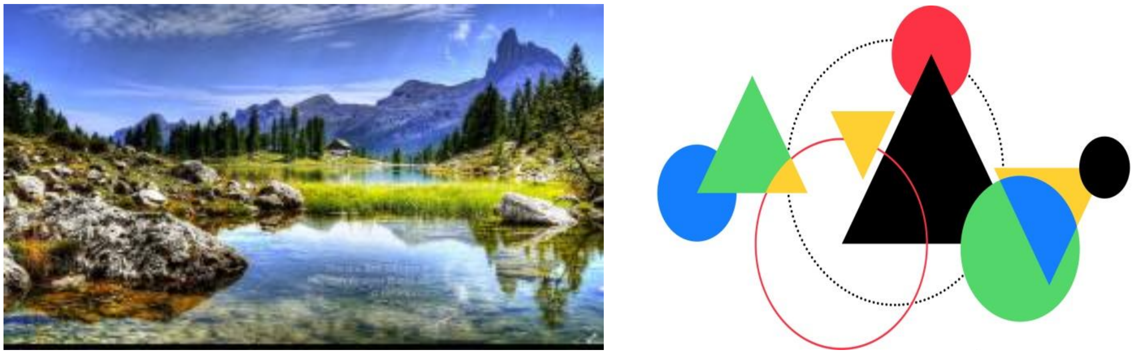
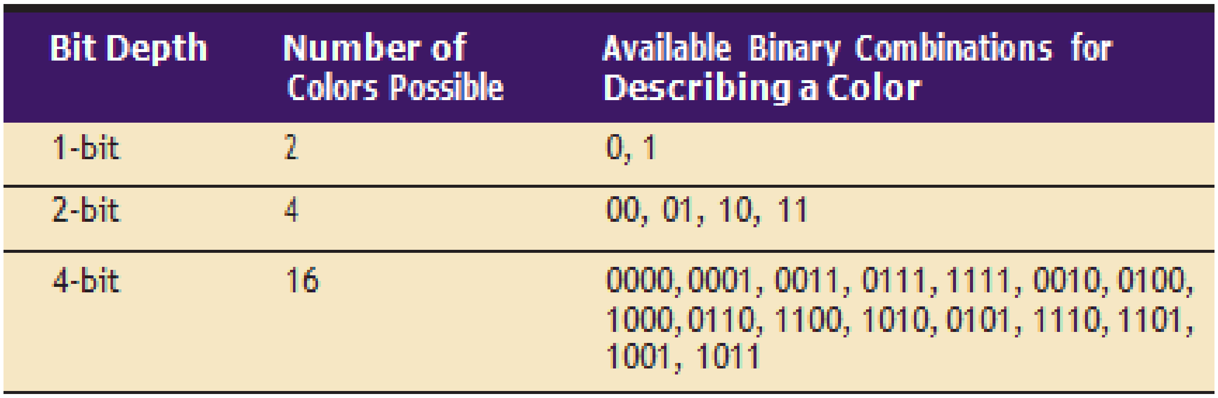


Fig 5.1 Bitmap Vs Vector Graphics

A **bit** is the simplest element in the digital world, an electronic digit that is either on or off, black or white, or true (1) or false (0). This is referred to as binary. A map is a two- dimensional matrix of these bits. A **bitmap**, then, is a simple matrix of the tiny dots that form an image and are displayed on a computer screen or printed.

A one-dimensional matrix (1-bit depth) is used to display monochrome images—a bitmap where each bit is most commonly set to black or white.

More information is required to describe shades of gray. These picture elements (known as **pels** or, more commonly, **pixels**) can be either on or off, as in the 1-bit bitmap, or, by using more bits to describe them, can represent varying shades of color (4 bits for 16 colors; 8 bits for 256 colors; 15 bits for 32,768 colors; 16 bits for 65,536 colors; 24 bits for 16,772,216 colors). Thus, with 2 bits, for example, the available zeros and ones can be combined in only four possible ways and can, then, describe only four possible colors:



Bit Depth	Number of Colors Possible	Available Binary Combinations for Describing a Color
1-bit	2	0, 1
2-bit	4	00, 01, 10, 11
4-bit	16	0000, 0001, 0011, 0111, 1111, 0010, 0100, 1000, 0110, 1100, 1010, 0101, 1110, 1101, 1001, 1011

BITMAPS

Together, the state of all the pixels on a computer screen make up the image seen by the viewer, whether in combinations of black and white or colored pixels in a line of text, a photograph-like picture, or a simple back- ground pattern.

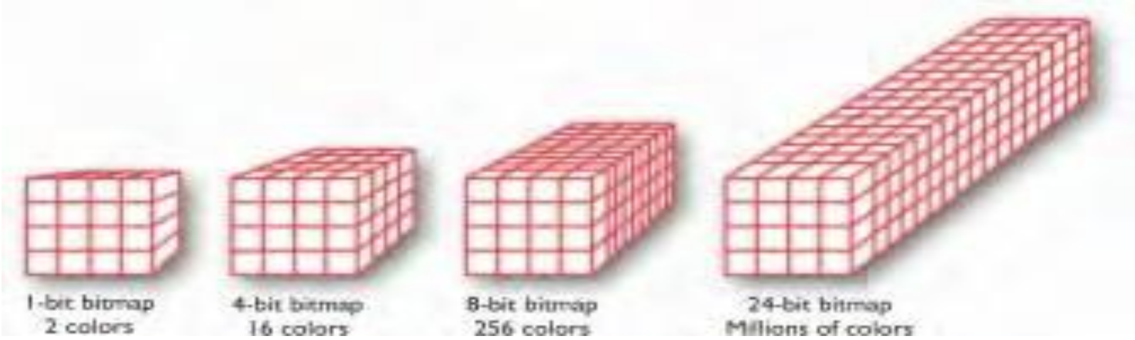


Fig 5.2 Bitmap representation

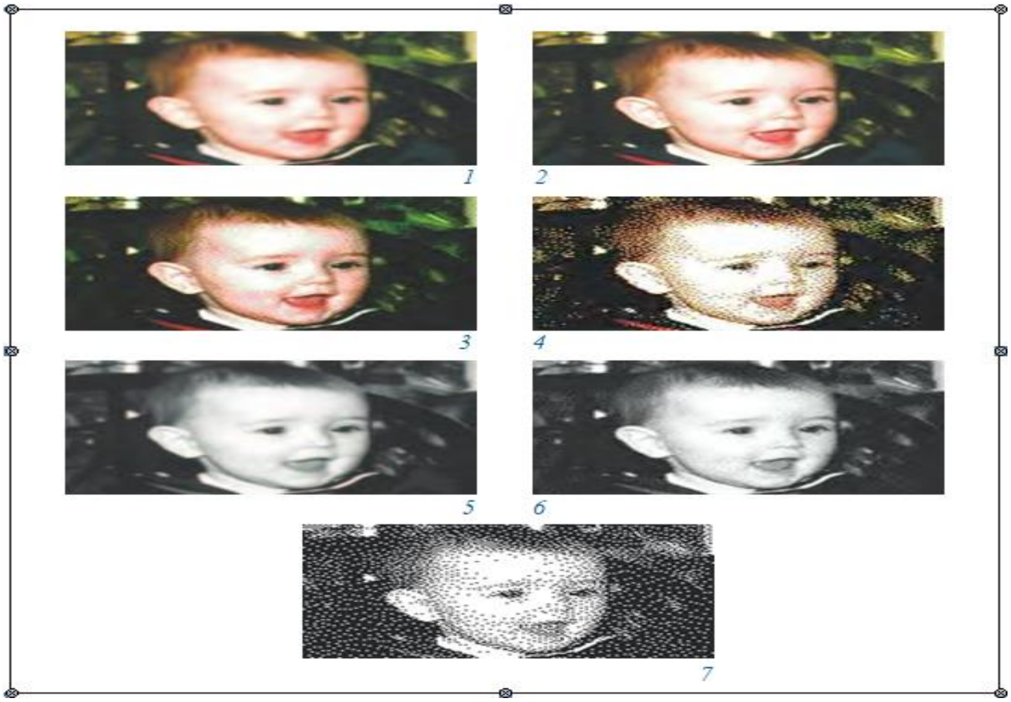


Fig 5.3 Images showing the color depth of bitmaps

Image 1 : 24 bits (millions of colors)
Image 2 : 8 bits uses adoptive palette (256 colors)
Image 3: 8 bits uses Mac system palette (256 colors)
Image 4: 4 bits (16 colors)
Image 5 : 8 bit gray scale (256 shades of gray)
Image 6 : 4 bit (16 shades of gray)
Image 7 : 1 bit (2 colors – Black & White)
Images 4 & 6 require the same memory but the gray-scale image is superior.

Where do Bitmaps come from ?

- Make a bitmap from scratch with a paint or drawing program.
- Grab a bitmap from an active computer screen with a screen capture program, and then paste it into a paint program or your application.
- Capture a bitmap from a photo or other artwork using a scanner to digitize the image.
- Once made, a bitmap can be copied, altered, e-mailed, and otherwise used in many creative ways.

ACQUIRING IMAGES

Very often multimedia authors use preexisting images to enhance their work. Images can be acquired from clip art collections on CDROM or through the use of a scanner. Royalty-free clip art collections are commonly available from mail order software stores. The images in these collections are free for you to use in printed and in some cases electronic publications.

A scanner can be used to take a digital picture of a photograph or other image and save that image as an electronic file on the computer's hard disk. Using photographs that you have taken is usually legal unless the photograph contains images of children other than your own or other persons who may require a release form before allowing you to publish the photograph.

Images scanned from books may be used for educational purposes only if the use complies with "fair use" provisions in the copyright law. In most cases, this means that copyrighted images from books can not be placed on web pages or otherwise distributed electronically without the permission of the copyright holder. Graphic images downloaded from web sites should also be used only with the permission of the copyright holder.

You can also download an image bitmap from a web site: in most browsers right-click over the image to see a menu of options.

Choose “Download image to disk,” “Copy Image,” or “Save picture as….”

Regardless of the source of the image, you should be aware of who owns the copyright to the image you wish to use and what is required to reproduce the image legally.

Legal rights protecting use of images from clip libraries fall into **three basic** groupings :

1. Public domain images are neither protected by a copyright or their copyright protection has ended.
2. Royalty-free images are purchased and then used without paying additional license fees
3. Rights-managed images require that you negotiate with the rights holder regarding terms for using the image and how much you will pay for that use.

Commercially available images

Images can be obtained from www.gettyimages.com. The Photodisc collections contain high- resolution bitmaps with a license for their “unlimited use.

Fig 5.4 gettyimages.com

Regardless of the source, once you have a bitmap, you can manipulate and adjust many of its properties (such as brightness, contrast, color depth, hue, and size). You can also cut and paste among many bitmaps using an image-editing program.

Bitmap Software

Macintosh computers do not ship with a painting tool, and Windows provides a default Paint program. Many multimedia authoring tools offer built-in bitmap editing features.

1. Director (image-editor with features such as onion-skinning and image filtering)

2. Adobe’s Photoshop (most widely used image-editing tool among designers)

Many designers use vector-based painting program such as :

- Adobe’s Illustrator
- Corel Draw

You can use your image- editing software to create original images, such as cartoons, symbols, buttons, bitmapped text, and abstract images that have a refined “graphic” look, but it is virtually impossible to create a realistic-looking photo from scratch using an image-editing program.

Capturing and Editing Images

In order to assemble images for your multimedia project, you may often need to capture and store an image directly from your screen. The simplest way to capture what you see on the screen at any given moment is to press the proper keys on your computer keyboard.

Windows environments have a **clipboard**— an area of memory where data such as text and images is temporarily stored when you cut or copy them within an application. In Windows, when you press print screen, a copy of your screen’s image goes to the clipboard. From the clipboard, you can then paste the captured bitmap into an application (such as Paint, which comes with Windows).

You can also press command- control-shift-4 to drag a rectangle on your screen and capture what is inside the rectangle onto the clipboard, ready for pasting.

Interesting image editing techniques

Croping

Morphing (is an effect that can be used to manipulate still images orto create interesting and often animated transformations).

Morphing allows to smoothly blend two images so that one image seems to melt into the next, often producing some amusing results.

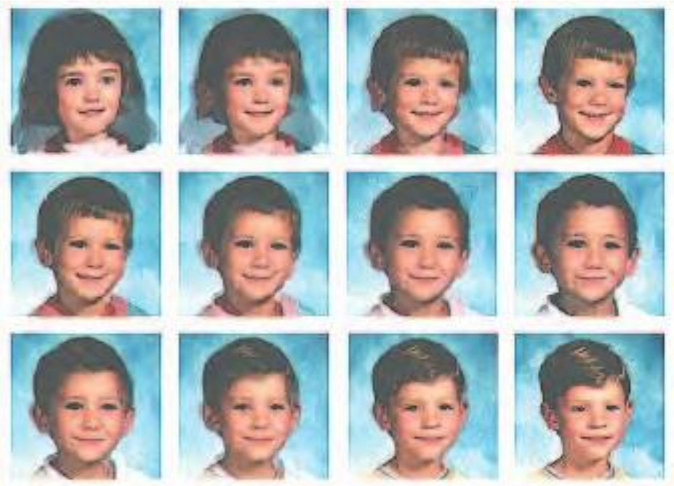


Fig 5.5 Morphing

Filtering

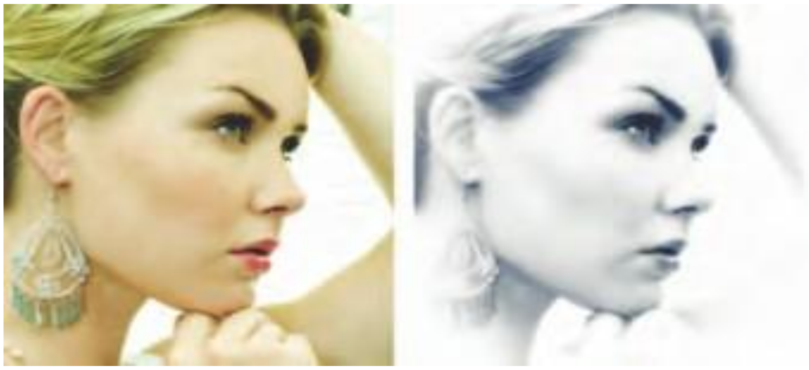


Fig 5.6 Filtering

Vector Drawing

Most multimedia authoring systems provide use of vector-drawn objects such as lines, rectangles, ovals, polygons, complex drawings created from those objects, and text.

- **Computer-aided design (CAD)** programs have traditionally used vector-drawn object systems for creating the highly complex and geometric renderings needed by architects and engineers.
- **Graphic artists** designing for print media use vector-drawn objects because the same mathematics that put a rectangle on your screen can also place that rectangle (or the fancy curves of a good line-art illustration) on paper without jaggies. This requires the higher resolution of the printer, using a page description format such as Portable Docu- ment Format (PDF).
- Programs for 3-D animation also use vector-drawn graphics. For example, the various changes of position, rotation, and shading of light required to spin an extruded corporate logo must be calculated mathematically

A **vector** is a line that is described by the location of its two endpoints. Vector drawing uses **Cartesian coordinates** where a pair of numbers describes a point in two-dimensional space as the intersection of horizontal and vertical lines (the x and y axes).

For eg., Line can be defined with 4 coordinates (2 starting and 2 ending coordinates)

Type the following code in notepad and save it with the extension .html and while opened in a browser will produce output as shown in Fig. below

```
<svg height="600" width="600">
<circle cx="50" cy="50" r="40" stroke="black" stroke-width="3" fill="red" />
<rect x="100" y="100" width="200" height ="200" fill ="green" stroke="yellow" />
<line x1="200" y1="20" x2="400" y2="20" stroke="blue“ stroke-width=“2"/>
</svg>
```

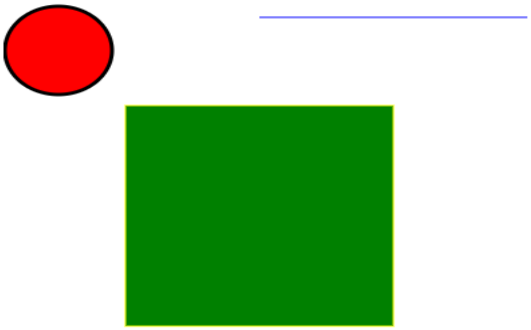


Fig 5.7 Output of HTML code

SVG files can be saved in a small amount of memory and they are scalable without distortion. SVG (Tiny) is supported by browsers on most mobile phones and PDAs. The SVG specification also includes time- based changes or animations that can be embedded within the image code.

The following link shows the animations that can be done using SVG :

www.w3.org/TR/SVG11/animate. html#AnimationElements

Vector Drawn Objects Vs Bitmaps

Vector-drawn objects are described and drawn to the computer screen using a fraction of the memory space required to describe and store the same object in bitmap form. The file containing colored rectangle which occupies **468 bytes** and compressed as **.svgz,** while converted to a 64-bit gif file occupies **1,100** bytes.

Because of this file size advantage, web pages that use vector graphics as SVG files or in plug-ins such as Flash download faster and, when used for animation, draw faster than pages displaying bitmaps.

It is only when you draw many hundreds of objects on your screen that you may experience a slowdown while you wait for the screen to be refreshed—the size, location, and other properties for each of the objects must be computed. Thus, a single image made up of 500 individual line and rectangle objects, for example, may take longer for the computer to process and place on the screen than an image consisting of just a few drawn circle objects.

A vector-drawn object is created “on the fly,” that is, the computer draws the image from the instructions it has been given, rather than displaying a precreated image. This means that vector objects are easily scalable without loss of resolution or image quality. A large drawn image can be shrunk to the size of a postage stamp, and while it may not look good on a computer monitor at 72 dpi, it may look great when printed at 300 dpi to a color printer.

Resizing a bitmapped image requires either duplicating pixels (creating a blocky, jagged look called **pixelation**) or throwing pixels away (eliminating details).

Because vector images are drawn from instructions on the fly, a rescaled image retains the quality of the original.

Converting bitmaps to drawn objects is more difficult. Flash has a **Trace Bitmap** menu option that converts a bitmapped image into a vector image.

Images used for multimedia presentations are often created or edited in drawing and painting programs.

In drawing programs the user typically uses a tool palette which contains lines and geometric shapes. The user selects a shape by clicking on it. The user then clicks and drags within the document to create the shape. For example, a user might create a simple rectangle by clicking on the rectangle tool and then clicking and dragging to produce a rectangle within the document. Once created, the rectangle can be filled with colors and/or patterns. Graphic objects created in drawing programs can be individually selected for later editing. Drawing programs support resizing, fill changes, border width changes, and other edits on individual drawing objects. Individual pixels within an object, however, can not be edited because the object is represented to the computer as a series of vectors rather than a series of pixels. Drawing programs are convenient to use when combining several graphic objects into a layout. In this case the user often prefers to retain the ability to individually select the objects. The layout in figure 1 contains two geometric objects which can be individually selected and resized to produce the layout in figure 2.

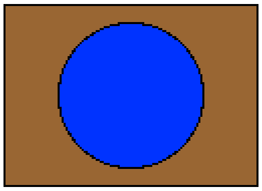


Figure 5.8 - two geometric objects created in a drawing program

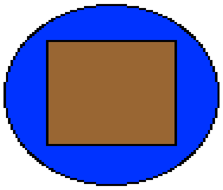


Figure 5.9 - the same two objects, resized.

COLOR

Color is a vital component of multimedia. Picking the right colors and combinations of colors for your project can involve many tries until you feel the result is right. Humans, for example, perceive colors with wavelengths ranging from 400 to 800 nanometers on the electromagnetic spectrum.

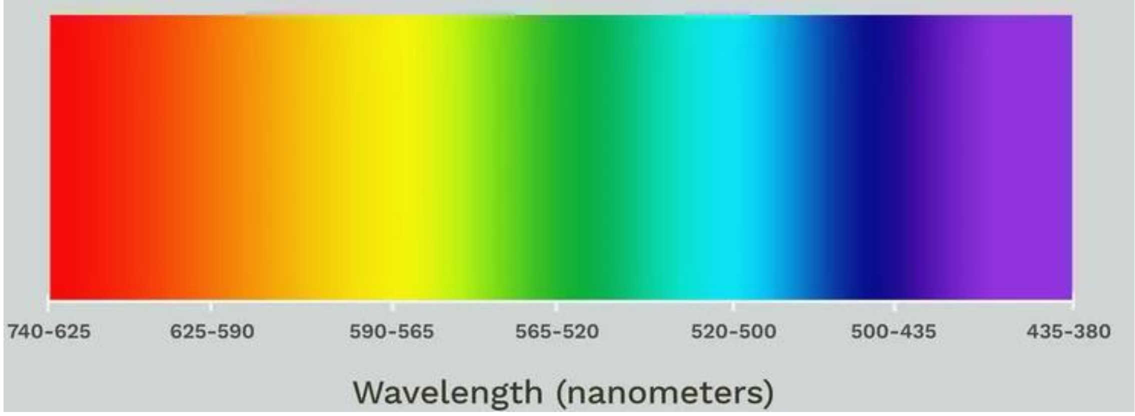


Fig 5.10 Wavelength of Colors

Understanding Natural Light and Color

Light comes from an atom when an electron passes from a higher to a lower energy level; thus each atom produces uniquely specific colors.

The color white is a noisy mixture of all the color frequencies in the visible spectrum. **Sunlight and fluorescent tubes** produce **white light** (though, technically, even they vary in color temperature—

sunlight is affected by the angle at which the light is coming through the atmosphere, and **fluorescent tubes** provide **spikes in the blue-green** parts of the color spectrum); **tungsten lamp filaments** produce **light with a yellowish cast**; **sodium vapor lamps**, typically used for **low-cost outdoor street lighting**, produce an **orange light** characteristic of the sodium atom. These are the most common sources of light in the everyday world.

The light these sources produce typically reaches your eye as a reflection of that light into the lens of your eye.

The cornea of the eye acts as a lens to focus light rays onto the retina. The light rays stimulate many thousands of specialized nerves, called rods, which cover the surface of the retina. Receptors in the cones are sensitive to red, green, and blue light, and all the nerves together transmit the pattern of color information to the brain. The eye can differentiate among about 80,000 colors, or **hues**, consisting of combinations of red, green, and blue.

As color information is sent to the brain, other parts of the mind massage the data en route to its point of cognitive recognition

In Western cultures, for example, red is the color of anger and danger; in Eastern cultures, red is the color of happiness. Red is the traditional color for Chinese restaurant motifs, to make them attractive and happy places; Western restaurants are often decorated in quieter pastels and earth tones. White, not black, is the color of funerals in Chinese culture.

Green, blue, yellow, orange, purple, pink, brown, black, gray, and white are the ten most common color-describing words used in all human languages and cultures.

COLOR MODELS

Because the eye's receptors are sensitive to red, green, and blue light, by adjusting combinations of these three colors, the eye and brain will interpolate the combinations of colors in between. This is the psychology, not the physics, of color: what you perceive as orange on a computer monitor is a combination of two frequencies of green and red light.

Although the eye perceives colors based upon red, green, and blue, there are actually two basic methods of making color: **additive and subtractive.**

1. ADDITIVE MODEL

In the additive color method, a color is created by combining colored light sources in three primary colors: red, green, and blue (RGB). This is the process used for cathode ray tube (CRT), liquid crystal (LCD), and plasma displays. On the back of the glass face of a CRT are thousands of phosphorescing chemical dots.

These dots are each about 0.30mm or less in diameter and are positioned very carefully and very close together, arranged in triads of red, green, and blue. These dots are bombarded by electrons that “paint” the screen at high speeds (about 60 times a second). The red, green, and blue dots light up when hit by the electron beam. Your eye sees the combination of red, green, and blue light and interpolates it to create all other colors.

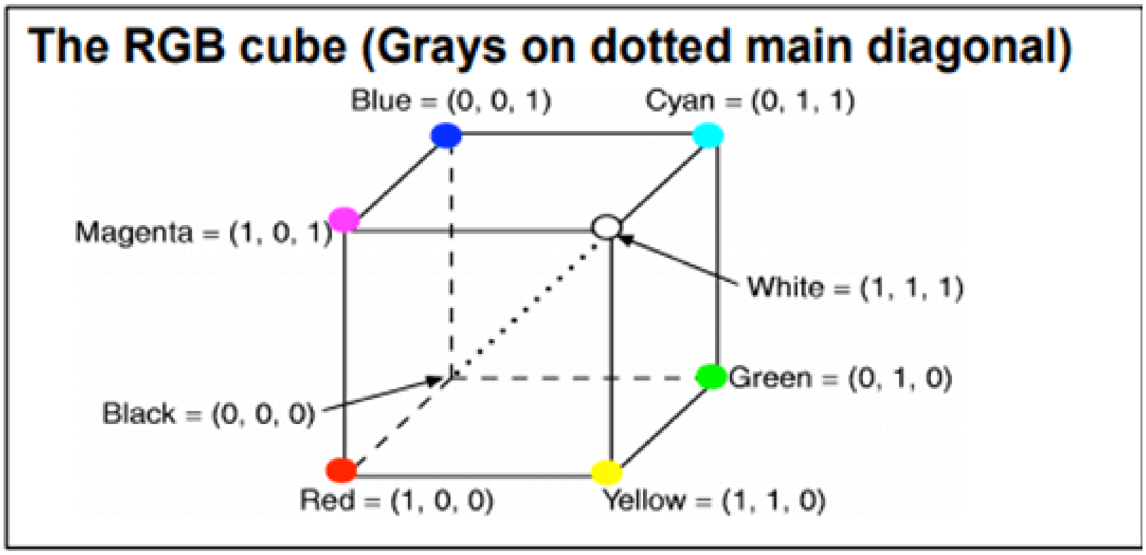
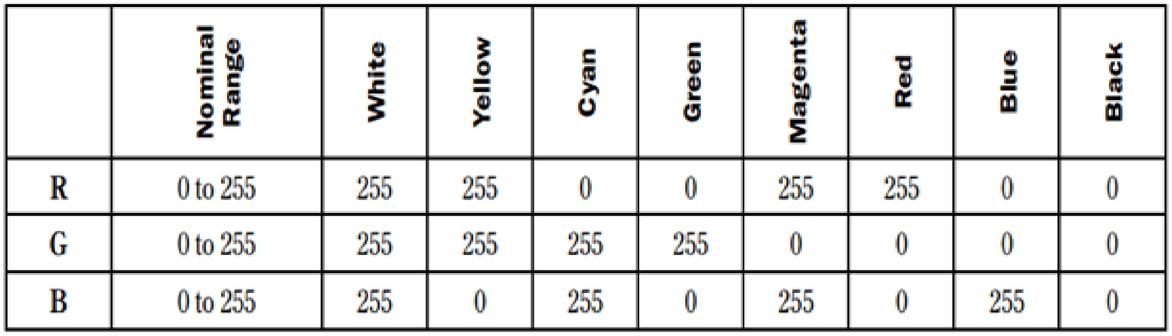


Fig 5.11 Additive Model



	Nominal Range	White	Yellow	Cyan	Green	Magenta	Red	Blue	Black
R	0 to 255	255	255	0	0	255	255	0	0
G	0 to 255	255	255	255	255	0	0	0	0
B	0 to 255	255	0	255	0	255	0	255	0

Fig 5.12 Table representing color combinations

2. SUBTRACTIVE MODEL

CMYK stands for **Cyan**, **Magenta**, **Yellow** and **Black**. CMYK color model is used in electrostatic and ink-jet plotters which deposits the pigmentation on paper. In these model, specified color is subtracted from the white light rather than adding blackness. It follows the Cartesian coordinate system and its subset is a unit cube.

In the **subtractive color** method, color is created by combining colored media such as paints or ink that absorb (or subtract) some parts of the color spectrum of light and reflect the others back to the eye. Subtractive color is the process used to create color in printing.

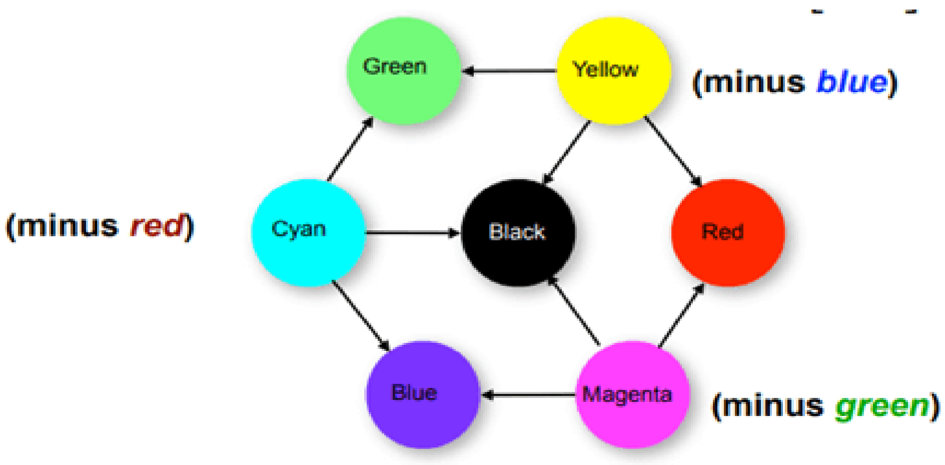


Fig 5.13 Subtractive Model

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} - \begin{bmatrix} C \\ M \\ Y \end{bmatrix} \qquad \begin{bmatrix} C \\ M \\ Y \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} - \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

Fig 5.14 Subtractive Model in Matrix form

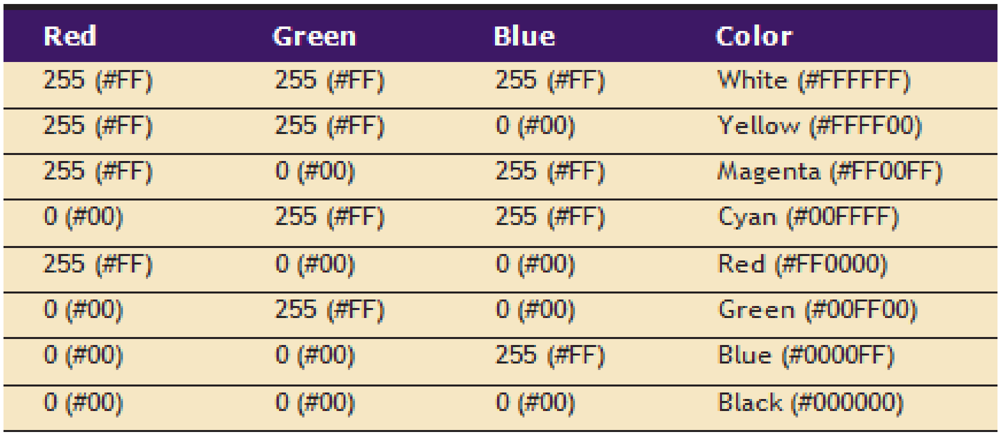
A paint program uses RGB to create the colors on your monitor, while printer uses CMYK to print any image. High- end image-editing programs such as Photoshop deal with this problem by allowing to calibrate your monitor with your printer.

Computer Color Models

Models or methodologies used to specify colors in computer terms are RGB, **HSB**, **HSL**, CMYK, **CIE**, and others. Using the 24-bit RGB (red, green, blue) model, specify a color by setting each amount of red, green, and blue to a value in a range of 256 choices, from 0 to 255.

Eight bits of memory are required to define those 256 possible choices, and that has to be done for each of the three primary colors; a total of 24 bits of memory (8 + 8 + 8 = 24) are therefore needed to describe the exact color, which is one of "millions" (256 X 256 X 256 = 16,777,216).

Rather than using one number between 0 and 255, two **hexadecimal** numbers, written in a scale of 16 numbers and letters in the range "0123456789ABCDEF" represent the required 8 bits (16 * 16 = 256) needed to specify the intensity of red, green, and blue. Thus, in HTML, you can specify pure green as #00FF00, where there is no red (first pair is #00), there is maximum green (second pair is #FF), and there is no blue (last pair is #00). The number sign (#) specifies the value as hexadecimal.



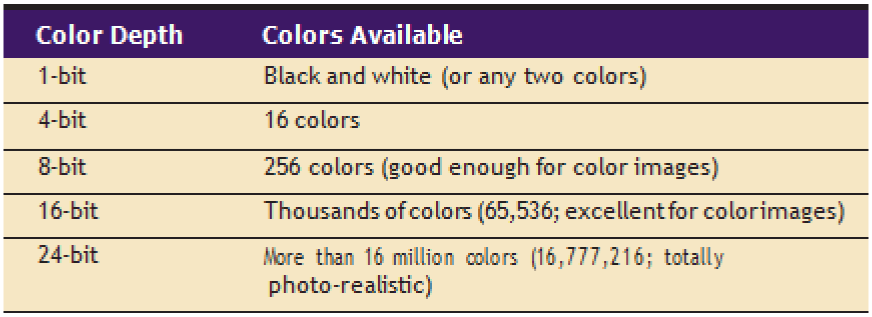
Red	Green	Blue	Color
255 (#FF)	255 (#FF)	255 (#FF)	White (#FFFFFF)
255 (#FF)	255 (#FF)	0 (#00)	Yellow (#FFFF00)
255 (#FF)	0 (#00)	255 (#FF)	Magenta (#FF00FF)
0 (#00)	255 (#FF)	255 (#FF)	Cyan (#00FFFF)
255 (#FF)	0 (#00)	0 (#00)	Red (#FF0000)
0 (#00)	255 (#FF)	0 (#00)	Green (#00FF00)
0 (#00)	0 (#00)	255 (#FF)	Blue (#0000FF)
0 (#00)	0 (#00)	0 (#00)	Black (#000000)

In the HSB (hue, saturation, brightness) and HSL (hue, saturation, lightness) models, specify hue or color as an angle from 0 to 360 degrees on a color wheel, and saturation, brightness, and lightness as percentages. **Saturation** is the intensity of a color. At 100 percent saturation a color is pure; at 0 percent saturation, the color is white, black, or gray. **Lightness** or brightness is the percentage of black or white that is mixed with a color. A lightness of 100 percent will yield a white color; 0 percent is black; the pure color has a 50 percent lightness.

The CMYK color model is less applicable to multimedia production. It is used primarily in the printing trade where cyan, magenta, yellow, and black are used to print process color separations.

COLOR PALETTES

Palettes are mathematical tables that define the color of a pixel displayed on the screen. The most common palettes are 1, 4, 8, 16, and 24 bits deep:



Color Depth	Colors Available
1-bit	Black and white (or any two colors)
4-bit	16 colors
8-bit	256 colors (good enough for color images)
16-bit	Thousands of colors (65,536; excellent for color images)
24-bit	More than 16 million colors (16,777,216; totally photo-realistic)

256 default system colors were statistically selected by Apple and Microsoft engineers to be the colors and shades that are most “popular” in photographic images.

GIF files using 256-color palettes (8 bits) are saved in a lossless format. The PNG format also uses palettes (24-bits or 32 bits), and is lossless. It was developed for the Internet (it supports only the RGB color space) to expand GIF’s limited 256 colors to millions of colors.

FILE FORMATS

Once created (or acquired through scanning) images can be stored in electronic files on a computer's hard disk, floppy disk, or other electronic storage mechanism. Contemporary graphics software allows the user to save image files in a variety of file formats. One of the most common file formats is **encapsulated PostScript (EPS).**

EPS files are ideal for storing images that are intended to be printed on high-resolution imagesetters or laser printers because they store detailed instructions in the PostScript page description language for recreating the image file.

A PostScript-equipped imagesetter or laser printer can then recreate the image at resolutions of **300, 600, 2400, or more dots per inch (dpi).** Color PostScript imagesetters can produce photorealistic output virtually indistinguishable from traditional photographic proofs. EPS is an ideal file format for the production of printed graphics but the appearance of the **graphic on screen at 72 dpi** is not always impressive. For multimedia applications, screen appearance is very important.

The **Macintosh picture format (PICT)** is commonly used within multimedia presentations intended to be viewed on a MacOS compatible computer. PICT files can be read by any Macintosh graphics program or mid to high-end word processor.

The cross-platform file format known as **Tagged Information File Format (TIFF)** is excellent for both screen display and printed output. TIFF files tend to be larger than equivalent PICT files but they offer greater color fidelity and resolution when printed. The screen appearance, however, is similar. **TIFF files are ideal for multimedia presentations** intended to be delivered both on the Macintosh and Windows computer platforms.

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The **Graphic Interchange Format (GIF)** is truly universal in its appeal because GIF files can be viewed on Macintosh, Windows, and UNIX platforms. GIF files are compressed to produce small file sizes which makes them very useful for transmitting electronically over the phone lines.

As a result, GIF has quickly become the standard file format used for graphics on the World Wide Web.

GIF was patented by UniSys in the 1980s and popularized by CompuServe. In 1994, UniSys explored the possibility of charging all GIF developers a fee for creating files in this file format.

GIF files are ideal for line art drawings, color icons, and low-resolution photographs. GIF files can also contain multiple images that are viewed in sequence to produce simple animations. Many web sites today exploit GIF files to enliven their pages with animated logos and drawings.

Graphic Interchange Format

GIF is the only file format that is understood by 100% of the web browsers in existence. Graphic software like Adobe Photoshop or GIFConverter allow users to create GIF files that are optimized to use only the number of colors needed to display the image. GIF files, however, are limited to 256 colors per file which means that photographs often appear grainy and blotchy.

The Joint Photographic Experts Group (JPEG) file format was designed to store high-resolution photographic images and display them attractively on screen. JPEG is ideal for photographs that must appear as realistic as possible when viewed on a web page. JPEG images can use millions of colors per file and looks efficient with lossy compression algorithm to reduce file size. A photograph stored as a JPEG file will have a smaller file size than the same photograph stored as a GIF file. Oddly though, simple graphics with large patches of solid color or line art often look better when using GIF than when using JPEG. All major web browsers support JPEG although a few older browsers do not.

Fig 5.14 A JPEG file of my puppy, Clara.

The choice of file format to use for any particular graphic depends on the intended platform and the need for high resolution.For printed materials, **EPS** is the professional's choice.

For **traditional multimedia presentations**, **TIFF** has cross-platform appeal but **PICT is a better choice for Macintosh-only presentations**.

For universal appeal on the web**, GIF is best for most graphics** and **JPEG is best for photographs** that must be displayed at high-resolution to achieve the desired effect.

The **device-independent bitmap (DIB)**, also known as a **BMP**, is a common Windows palette–based image file format similar to PNG.

Adobe creates a PSD file for Photoshop and an AI file for Illustrator; Corel creates a CDR file. **DXF** was developed by AutoDesk as an ASCII-based drawing interchange file for AutoCAD, but the format is used today by many computer-aided design applications. **IGS** (or **IGES**, for **Initial Graphics Exchange Standard**) was developed by an industry committee as a broader standard for transferring CAD drawings. These formats are also used in 3-D rendering and animation programs.

JPEG, PNG, and GIF images are the most common bitmap formats used on the Web and may be considered cross-platform, as all browsers will display them. Adobe's popular PDF (Portable Document File) file manages both bitmaps and drawn art and is commonly used to deliver a "finished product" that contains multiple assets.

ANIMATION

By definition, **animation** makes static presentations come alive. It is visual change over time and can add great power to multimedia projects and web pages. Many multimedia applications for both Macintosh and Windows provide animation tools.

The Power of Motion:

You can animate your whole project, or you can animate here and there, accenting and adding spice. For a brief product demonstration with little user interaction, it might make sense to design the entire project as a video and keep the presentation always in motion.

For speaker support, you can animate bulleted text or fly it onto the screen, or you can use charts with quantities that grow or dwindle; then, give the speaker control of these eye-catchers. In a parts-assembly training manual, you might show components exploding into an expanded view.

But animation is more than wipes, fades, and zooms. Animation is an object actually moving across or *into* or *out of* the screen; a spinning globe of our earth; a car driving along a line-art highway; a bug crawling

Visual effects such as wipes, fades, zooms, and dissolves are available in most multimedia authoring packages, and some of these can be used for primitive animation. For example, you can slide images onto the screen with a wipe, or you can make an object implode with an iris/close effect.

Warning: Overuse of animation and annoying visual effects can ruin a multimedia project.

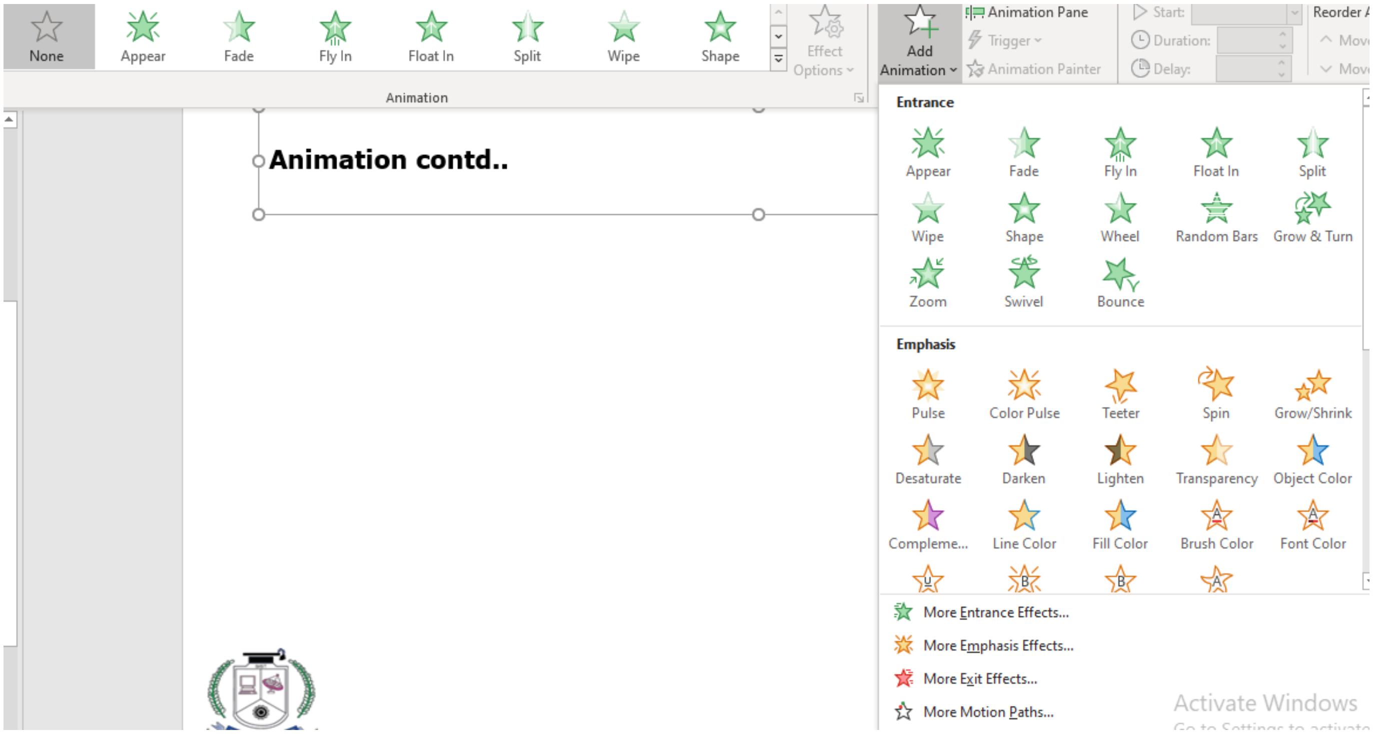


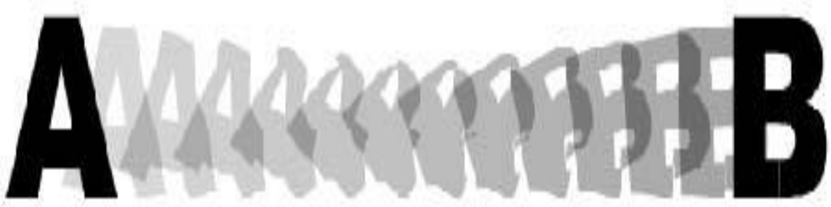
Fig 5.15 Animations in Powerpoint

Animation with Flash

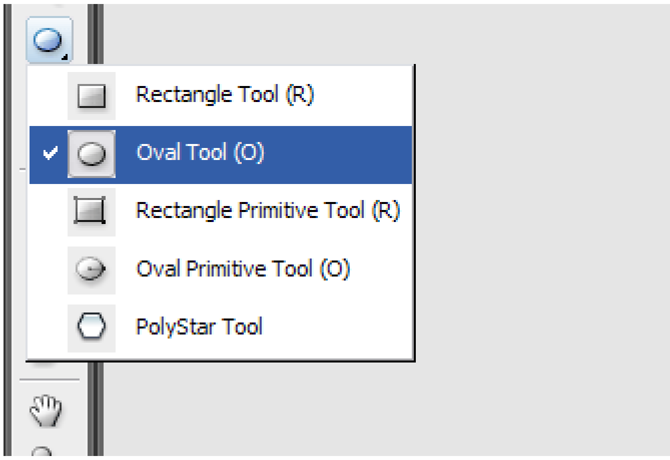
Animating in Flash requires certain understanding of motion and a lot of patience.

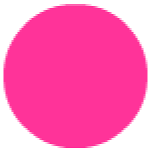
Shape Tweening

The basic idea is that at point A in time you have one object, and at a later point B you have another object. Between the two points, you have a gradual shapeshifting transformation from object A to object B.



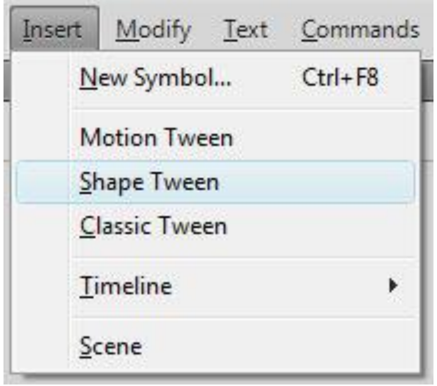
Transition from one shape to another : (Pink Oval to Blue Square)





Select the keyframe at frame 15, choose the rectangle tool , and draw a large, blue square on the right side of the work area.

Then select anywhere in the extended frame 1, and Insert a Shape Tween from the menu (or rt-click on the frame and select Shape Tween).



Between frames 1 to 15, a transformation occurs, which is a **shape tween.**

Principles of Animation

- Animation is possible because of a biological phenomenon known as **persistence of vision** and a psychological phenomenon called **phi.** An object seen by the human eye remains chemically mapped on the eye's retina for a brief time after viewing. Combined with the human mind's need to conceptually complete a perceived action, this makes it possible for a series of images that are changed very slightly and very rapidly, one after the other, to seemingly blend together into a visual illusion of movement. The illustration shows a few cels, or frames, of a rotating logo. When the images are progressively and rapidly changed, the arrow of the compass is perceived to be spinning.

- Digital television video builds 24, 30, or 60 entire frames or pictures every second, depending upon settings; the speed with which each frame is replaced by the next one makes the images appear to blend smoothly into movement.

Movies on film are typically shot at a shutter rate of 24 frames per second, but using projection tricks (the projector's shutter flashes light through each image twice), the flicker rate is increased to 48 times per second, and the human eye thus sees a motion picture. On some film projectors, each frame is shown three times before the pull-down claw moves to the next frame, for a total of 72 flickers per second, which helps to eliminate the flicker effect: the more interruptions per second, the more continuous the beam of light appears.

Quickly changing the viewed image is the principle of an animatic, a flip-book, or a zoetrope. To make an object travel across the screen while it changes its shape, just change the shape and also move, or **translate**, it a few pixels for each frame. Then, when you play the frames back at a faster speed, the changes blend together and you have motion and animation.

ANIMATION BY COMPUTER

Using appropriate software and techniques, you can animate visual images in many ways. The simplest animations occur in two-dimensional (2-D) space; more complicated animations occur in an intermediate "2½-D" space (where shadowing, highlights, and forced perspective provide an illusion of depth, the third dimension) and the most realistic animations occur in three-dimensional (3-D) space.

In 2-D space, the visual changes that bring an image alive occur on the flat Cartesian x and y axes of the screen. A blinking word, a color-cycling logo (where the colors of an image are rapidly altered according to a formula), a cel animation or a button or tab that changes state on mouse rollover to let a user know it is active are all examples of 2-D animations. These are simple and static, not changing their position on the screen.

Path animation in 2-D space increases the complexity of an animation and provides motion, changing the location of an image along a predetermined path (position) during a specified amount of time (speed). Authoring and presentation software such as Flash or PowerPoint provide user-friendly tools to compute position changes and redraw an image in a new location, allowing to generate a bouncing ball on the screen.

In 2½-D animation, an illusion of depth (the z axis) is added to an image through shadowing and highlighting, but the image itself still rests on the flat x and y axes in two dimensions. Embossing, shadowing, beveling, and highlighting provide a sense of depth by raising an image or cutting it into a background. Zaxwerks' 3D Invigorator (www.zaxwerks.com), for example, provides 3-D effects for text and images and, while calling itself "3D," works within the 2-D space of image editors and drawing programs such as Adobe Illustrator, Photoshop, Fireworks, and after Effects.

- In 3-D animation, software creates virtual reality in three dimensions, and changes are calculated along all three axes (x, y, and z), allowing an image or object that itself is created with a front, back, sides, top, and bottom to move toward or away from the viewer, or, in this virtual space of light sources and points of view, allowing the viewer to wander around and get a look at all the object's parts from all angles. Such animations are typically rendered frame by frame by high-end 3-D animation programs such as NewTek's Lightwave or AutoDesk's Maya.

Today, computers have taken the handwork out of the animation and rendering process, and commercial films such as *Avatar, Kochadaiyan, etc.* have utilized the power of computers.

Animation Techniques

When you create an animation, organize its execution into a series of logical steps. First, gather up in your mind all the activities you wish to provide in the animation. If it is complicated, you may wish to create a written script with a list of activities and required objects and then create a storyboard to visualize the animation.

Choose the animation tool best suited for the job, and then build and tweak your sequences. This may include creating objects, planning their movements, texturing their surfaces, adding lights, experimenting with lighting effects, and positioning the camera or point of view. Allow plenty of time for this phase when you are experimenting and testing. Finally, post-process your animation, doing any special renderings and adding sound effects.

Cel Animation

The animation techniques made famous by Disney use a series of progressively different graphics or cels on each frame of movie film (which plays at 24 frames per second). A minute of animation may thus require as many as 1,440 separate frames, and each frame may be composed of many layers of cels. The term **cel** derives from the clear celluloid sheets that were used for drawing each frame, which have been replaced today by layers of digital imagery. Cels of famous animated cartoons have become sought-after, suitable-for-framing collector's items

Cel animation artwork begins with **keyframes** (the first and last frame of an action). For example, when an animated figure of a woman walks across the screen, she balances the weight of her entire body on one foot and then the other in a series of falls and recoveries, with the opposite foot and leg catching up to support the body. Thus the first keyframe to portray a single step might be the woman pitching her body weight forward off the left foot and leg, while her center of gravity shifts forward; the feet are close together, and she appears to be falling. The last keyframe might be the right foot and leg catching the body's fall, with the center of gravity now centered between the outstretched stride and the left and right feet positioned far apart.

The series of frames in between the keyframes are drawn in a process called tweening. **Tweening** is an action that requires calculating the num-ber of frames between keyframes and the path the action takes, and then actually sketching with pencil the series of progressively different outlines. As tweening progresses, the action sequence is checked by flipping through the frames. The penciled frames are assembled and then actually filmed as a **pencil test** to check smoothness, continuity, and timing.

- When the pencil frames are satisfactory, they are permanently inked, photocopied onto cels, and given to artists who use acrylic colors to paint the details for each cel. Women were often preferred for this painstaking inking and painting work as they were deemed patient, neat, and had great eyes for detail. In the hands of a master, cel paint applied to the back of acetate can be simply flat and perfectly even, or it can produce beautiful and subtle effects, with feathered edges or smudges.
- The cels for each frame of our example of a walking woman—which may consist of a text title, a background, foreground, characters (with perhaps separate cels for a left arm, a right arm, legs, shoes, a body, and facial features)—are carefully registered and stacked. It is this composite that becomes the final photographed single frame in an animated movie. To replicate natural motion, traditional cel animators often utilized "motion capture" by photographing a woman walking, a horse trotting, or a cat jumping to help visualize timings and movements. Today, animators use reflective sensors applied to a person, animal, or other object whose motion is to be captured. Cameras and computers convert the precise locations of the sensors into x,y,z coordinates and the data is rendered into 3-D surfaces moving over time.

Computer animation programs typically employ the same logic and procedural concepts as cel animation and use the vocabulary of classic cel animation—terms such as layer, keyframe, and tweening.

The primary difference among animation software programs is in how much must be drawn by the animator and how much is automatically generated by the software.

In path-based 2-D and 2½-D animation, an animator simply creates an object (or imports an object as clip art) and describes a path for the object to follow. The computer software then takes over, actually creating the animation on the fly as the program is being viewed by your user. In cel-based 2-D animation, each frame of an animation is provided by the animator, and the frames are then composed into a single file of images to be played in sequence.

ULead's GIF Animator (www.ulead.com/ga) and Alchemy's GIF Construction Set Pro (www.mindworkshop.com) simply string together your collection of frames.

- For 3-D animation, most of your effort may be spent in creating the models of individual objects and designing the characteristics of their shapes and surfaces. It is the software that then computes the movement of the objects within the 3-D space and renders each frame, in the end stitching them together in a digital output file or container such as an AVI or QuickTime movie.
- On the computer, paint is most often filled or drawn with tools using features such as gradients and anti-aliasing. The word **inks**, in computer animation terminology, usually means special methods for computing color values, providing edge detection, and layering so that images can blend or otherwise mix their colors to produce special transparencies, inversions, and effects.
- You can usually set your own frame rates on the computer. 2-D cel- based animated GIFs, for example, allow you to specify how long each frame is to be displayed and how many times the animation should loop before stopping. 3-D animations output as digital video files can be set to run at 15 or 24 or 30 frames per second. However, the rate at which changes are computed and screens are actually refreshed will depend on the speed and power of your user's display platform and hardware, especially for animations such as path animations that are being generated by the computer on the fly. Although your animations will probably never push the limits of a monitor's scan rate (about 60 to 70 frames per second), animation does put raw computing horsepower to task. If you cannot compute all your changes and display them as a new frame on your moni- tor within, say, 1/15th of a second, then the animation may appear jerky and slow. Luckily, when the files include audio, the software maintains the continuity of the audio at all cost, preferring to drop visual frames or hold a single frame for several seconds while the audio plays.

VIDEO

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Digital video is the most engaging of multimedia venues, and it is a powerful tool for bringing computer users closer to the real world. It is also an excellent method for delivering multimedia . With video elements in project, you can effectively present your messages and reinforce your story, and viewers tend to retain more of what they see.

Using Video

Carefully planned, well-executed video clips can make a big difference in a multimedia project. Before deciding whether to add video to your project, however, it is essential to have an understanding of the medium, its limitations, and its costs.

Video standards and formats are still being refined as transport, storage, compression, and display technologies take shape in laboratories and in the marketplace and while equipment and post-processing evolves from its analog beginnings to become fully digital, from capture to display.

Consider that a high-quality color still image on a computer screen could require as much as a megabyte or more of storage memory. Multiply this by 30—the number of times per second that the picture is replaced to provide the appearance of motion—and you would need at least 30 megabytes of storage to play your video for one second, more than 1.8 gigabytes of storage for a minute, and 108 gigabytes or more for an hour. Just moving all this picture data from computer memory to the screen at that rate would challenge the processing capability of a supercomputer.

Some of the hottest and most arcane multimedia technologies and research efforts have dealt with compressing digital video image data into manageable streams of information. Compression (and decompression), using special software called a codec, allows a massive amount of imagery to be squeezed into a comparatively small data file, which can still deliver a good viewing experience on the intended viewing platform during playback.

If you control the delivery platform for your multimedia project, you can specify special hardware and software enhancements that will allow to work with high-definition, full-motion video, and sophisticated audio for high-quality surround sound.
Or you can design a project to meet a specific compression standard, such as MPEG2 for Digital Versatile Disc (DVD) playback or MPEG4 for home video. You can install a superfast RAID (Redundant Array of Independent Disks) system that will support high-speed data transfer rates. You can include instructions in your authoring system that will spool video clips into RAM, ready for high-speed playback *before* they need to play.

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How Video Works and is displayed ?

When light reflected from an object passes through a video camera lens, that light is converted into an electronic signal by a special sensor called a **charge-coupled device (CCD)**. Top-quality broadcast cameras and even camcorders may have as many as three CCDs (one for each color of red, green, and blue) to enhance the resolution of the camera and the quality of the image.
It's important to understand the difference between analog and digital video. Analog video has a resolution measured in the number of horizontal scan lines (due to the nature of early cathode-tube cameras), but each of those lines represents continuous measurements of the color and brightness along the horizontal axis, in a linear signal that is analogous to an audio signal. Digital video signals consist of a discrete color and brightness (RGB) value for each pixel. Digitizing analog video involves reading the analog signal and breaking it into separate data packets. This process is similar to digitizing audio, except that with video the vertical resolution is limited to the number of horizontal scan lines.

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Digital Video Containers

A digital video architecture is made up of an algorithm for compressing and encoding video and audio, a container in which to put the compressed data, and a player that can recognize and play back those files. Common containers for video are Ogg (.ogg, Theora for video, Vorbis for audio), Flash Video (.flv), MPEG (.mp4), QuickTime (.mov), Windows Media Format (.wmv), WebM (.webm), and RealMedia (.rm). Containers may include data compressed by a choice of codecs, and media players may recognize and play back more than one video file container format.

Container formats may also include metadata mportant information about the tracks contained in them and even additional media

BROADCAST VIDEO STANDARDS

Four broadcast and video standards and recording formats are commonly inuse around the world: NTSC, PAL, SECAM and HDTV.

NTSC : NATIONAL TELEVISION STANDARDS COMMITTEE

U.S, Japan, and manyvother countries use a system for broadcasting and displaying video that is based up on the specifications set forth by the 1952 National Television Standards Committee. These standards define a method for encoding information in to the electronic signal that ultimately creates a television picture. As specified by the NTSC standard, a single frame of video is made up of 525 horizontal scan lines drawn onto the inside face of a phosphor-coated picture tube every 1/30th of a sec by a fast moving electron beam. The drawing occurs so fast that your eye perceives the image as table.The electron beam actually makes two passes as it draws a single videoframe, first laying down all the odd-numbered lines, then all the even-numbered lines. Each of these passes (which happen at a rate of 60 per sec,or 60Hz) paints a field. The process of building a single frame from twofields is called interlacing, a technique that helps to prevent flicker on television screens. Computer monitors use progressive-scan technologies and draw the lines of an entire frame in asingle pass, with outinterlacing them.

PALplus (or PAL+) is an analogue television broadcasting system aimed to improve and enhance the **PAL** format while remaining compatible with existing television receivers. It followed experiences with the HD-MAC and D2-MAC, hybrid analogue-digital formats that were incompatible with PAL receivers. It was developed at the University of Dortmund in Germany, in cooperation with German terrestrial broadcasters and European and Japanese manufacturers.

A standard PAL receiver will display the 16:9 image in letterbox format with 432 active lines. This reproduces noticeably less detail than the 576 lines used for 4:3 broadcasts. A PALplus receiver can use extra information hidden in the black bars above and below the image to fully recover the 576 lines of vertical resolution

SECAM

Soviet technicians were involved in the development of the standard, and created their own incompatible variant called NIIR or SECAM IV, which was not deployed. SECAM is a standard which permits existing monochrome television receivers predating its introduction to continue to be operated as monochrome televisions. Because of this compatibility requirement, color standards added a second signal to the basic monochrome signal, which carries the color information. The color information is called chrominance or C for short, while the black-and-white information is called the luminance or Y for short. Monochrome television receivers only display the luminance, while color receivers process both signals.

HDTV

High-definition video (HDTV Video or HD video) is video of higher resolution and quality than standard-definition. While there is no standardized meaning for high-definition, generally any video image with considerably more than 480 vertical scan lines (North America) or 576 vertical lines (Europe) is considered high-definition. 480 scan lines is generally the minimum even though the majority of systems greatly exceed that. Images of standard resolution captured at rates faster than normal (60 frames/second North America, 50 fps Europe), by a high-speed camera may be considered high-definition in some contexts. Some television series shot on high-definition video are made to look as if they have been shot on film, a technique which is often known as filmizing.

INTEGRATING COMPUTERS AND TELEVISION

SHOOTING AND EDITING VIDEO

Setting up a production environment for making digital video requires hardware that meets minimum specifications for processing speed, data transfer, and storage. There are many considerations to keep in mind when setting up your production environment, depending on the capabilities of your camcorder:

- Fast processor(s)
- Plenty of RAM
- Computer with FireWire (IEEE 1394 or i.Link) or USB connection and cables
- Fast and big hard disk(s)
- A second display to allow for more real estate for your editing software
- External speakers
- Nonlinear editing (NLE) software

Expensive professional video equipment and services may not yield proportionately greater benefits. Various combinations of video recording and playback devices are hooked to your computer, and test the results using your multimedia authoring platform.

VIDEO TIPS

1. Use Plenty of Light.

Lighting makes a huge difference in the quality of a finished professional video, so make it one of your top priorities during filming. If you don’t use enough properly-placed light, your video will probably look amateurish, even if it’s great in every other way.

The sun is one of the best light sources for video. If you’re filming in natural light, do your best to get your footage in the morning or evening, when the light is softer. Midday light coming from straight overhead can cast harsh shadows on your subjects, while morning and evening light is more flattering. If you do have to film in the middle of the day, try to do so on a cloudy day, or find a shady area for softer light.

2. Use a Clean Background

Be deliberate about the background you use for filming. Nothing looks less professional than a messy or distracting background.One easy way to get a professional look for your video is to use a solid-colored background. A wall, a bedsheet, or a large sheet of backdrop paper are all good options. Make sure your subject stands several feet away from the backdrop to avoid casting shadows on it.

3. Choose a Good Video Editing Program

Good video editing software can help you turn your raw footage into something great. There are some simpler tools like Wave.video, Camtasia or iMovie. More professional options include Final Cut Pro and Adobe Premiere Pro.

Here are the key features to pay attention to when choosing a video editor:

- The ability to add text to video;
- The ability to trim and crop videos;
- Scene transitions;
- The ability to change the aspect ratio;
- Adding filters and overlays;
- A library of stock videos and sounds.

4. Keep Your Editing Simple.

A simple, clean editing style generally looks most professional.
A few things you should be sure to do during the editing stage include:
Using noise cancelling to clean up any background noise

Adjusting the lighting a little if you need to.

Cutting out awkward pauses and silences.

Adding background music and transitions.

Another editing tip: If you cut from one scene to another in your professional video, make the jump when there's motion in both segments. This is smoother and more natural than jumping from one scene where nothing is happening to another.

5. Prioritize Crisp, Clear Audio

Your audio quality is actually more important than your professional video quality. Most people are willing to watch a video that's not shot in HD or that's even a little grainy, as long as everything else about it is good. But fuzzy, indistinct audio is usually enough to make anybody hit the "back" button within a few seconds of starting to play a video.

6. Avoid Shaky Footage

Shaky footage will make any professional video look like a home movie (and it can make your viewers feel seasick, to boot). It's hard to hold a camera completely steady, so try not to hold your camera at all if you can help it. Instead, use a tripod, or set your camera on a sturdy surface.

7. Understand the Rule of Thirds

The rule of thirds is one of the most basic principles of film composition. Imagine that there's a 3-by-3 grid laid over the field you're filming. Instead of placing your subject right in the middle of the shot, you should place your subject along one of the lines of the grid. The points where the lines intersect are particularly strong areas of focus, so situate important elements of the video there, if you can.

8. Use Your Phone the Right Way

Use the camera on the back of your phone. The front camera's quality is not as good on most phones.

Record in landscape mode (that is, horizontally instead of vertically). This will give you footage that looks good on larger devices, not just phone screens.

If your phone has a feature that allows you to overlay a grid on your screen, use it. This will help you keep your phone level and avoid tilted footage.

9. Work On Your Camera Presence

If you appear in your professional videos, the way you carry yourself on camera has an enormous impact on how professional your content looks. Appearing nervous, fidgety, or uncomfortable on camera will distract viewers from your message.

10. Shoot from a Variety of Angles

Cutting from one angle to another is a good (and simple) way to add visual interest to your professional videos. This is an especially useful technique if you're making a how-to video, a product demo, or another type of video that shows you doing something rather than just talking. Shoot plenty of B-roll footage for each video so you have the option of using it later if you want to.

11. Plan Your Videos in Advance

A lack of planning can also leave viewers underwhelmed with your finished product. By taking the time to plan your video thoroughly before you start production, you can ensure that the quality of your actual content is just as good as the quality of your footage.

Every time you make a video, start by defining its purpose. Ask yourself what you want to achieve or communicate by making this video. In addition, define your target audience. Once you've defined your video's goals, write a script and create a storyboard.Then revise them until they're as good as you can make them.

12. Promote Your Videos.

Creating your videos is only half the battle. The other half is getting people to watch them. If you want to present yourself as a serious and professional video creator, you've got to promote your videos.

RECORDING FORMATS

MP4. MPEG-4 Part 14 or MP4 is one of the earliest digital **video file formats** introduced in 2001. ...

- MOV. MOV is a popular **video file format** designed by Apple. ...
- WMV. ...
- FLV. ...
- AVI. ...
- AVCHD (Advanced **Video** Coding High Definition) ...
- WebM. ...
- MKV.

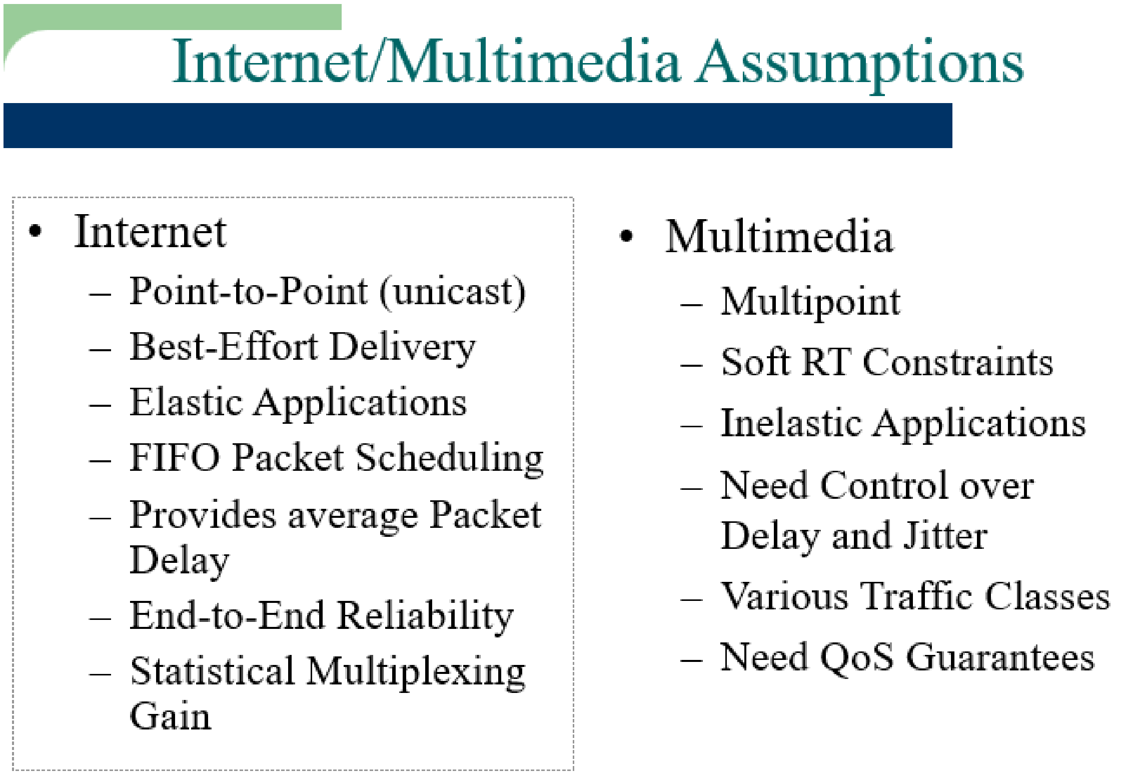
DIGITAL VIDEO

Digital video is an electronic representation of moving visual images (video) in the form of encoded digital data. This is in contrast to analog video, which represents moving visual images with analog signals. Digital video comprises a series of digital images displayed in rapid succession.

Digital video was first introduced commercially in 1986 with the Sony D1 format which recorded an uncompressed standard definition component video signal in digital form. In addition to uncompressed formats, popular compressed digital video formats today include H.264 and MPEG-4. Modern interconnect standards for digital video include HDMI, DisplayPort, Digital Visual Interface (DVI) and serial digital interface (SDI).

Digital video can be copied with no degradation in quality. In contrast, when analog sources are copied, they experience generation loss. Digital video can be stored on digital media such as Blu-ray Disc, on computer data storage or streamed over the Internet to end users who watch content on a desktop computer screen or a digital smart TV. In everyday practice, digital video content such as TV shows and movies also includes a digital audio soundtrack.

MULTIMEDIA ON THE INTERNET

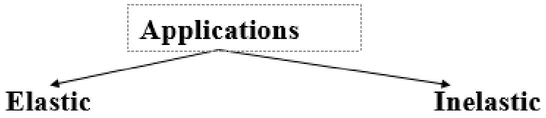


Internet/Multimedia Assumptions

- Internet
  - Point-to-Point (unicast)
  - Best-Effort Delivery
  - Elastic Applications
  - FIFO Packet Scheduling
  - Provides average Packet Delay
  - End-to-End Reliability
  - Statistical Multiplexing Gain

- Multimedia
  - Multipoint
  - Soft RT Constraints
  - Inelastic Applications
  - Need Control over Delay and Jitter
  - Various Traffic Classes
  - Need QoS Guarantees

Application Taxonomy (1)



Elastic Applications:

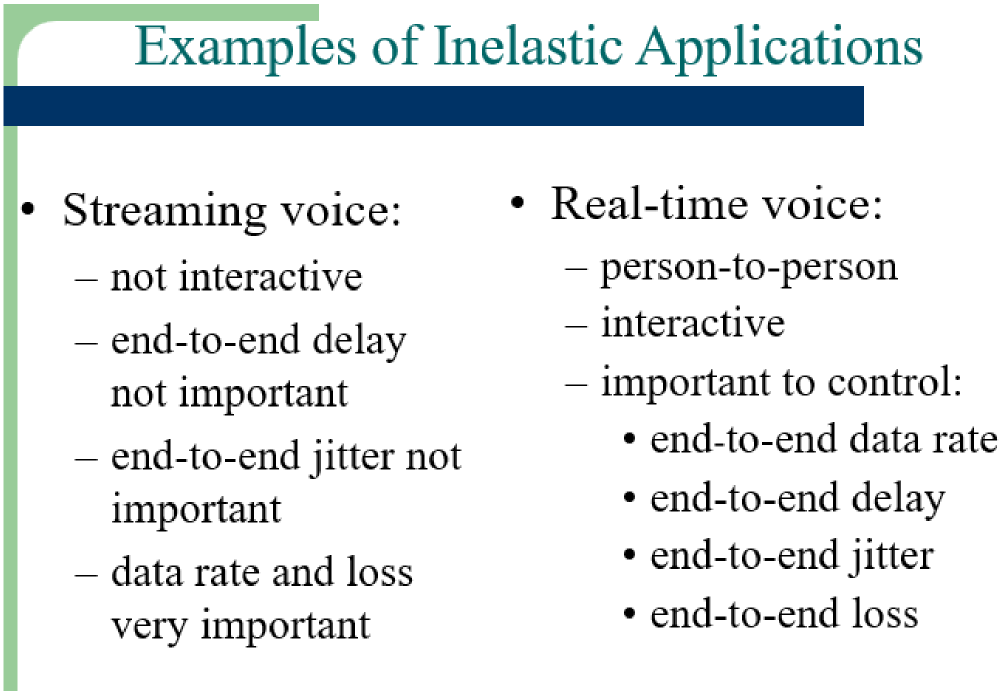
Can tolerate relatively large delay variance – essentially the traditional data application.

Inelastic Applications:

Comparatively intolerant to delay, delay variance, throughput variance and errors.

Examples of Elastic Applications

- Email:
  - asynchronous
  - message is not real-time
  - delivery in several minutes is acceptable
- File transfer:
  - interactive service
  - require “quick” transfer
  - “slow” transfer acceptable
- Network file service:
  - interactive service
  - similar to file transfer
  - fast response required
  - (usually over LAN)
- WWW:
  - interactive
  - file access mechanism
  - fast response required
  - QoS sensitive content on WWW pages



Examples of Inelastic Applications

- Streaming voice:
  - – not interactive
  - – end-to-end delay not important
  - – end-to-end jitter not important
  - – data rate and loss very important

- Real-time voice:
  - – person-to-person
  - – interactive
  - – important to control:
    - end-to-end data rate
    - end-to-end delay
    - end-to-end jitter
    - end-to-end loss